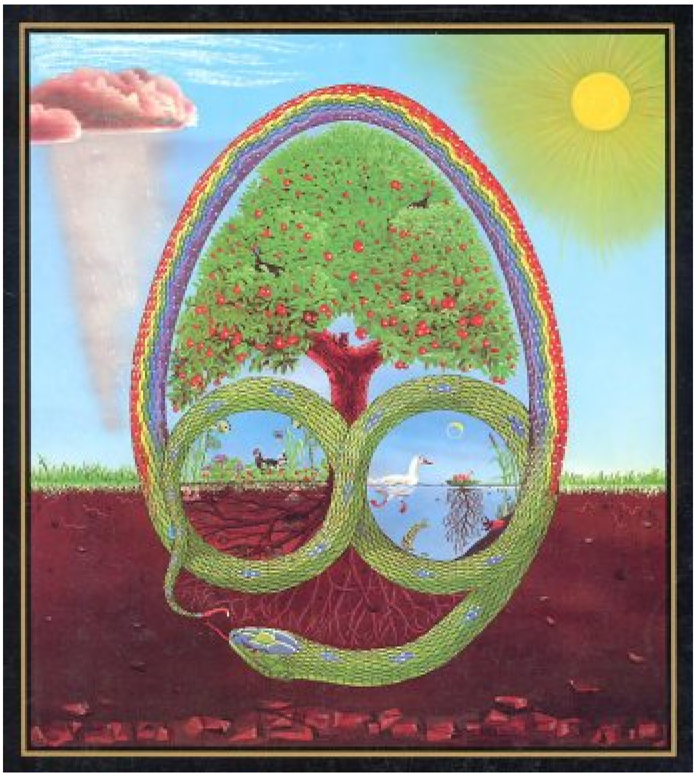
- Ecological Agriculture I -

Earth Care, People Care, Fair Shares

Rural and Urban Permaculture in the Context of Danish Society



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KVL The Royal Agricultural and Veterinary University

“What Permaculturalists are doing is the most important activity that any group is doing on the planet.

We don’t know what details of a truly sustainable planet are going to be like, but we need options, we need people experimenting in all kinds of ways and Permaculturalists are one of the critical gangs that are doing that.”

David Suzuki, 2002 –Hope Dance USA

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Picture from the cover page

"The great oval of the design represents the egg of life; that quantity of life which cannot be created or destroyed, but from within which all things that live are expressed. Within the egg is coiled the rainbow snake, the Earth-shaper of Australian and American peoples."

Mollison, 1988

Abstract

Motivated by the need to develop new, more environmentally friendly and sustainable farming systems, the Permaculture ("Permanent Agriculture") movement began in the 1970's as an alternative farming strategy. Over time, the concept gathered momentum around the globe and has now grown to incorporate many aspects of "Permanent Culture," not just food production. Permaculture, as it is today, has three main goals: "Earth-care, People-care and Fair-Shares."

The prime objective of this project was to analyse the Permaculture system, in a holistic and inclusive manner. To reach this goal, the project assessed the various aspects of Permaculture - discussing its origins with the theories and principles; moving onto on-site functional and design analyses; a qualitative review of Permaculture and its relevance to Urban and Peri-Urban agriculture (UPA); and then a broad discussion of Permaculture in the context of global food production history and philosophies. The final assessment considered the sustainability, feasibility and applicability of Permaculture in Denmark, through extensive reviews of Permaculture and Agriculture literature; on-site analysis and personal interviews.

It was concluded that the Permaculture system is inherently "information and design intensive." Adoption of the Permaculture ethos, in both rural and urban environments can lead to benefits in energy efficiency, closed nutrient cycling, ecological balance, reduced work and disturbance, and community development. These can all be sustained and enhanced in the long-term, and may be a real means of food production achieving true sustainability goals.

However, Permaculture in Danish rural and urban environs is currently not well developed. The future success and extension of Permaculture, in Denmark, will not be limited by deficiencies in the Permaculture system itself, but rather by external factors, such as lack of political support, low community interest and other polemics of Denmark.

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Introduction

Severe global land degradation, disillusioned farmers, the starving millions in Least Developed Countries (LDCs) and poisonous food products are clearly telling us there is something wrong with our agricultural production and management systems. Given the impact that expansion of agricultural lands has had on the global environment, the development and implementation of more sustainable, ecologically focused farming techniques is of paramount importance.

The first major wave of modern environmental awareness emerged following the Club of Rome report in 1972 and the oil shocks of 1973 and 1975 (Holmgren, 2003). This broad-scale public awareness triggered a strong movement towards alternative land management strategies, which could meet global food needs without depleting the earth's resources. One, perhaps lesser-known movement, which evolved during that period, is called "Permaculture." This Australian conceived idea began in the late 1970s and has slowly gathered momentum around the globe. This project attempts to document the philosophies, theories and history behind Permaculture and, in a Danish context, analyse the Permaculture system in both a rural (land management and design) and urban (community agricultural) context.

The concluding analysis of Permaculture in Denmark will involve assessment (primarily qualitative) of the sustainability, feasibility and applicability of this "alternative" farm management strategy. The authors of this project believe that such an analysis can facilitate an integrated and holistic approach to land management-related decision-making. Farmers, at least, can be provided with more objective information pertaining to the ideal management of land and business. This, we believe, can lead to a "net-benefit" outcome for society that provides social, economic and environmental returns to land managers (farmers, community gardeners etc), as well as numerous other benefits to society (EA, 2002).

The project follows in five main parts – the literature review of agriculture in general and the Permaculture philosophy (origins, principles, differences with organic and case studies); on-site analyses of rural Permaculture management systems; a review of Permaculture in the context of urban (community-based) agriculture; a discussion of global and societal issues in Permaculture and the final synthesis of the project, including an overall discussion, conclusions and recommendations.

It is beyond the scope of this study to examine all of the criteria for sustainable agriculture, therefore the primary focus in the concluding chapter will relate to:

- Current practices
- Feasibility
- Applicability

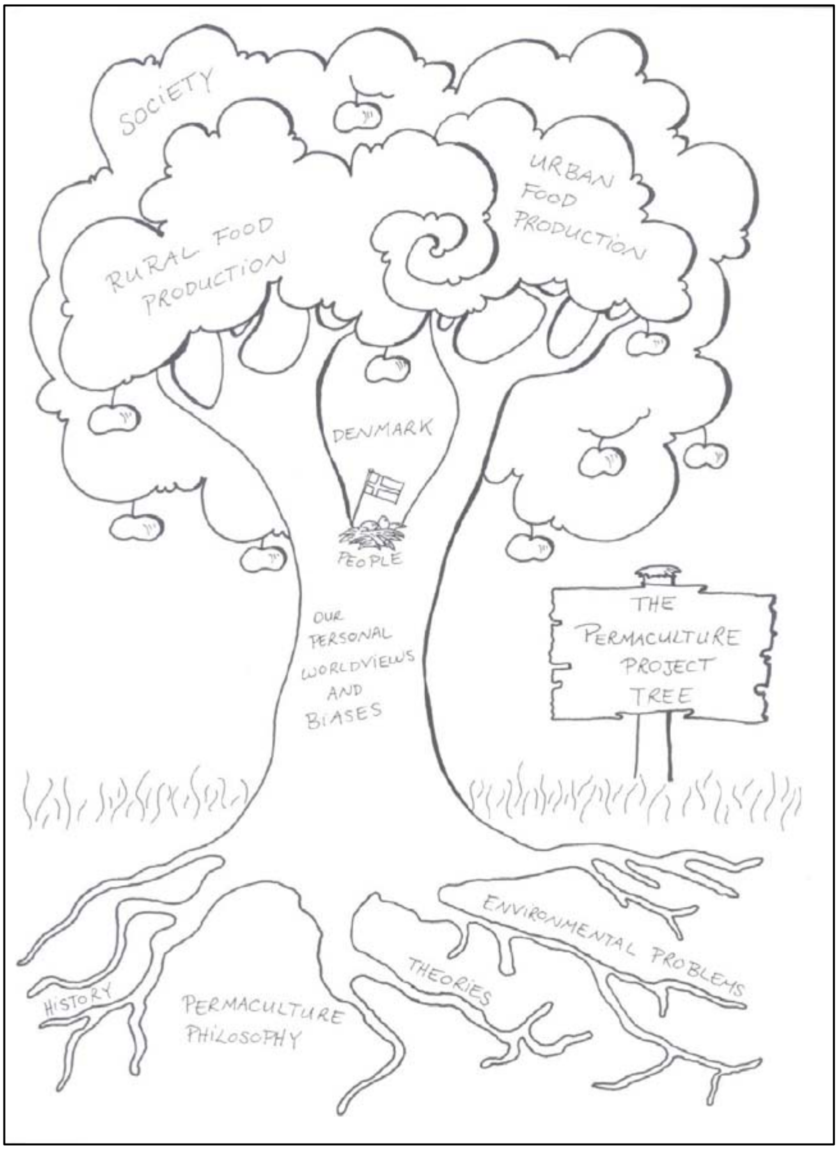


Figure I-1. The Permaculture Project Tree

This tree represents the evolution, structure and final outcome of our Permaculture Project. In wanting to create a project that mimicked the Permaculture Philosophies, we adopted a holistic and integrated approach. We believed that any analysis of the Permaculture system must be inclusive of the fundamental Permaculture ideals, that is "Earth-Care, People-Care and Fair Shares". A mere functional design analysis would clearly omit a lot of the key goals that are fundamental to Permaculture, such as people care.

Therefore our project tree begins at the roots with Environmental Problems, Permaculture Philosophy, the History of Permaculture, and its Theories. Our personal worldviews and biases have filtered and affected what we write, so these aspects form the trunk (or main structure) of the tree. The branches of the Permaculture tree are made from the Rural Food Production analysis and the review of Urban and community-based farming systems. These branches sit above the Danish nest, as we have looked primarily at Permaculture in the Danish context. The tree canopy integrates all aspects of Permaculture to form the final chapter - the global and societal component of the Permaculture Tree.

Chapter 1. Review of Literature: Theories Behind the Permaculture Concept

The aim of this chapter is to introduce the topic of Permaculture and give a brief summary of the environmental and economic challenges leading to its inception. The main components include the philosophy of the Permaculture system, its principles and how Permaculture differs from conventional and organic production systems. In order to set the basis, for the proceeding studies of Danish Permaculture, the chapter concludes with two case studies of Permaculture in Temperature climates. Primarily, this chapter shall introduce the ideas and topics covered in the following Chapters Two, Three, Four and Five.

1.1 The need for a New Agriculture - Righting the Wrongs

At both a local and global level, consequences of conventional farming have impacted negatively across environmental, social and economic spheres. This includes soil erosion; low soil biological fertility; reduced biodiversity; loss of income for farmers; greater dependence on agribusiness corporations; loss of small family farms (due to increasing economies of scale); increases in malnutrition and famine; increases in agricologenic diseases such as BSE; and the breakdown of rural communities.

A study conducted by the US Department of Agriculture suggested that current agricultural practices are destroying 6 pounds of food for each pound of food produced (Jeavons, 1995). A study in Britain found that, the average domestic vegetable plot (in Britain) yields three and a half times as much per square metre as the average farm, due to the extra attention that can be given to smaller areas (Whitefield, 1997). The following discussion outlines the problems with Conventional Agriculture, defines different methods of agriculture and presents Permaculture as a possible solution to the “Sustainability Crisis”.

1.1.1 Environmental Degradation and the Green Revolution

The “Green Revolution” of the 1960’s allowed for major increases in the productivity and profitability of agricultural systems in the developed world (Matson *et al*., 1997). Through the use of high yielding crop varieties, chemical fertilisers, pesticides, irrigation and mechanization farmers were able to greatly increase the productive capacity of their land and hence increase global food supplies (Tilman *et al*., 2002).

However, four decades after its adoption, the severe resultant problems are clearly apparent. Looking at the major widespread land degradation and diminishing economic returns we are now faced with, many concerns have arisen over the long-term sustainability (incorporating environmental, economic and social consequences) of conventional, "chemical" production systems. At a local level, negative consequences of conventional farming have included increased soil erosion, low soil biological fertility and reduced biodiversity. Negative consequences, at the regional scale, include pollution of ground waters and eutrophication of rivers and lakes, just to name a few (Matson *et al.*, 1997).

It is now known that conventional agricultural practices deplete the soil around 8 to 80 times more rapidly than natural soil building processes. This happens when soil humus depleted without replacement, when cropping patterns destroy soil structure and when minerals are removed from soil more rapidly than they are replaced (Jeavons, 1995).

At present, the paradigm driving the Green Revolution is still dominant with scientists and farmers alike, looking upon technologies such as genetic modification and chemical no-till farming to improve the problems we are faced with today, such as poor soil fertility and chemical resistant weeds. However, movements such as Organic Farming and Permaculture have started to "take-off" at a more mainstream level and are now contributing to positive environmental externalities.

1.1.2 Economic Challenges in Agriculture

Following the Green Revolution, the adoption of "high tech" cultivars, high yielding varieties of seeds, the use of fertiliser, insecticides, pesticides and mechanical devices greatly increased both the costs and levels of production (Bansal, 1992). For farmers, this has directly translated to an increase in the costs of production per hectare, coupled with the problems of environmentally unsustainable farming techniques. The increase in annual cost requirements for production and dependability on "chemical farming" has now, in many cases, reduced annual cash flow and increased farm debt (Bansal, 1992; Hooper *et al.*, 2003; Lambeck, 2003). In the case of many farmers in LDC's the Green Revolution has meant that they have completely lost access to farmland (Madeley, 2002).

In some instances, nitrogenous and phosphoric fertilisers are approaching diminishing returns (Tilman *et al*., 2002). Higher levels of inputs are applied annually with decreasing benefits (as yield and profit returns) to the farmer.

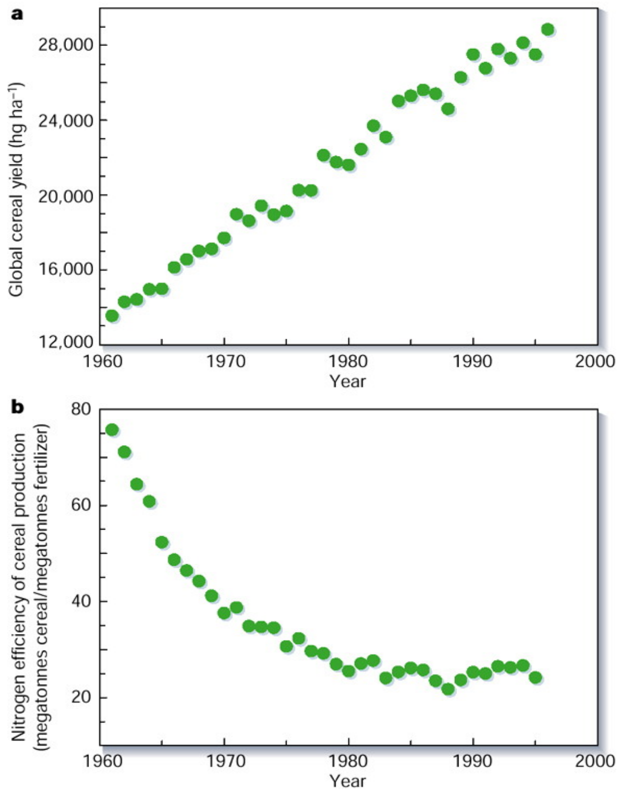


Figure 1.1.2 Diminishing returns of fertiliser application imply that further fertiliser applications may not be as effective at increasing yields. Taken From**:** Tilman *et al.* (2002)

a, Trends in average global cereal yields;

b, trends in the nitrogen-fertilization efficiency of crop production (annual global cereal production divided by annual global application of nitrogen fertiliser)

There exists a real and tangible need for widespread adoption of farm management systems, which improve the quality of degraded agro-ecosystems as well as reduce the growing cycle of high input requirements and increasing debts and liabilities.

1.2 Definition of Agro-production Systems

"*Traditional agriculture was labour intensive, industrial agriculture is energy intensive, and* ***Permaculture-designed systems*** *are* ***information*** *and* ***design intensive***." (Holmgren, 2003)

1.2.1 Definition of Conventional Agriculture

At the extreme, conventional agriculture can be classified as "high external input" agriculture, where the focus is primarily on maximizing production (or yield) and the soil is treated as a practically inert medium in which to grow crops (Munro *et. al*., 2002). The main tenet of conventional agriculture is maximising yields using mechanisation and chemical farming practices.

1.2.2 Definitions and Goals of Organic Agriculture

Organic agriculture places an emphasis on soil biological fertility, with the underlying philosophy that fostering biological cycles within the soil will lead to improvements in the farmland as well as crop quality and yield (IFOAM, 2004a).

What is organic agriculture? **Organic agriculture** is an agricultural system that promotes environmentally, socially and economically sound production of food, fibre, timber etc. In this system soil fertility is seen as the key to successful production. Working with the natural properties of plants, animals and the landscape, organic farmers aim to optimise quality in all aspects of agriculture and the environment.

Figure 1.2.2 IFOAM definition of organic agriculture

The principles of Organic Farming are based primarily on the following three principles (DARCOF, 2000):

- The Cycling Principle
- The Precautionary Principle
- The Nearness Principle

However, given the expansion of organic practices and the global trade of organic products, the extent to which these principles are met, in practice, is somewhat challenged. DARCOF (2000) noted that "in comparison with earlier times, far less attention is currently being paid to societal and cultural values."

1.2.3 Definitions and Goals of Permaculture

The word "Permaculture," broken down into its components, means "Permanent Culture[1]", and implies a system that can truly sustain the needs of current and future generations. Culture, is mostly interpreted as food production culture, given the origin of Permaculture. However, the Permaculture movement has embodied a multifaceted view

[1] Initially Permaculture began as Permanent Agri-Culture, however as the Permaculture concept gathered momentum, it was increased to cover all aspects of sustainable living, not just food production.

of "culture" to include many things from self-sufficient energy designs, houses made from natural materials to bio-intensive food production systems. In all aspects of Permaculture, sustainability is clearly the prime tenet.

What is Permaculture?

Permaculture is a **practical concept** applicable from the balcony to the farm, from the city to the wilderness. It is a **design system** for sustainable environments providing **food**, **energy**, **shelter**, **material** and **non-material needs**, as well as the social and economic infrastructures that support them.

Permaculture means **thinking** carefully about our **environment**, our **use of resources** and how we supply our **needs**. It aims to create systems that will sustain not only our present, but also future generations (PIJ, 1999).

Figure 1.2.3 Permaculture International Journal definition of Permaculture.

Defining Permaculture as a concept is as dynamic as the Permaculture system itself. Since the inception of the Permaculture design concept in the late 1970s a diverse range of authors, teachers and students have defined and evolved the Permaculture ethos. As discussed by Holmgren (1992), "*Permaculture means different things to different people… These uncertainties stem from the wholistic (sic) nature of the concept and because Permaculture has always being developing.*"

Nowadays the Permaculture Ethos involves many ethical, conceptual and technical ideas directing the practice of a world-wide movement (Holmgren, 1992). **Permaculture is NOT just about gardening or buying a bit of land in the country, it encompasses many activities such as community gardens, LETS (Local Exchange Trading System) Schemes, Organic Allotment sites, and Community Composting Systems.**

Permaculture means many things!

There is no such thing as a *complete* Permaculture because it is also a process of development over time. Permaculture is a name given to a very old process. Ancient native cultures understood if you ever squandered a resource, you would some day run out of that supply. So there are remnant examples of Permaculture in practice all around you. Some people are members of the Permaculture Institute, and consciously study the subject as a design discipline. Some people just do it for pleasure. Many more have never heard of the word but practice it every day through common sense (Bell, 1992).

1.3 The History of Permaculture

> *"Permaculture was designed as a bottom-up evolving system of agriculture which developed directly from human needs expressed at a site and a bio-region, rather than a system for modifying existing industrial agriculture. In that sense it was proposed as a truly alternative system which saw unsustainable industrial agriculture and culture as essentially doomed to collapse (Holmgren, 1992)."*

When first introduced by Mollison and Holmgren in the Permaculture One Manual (1978), Permaculture was proposed as an agricultural system based on perennial plants, modelled on natural ecosystems and developed through the application of design. It has been suggested that Permaculture emerged from the Organic Growers movement in Tasmania with its first official published documentation, circa 1976 in the Tasmanian Organic Gardener and Farmer Journal Holmgren (1992).

The Permaculture idea rapidly spread from Tasmania to other parts of rural and urban Australia. In the mid-1980s, Permaculture began to gather momentum as a worldwide movement. Permaculture, as it is known today, has been extended to cover all types of climates, in all countries of the globe – from profitable broad-acre farming systems to sustainable backyard food production and community agriculture programs in Lesser Developed Countries (LDCs). The broad applicability of the Permaculture design system and the persistence and commitment of founder Bill Mollison, has no doubt facilitated its successful adoption in many different contexts across the globe.

Nowadays, the best examples of Permaculture in Western Societies are often found in rural areas and have been created by "disillusioned-alienated urbanites" that have sought another lifestyle. However, aspects of Permaculture, such as bioregionally specific design models, techniques and species are gradually emerging and being more widely taken up. Sheet mulch garden establishment techniques, multi-tier mixed gardens and fire resistant landscape design are examples of Permaculture that have gained acceptance across a wide audience (Holmgren, 1992).

1.3.2 The Extension of Permaculture

The Permaculture Design System is heavily extension based and much of the "Permaculture movement" has been focussed on education and training, using the two week Permaculture Design Course (PDC). The word Permaculture is copyright and can be used by anyone adhering to the principles and ethics of Permaculture. Only graduates of a Permaculture Institute can teach Permaculture, and they adhere to an agreed on curricula developed by the College of Graduates of the Institutes of Permaculture (Bell, 1992). Registered graduates are authorised to teach Permaculture anywhere in the world.

1.4 The Permaculture Design Principles

> *"Don't cut the sun out as a source of energy, and keep the water running downhill; store it in the soil, and release it clean. Let heated air and water rise, as they will, and forget about pumps to force the reverse of natural flows* (Mollison, 1999)."

This statement by Mollison clearly indicates the practicality of Permaculture Design Strategies (PDS) and the emphasis on working with natural energy flows, rather than against. In harnessing and encouraging natural processes the system is able to function most efficiently with the least effort (labour and energy inputs). The main criteria used in design strategies, as outlined by Mollison (1999) are:

- Passive energy systems
- Adequate climate control on site
- Future developments planned
- Provision for food self-sufficiency on site
- Minimal external energy needs
- Wastes safely disposed of on site
- Low maintenance structures and grounds
- Water supply assured, conserved and
- Fire, cold, excess heat and wind factors controlled and directed

1.4.1 Permaculture and Food Production

One of the key goals in Permaculture food production systems is the design of "Food Forests" or "Edible Landscapes". This involves creating ecosystems that mimic those found naturally, that contain a large variety of edible fruits, vegetables and herbs – essentially ecosystems designed to meet human needs. The food forest concept may be broadened to also contain plants and resources useful for building, clothing, fuel, medicine, decoration, animal fodder, etc. In mimicking the natural forest, the Permaculture garden contains a high canopy of trees, lower layers of small trees, large shrubs, herb layers as well as plants which are below ground and creepers which move everywhere (Whitefield, 1997). (Example of Permaculture Farm, see Appendix 1)

1.4.2 Zone Analysis

Zone analysis, in the Permaculture design system, is the underlying factor in assessment and implementation of the principles. According to Mollison (1988), using a zone analysis is "design by the application of a master pattern." Generally zones can be envisaged as a series of concentric circles, with the innermost circle (or nuclei of activity) as the home or dwelling. This moves outwards to the most frequently visited and intensively managed areas and finally onto the least visited areas or wilderness.

Of course, in reality, the zone model is derived less from concentric circles and more from fluid areas modelled depending on the access, site characteristics (eg. slopes and soils), local wind patterns and technical problems (such as previously existing structures) (Mollison, 1988). With respect to orchards (Zone 2 or 3) and wilderness (Zone 5) areas, they may exist in the form of wedges, which penetrate through to Zone 0.

Zoning is essentially determined on two criteria:

1. The number of times you must visit the plant, animal or structure.
2. The number of times the plant, animal or structure needs you to visit it.

Table 1.4.2. Zones in the Permaculture design system (adapted from Mollison, 1988)

Zone Number	Intensity	Components
0	Energy Origin	The village or dwelling, attached glass- or shade-houses, vines, trellis, pot plants, roof gardens and companion animals.
1	High	Elements needing continual observation, work input and visitation. Include fully-mulched or pruned gardens, culinary herbs, foods necessary for existence, chicken laying boxes, seedlings, delicate species and quiet domestic animals (eg. fish, rabbits & guinea pigs)
2	Medium	Include larger elements such as spot mulched orchards, main-crop beds, and ranging domestic animals whose shelters or sheds may adjoin Z0 or Z1. Also includes terraces, small ponds, hedges and trellis. Forage ranges for milder climate animals (such as milk cows, poultry or goats). Some home orchards may also go here.
3	Medium to Low	The "Farm Zone" for commercial crops and animals for sale. Contains natural or little-pruned trees, broad scale farm systems, large water storages, soil adsorption of water, feed- or store-barns and field shelters as hedgerows or

		windbreaks.
4	Low	Areas bordering on forest or wilderness but still used for wild harvesting, forest and fuel needs of household, pasture or range and is planted to hardy, unpruned or volunteer trees. May contain water- (dams only) or wind-harvesting technology.
5	Very Low to Nil	Natural, unmanaged environments used for occasional foraging, recreation, or just let be.

1.4.3 Energy Management (Sector Analysis)

In Permaculture, efficient energy planning is achieved through the use of the Zone Analysis, and careful placement of plants, animals (as outlined in previous section). Permaculture design recognises that energy and nutrient systems are inherently leaky, and as a result, instructs that we should design components, elements, structures, plants etc to *minimise,* or at least reduce, the leakage from the system – be it an entire farm or just a small backyard plot. In doing so, external inputs and energy requirements will be minimised, thus reducing work, costs etc.

With respect to energy relations, Permaculture is about primarily about reducing the amount of work needed to meet a given end. Whitfield (1997) redefines work in the Permacultural context - “Work = any need not met by the system.” Bell (1992) notes that, in an ecologically kind society, we need to minimise our energy expenditure and to maximise the creative and rewarding nature of our personal work. Basically, in working with nature to achieve maximum benefit (highest productivity and lowest energy expenditure) we should do the least! This does not mean doing nothing at all – it means working with natural ecological processes (trophic levels, plant strata etc) and harvesting maximum natural energy (wind, sun, water) to achieve the best outcome. Any element in the system is carefully placed to reach maximum efficiency. The key question is “Why did you put that structure (or plant) there?”

In Permaculture, massive efforts used to “tame nature” are seen as unnecessary, energy consuming and unsustainable. Practices such as field ploughing are therefore replaced with “no-dig” beds, which minimise soil disruption, reduce weeds and require very little maintenance.

The use of wild energies (wind, sunlight) is paramount to the “sustainability” and “self-reliance” principles of Permaculture. In conjunction with using wild energies, the use of biological resources and machinery is also important, depending on the degree of adoption of the Permaculture ethos.

1.4.4 Nutrient and Waste Management

Bell, (1992) states that "systems which pollute are wasteful, not just financially, but in that they create unnecessary work. Nature does not waste, it is a complete system in which each element produced by one part of the process is indisputably needed elsewhere as a resource." Whitefield (1997) defines "pollution" as any input not used by the system.

The Permaculture approach to nutrient management is reflective of its approach to energy management. Just as Permaculture design strategies attempt to achieve the maximum cycling of energy within the system, nutrients too are a resource that should not be "lost" from the system.

Design strategies identify nutrient flows and will incorporate elements that can either catch or trap the nutrients before they leave the system. Ponds and wetlands are a common example of catching nutrients, as productive aquaculture systems can be developed to filter and utilise nutrient runoffs. Another strategy is to position food or other useful crops to uptake nutrients before they leave the system.

A complex and high yielding example, is the use of integrated aquaculture systems within Permaculture design. These systems are based upon traditional methods of organic waste treatment in China, and have been incorporated in many Permaculture designs. Organic waste consisting of human and animal manures, crop and other food wastes are digested anaerobically to produce methane, which is then used as a fuel in household cooking. The remaining slurry is oxygenated, and then added to shallow ponds where it is used to grow algae, which removes a large amount of the nutrients from the pond. The algae is used to feed fish, which are grown for human consumption, and the high nutrient water from the algae and fish ponds (due to fish manure) is used to fertilise gardens and fields. These systems are flexible in size, and can be used for small communities, medium – large farms (with sufficient livestock to generate waste) or even towns and cities (Mollison 1988).

1.4.5 Permanence in Agriculture

The use of perennial plants, especially trees, is a key component of a Permaculture design strategy. Modern agricultural practices are based on rotations of annual crops, and thus the agro ecosystem does not have an opportunity to mature, but is kept young. Such an approach forgoes the ecological niches (opportunities in space and time for plants, animals, people to obtain a yield) that are created in mixed maturity ecosystems, and the stability and self-regulation that comes with maturity.

Whilst continual cropping of annual plants every year has a greater maximum yield than a mixed maturity polyculture based upon perennial plants, much more energy and management has to be expended to gain this yield (Mollison, 1988). The immaturity of the annual-based agro ecosystem is also subject to the inherent weaknesses of young organisms – pests, diseases, and reliance on care/management.

Mixed maturity polycultures are consciously designed to reflect the local ecosystem around the site, with some "tweaking" of microclimate to increase yield. This provides a wide range of benefits, including:

- The continuity of the supply from the system (throughout the year)
- Perennial plants mean non-tillage of the soil, therefore building soil structure
- Reduces weeds as ground is always covered
- Reduces labour involved in sowing annual crops and weeding
- Reduces overall management needs of the site as perennial crops, once established require little maintenance beyond harvesting
- Increases opportunities to create microclimate
- Increases habitat necessary for ecosystem services (eg biological pest control)
- Increases infiltration of water into the soil due to large root penetration
- Slows surface flow of water, therefore decreasing erosion
- Deposition of condensation on branches mostly runs into the ground in temperate – cold climates (Mollison, 1988)
- Production of soil conditioning biomass through leaf drop

1.4.6 Optimising Ecological Relationships

One of the key attributes of the Permaculture design system is the arrangement of structures to maximise efficiency. Spatial arrangement of the different elements within the system (be it the whole farm ecosystem, or a microcosm on one edge of a pond) is used to optimise the ecological relationship between the components. In optimising ecological relationships, the maximum benefit is derived from the system, in the form of symbiotic relationships that lead to higher yields; beneficial predator-prey relations; and nutrient production. The basis of this understanding is linked to nature, in that the most productive and efficient ecosystems are those found at the interacting edges (Mollison, 1978). For example, wetlands that form barriers between marine and estuarine environments and act as filters, feeding grounds, breeding grounds etc while being highly productive. The primary mechanisms used in Permaculture to optimise ecological relationships are "The Edge Effect, Guilds and Stacking." The following paragraphs outline these mechanisms.

In Permaculture, one way to optimise ecological relationships is the "Edge Effect". In short, it refers to the additional productivity and efficiency that is found at the interactive edge between two (or more) ecosystems. The edge is defined as the junction or zone that lies between two media or landscape forms; a border where materials or resources accumulate (Mollison, 1991).

In Permaculture design, the edge effect is maximised through the use of non-linear borders and patterns such as keyhole shaped garden beds. Maximum edge effect is also developed by placing two converse ecosystems near each other, such as a pond near the vegetable beds.

Guilds are defined as "a species assembly of plants and animals which benefit each other, or to a selected crop species, usually for pest control." Guilds need to be placed in a sensible pattern for management and to effect the benefits of interaction" (Mollison, 1988 and 1991). Therefore Permaculturalists are encouraged to observe which plants benefit each other when grown together. Often effective guilds are formed when these beneficial plants are planted or "stacked" together.

Another important mechanism used to optimise ecological relations is "stacking." Stacking refers to the arrangement of plants to take advantage of all possible space, using tall and medium-sized trees with a lower shrub and herb layer. Generally, the plants are arranged to ensure that water and light competition is at a minimum (Mollison, 1991).

1.5 The Permaculture System: Differences with Organic and Conventional

1.5.1 Earth-care, People-care and Fair-shares

Although the outcome, definitions etc of Permaculture may differentiate – the key ethical basis remains the same. That is “Earth-care, People-care and Fair Shares.” This topic has been discussed at length in Chapter Four.

1.5.2 Permaculture and Community

Permaculture is viewed by its advocates as striving to achieve an “information rich culture which is local, autonomous and land based (Holmgren, 1992).” More so than any other proposed agricultural system, does Permaculture incorporate social, economic and cultural factors into the context of food production. Where other systems have failed to consider the “Triple Bottom Line,” Permaculture considers each component as equally important as the next.

One of the most crucial differentials between Permaculture and conventional agriculture is the intention of the system. The aim of conventional agriculture is to yield products for an external commodity market – influenced by many different practices such as international trade agreements, global price fluctuations etc. Conversely, Permaculture is a design system for creating sustainable human settlements, based on local and community orientated interactions. Although, this must not confuse the fact that the Permaculture design principles are broadly applicable and have been successfully implemented in more “conventional” contexts.

1.5.3 Permaculture, Organics and Certification

While the concept of Permaculture has been copyrighted, at present there is no official certification program for Permaculture farms. As a result it is very difficult to give an estimate of the number of persons using these principles at a global scale. Many farms receiving ‘Organic’ and/or ‘Biodynamic’ certification are using the Permaculture design system as a part of their management practices, some knowingly and others not. In addition to production-based farms, the Permaculture system is also utilised by home gardeners, hobby farmers and community gardeners – thus indicating the broad scale applicability of the Permaculture system and its “common sense” principles (Holmgren, 1992).

Given that the majority of people practising Permaculture (for profitability) are certified organic farmers, the line between the two "alternative" management systems is somewhat blurred. However, if the two systems are compared by looking at the organic certification standards and the Permaculture design principles, it can be said that Permaculture takes the philosophy of organic agriculture one (big) step further.

Rather than just omitting chemicals from the system and focussing on the soil as the means to improving the overall biological functionality, Permaculture incorporates whole system design into farm management. In doing so, the Permaculture system attempts to maximise beneficial interactions between plants, animals, energy and nutrient cycles and other on-farm factors, such as topography and hydrological features. Permaculture also attempts to maximise off-farm factors such as local markets, local employment, investment in community resources and development of local infrastructure. This may potentially enable land managers to make better use of their yields and obtain a more satisfactory and environmentally benign lifestyle.

The following table provides a summary of the main differences between Organic and Permaculture farm management systems. **NB.** As previously mentioned there are also many similarities between the two systems. These have been omitted in order to focus on that which differs. Organic farmers may, in some cases, use Permaculture principles however the above points are not explicitly included in the Organic Certification criteria.

Table 1.5 Differences between Organic Agriculture and Permaculture

Criteria	**Organic Agriculture**	**Permaculture**
Prime Tenet of the System	Non-use of chemicals	Conscious design for minimising external requirements and maximising efficiency, leading to sustainable resource use.
Farm design	Not explicitly designed	Consciously designed for maximum efficiency
Site and Bio-region specific*	No	Yes
Permanence of the system	Very low, annual or bi-annual changeover.	High, permanent crops (ie. Nuts) intercropped with annuals
Attempts to mimic natural ecosystems	No	Yes
Soil Disturbance (ie. Tillage)	Yes, as weed management	Strictly no tillage
Fossil Fuel Use	Mainly fossil fuels ie. Tractors for tillage, sowing and harvesting	Mainly uses biological energy sources ie. People and horses
Water Harvesting	Not explicitly mentioned	Uses 'keyline' farm plan with

		swales etc to maximise water efficiency
Encourages reduced personal consumption	No	Yes
Training required	Can be done but not always necessary	Must have a PC design certificate
Community Involvement	May have farmers markets	Incorporates urban agriculture, community education (ie. primary schools) and farmers markets.
Certification	Yes	No

* This criterion is a subset of the farm design criteria, ie. Permaculture achieves site specificity and bio-region through the "conscious design" process.

1.6 Sustainable Agriculture and Permaculture

1.6.1 Definition of Sustainability

Sustainability is an ecological, social and economic concept. As defined in the Brundtland Report, it most often refers to meeting the needs of the present without compromising the ability of future generations to meet their own needs[2]. Another group of student in our class conducted their project on the concept of sustainability, and can be consulted for a more comprehensive discussion on the topic (Molero-Cortes et al., non-submitted project).

1.6.2 Permaculture as Sustainable Agriculture

"The Eco-crisis is largely a consequence of the way that we in the West consume. Permaculture is about recognising this and taking responsibility for our actions and for our planet, and turning around our behaviours of consumption and exploitation so that we can recreate a world without destruction and pollution."(Burnett, 2000)

The capacity for current "conventional" or "chemical-based" agricultural systems to meet these sustainability goals is limited (EA, 2002). Without a large-scale shift in paradigm, leading to major changes in the operation of our farming production systems, the afore-mentioned outcomes of sustainability will not be achieved (EA, 2002). The combined effects of soil erosion, desertification and salting may mean that agriculture has to feed twice the worlds population on half the present arable land by the year 2020. Much of the lost land will be in food exporting countries, like the USA and Australia (Whitefield, 1997).

[2] Taken from http://encyclopedia.thefreedictionary.com/Sustainability

A proposed (and practiced) alternative to the current problem-inducing conventional farming method is a more ecologically based ethos. Matson *et al.* (1997) noted that ecologically driven management strategies, such as Permaculture, can increase the sustainability of agricultural production while greatly reducing off-site consequences.

Permaculture offers practical solutions to the aforementioned problems. Soil erosion can be changed to soil creation by adopting no-till methods and by growing tree crops or other perennials on steep slopes. Desertification is being addressed by introducing people in arid areas to gardening, as a less destructive form of food production than extensive cropping or grazing. Re-establishing trees in arid areas is also a Permaculture speciality and, once they are established, trees make their own rain (Whitefield, 1997).

As suggested by Tilman *et al.* (2001) and Whitefield (1997), ecological farm management strategies may be a means of society accomplishing dual objectives of improving yield levels and of preserving the quality and quantity of ecosystem services provided by land and water resources.

Given the land design considerations and emphasis on biological diversity, the Permaculture philosophy has, in theory, a much higher capacity to meet new sustainability agendas in food production, than both conventional *and* organic systems (Jeavons, 1995; Holmgren, 2003).

Table 1.6.4. Area required to grow the average diet for one person, for one year (after Jeavons, 1995)

Average US Diet	Farming Technique	Land Required (sq. ft)
	Conventional Mechanised	22 000 – 42 000
	Biointensive (ie. Permaculture)	4 000

1.6.3 Why Can't We Just Adopt Organic Farming?

A primary objective behind any "Ecological Farming" ethos is to maximise the activity of soil micro-organisms and utilize their ability to make soil nutrients available for plant growth (Mader *et al*., 2002). The increased microbial activity of the soil can increase the soil fertility and increase the availability of nutrients therefore leading to improved nutrient uptake of plants (Mader *et al*., 2002). This undoubtedly leads to spill-over environmental and production based benefits.

However, it is important to clarify that Organic Agriculture is a method of growing – a technique - whilst Permaculture is a design system – an overall strategy. To a certain extent they complement each other, each providing an essential component in an overall system. However, there are a few distinct differences between the two, leading to different strengths of the sustainability of the systems.

Organic farming is based on crop rotations, growing a different crop on each piece of land each year. Permaculturalists, on the other hand, prefer to grow a diversity of crops on the same piece of land at the same time, some constituting annuals while others are perennials and stay permanently in the system. A second difference is that Permaculture places a strong emphasis on no-till methods. This philosophy, derived from Fukuoka (1978), is central to Permaculture and is absent from most organic farming techniques. No-Till is seen as an essential element of a low energy and “soil building” strategy for the future (Fukuoka, 1978; Whitefield, 1997).

In the No-Till farming system, a combination of tree crops, mulch and green manure is used to build soil fertility. Weeds are controlled by slashing, mulching, browsing or flooding (Mollison, 1991).

Fukuoka’s Four Principles of No-Till Farming

1. No ploughing or other forms of cultivation which disturb the delicate soil balances
2. No added fertilisers – soil naturally maintains its fertility in harmony with nature’s cycles
3. No weeding – native plants are an important element in building soils
4. No pesticides – when healthy crops are grown in a healthy soil, diseases and insect pests are naturally kept in check

(Fukuoka, 1978)

While the General Principles of Organic Farming, as outlined by IFOAM, are inclusive of environmental, economic and social criterion, the *actual* recommendations for the certification standard do not include these aspects of sustainability (IFOAMb, 2004). While environmental, best management practices are indeed a step towards increasing the environmental sustainability of agro-ecosystems, they do not, in themselves, meet the necessary economic and social criterion for complete *(or Triple Bottom Line)* sustainability. See Section 1.5 and Figure 1.5 for a full summary of the difference between the two systems.

1.7 The Success and Viability of Permaculture in Temperate Climates

This last section documents two case studies as successful examples of Permaculture in temperate climates. This provides a justification for our further analysis and study of Permaculture in the Danish context and provides a basis for understanding Permaculture in practice.

1.7.1 Isn't Permaculture Best Suited to "Year-round" Growing Seasons?

No! Whilst Permaculture was conceived and developed in Australia, its foundations actually lie in the *temperate climates* of Tasmania, south of the Australian mainland. Although many critics of Permaculture have suggested that Permaculture is best in tropical or continuous growing seasons, it has been proven that Permaculture design is well suited to many different locales (Bell, 1992).

Since its beginning Permaculture has successfully spread throughout Australia and the world, from desert 'waste-lands' to many temperate-cold regions. The design philosophy and principles encourage designers to maximise the resources they have and, in doing so have placed emphasis on bio-regional specificity and design requirements such as heat storage for cold climates.

Sensible design to maximise the efficiency and efficacy of heat energy that enters a system can allow people to live more comfortably and increase yields, whilst at the same time reduce reliance on secondary energy sources (the sun being the primary energy source for life systems on earth), such as central heating and electricity.

1.7.2 Case Studies from Temperate Climates

Beyond the backyard greenhouse, there are a number of good examples of successful cold climate Permaculture systems that have been successfully developed for commercial enterprise. Two case studies focusing on Permaculture in temperate climates will be briefly discussed here.

The first case study (PIJ, 1992) is from a Permaculture market garden in the Rocky Mountains that has only 100 days of frost-free growing. In accordance with the Permaculture design recommendations a variety of techniques have been integrated to form a low maintenance and highly productive system. These include:

- [3]*Energy management and passive solar design:* glass houses on a steep gradient; dark stone used for garden terraces and position in a southerly aspect
- *Optimised ecological relationships*: integrated pest management through diverse intercropping, with pest losses estimated at around 5%
- *Nutrient and Waste management*: animals are integrated into the fertility cycle
- *Water conservation techniques*: mulching, drip irrigation, soil conditioning

Five years after implementing the Permaculture Design the farmer is quoted: "in terms of site development and the infrastructure, most of the hard work has been done and the facilities paid for. The soil is now very fertile, and the productivity of the system has a lot of momentum. Very little effort now has to go in to get a lot of output." In 1992, the annual net income for the business was estimated at $40 000 (USD), clearly indicating the productive and economic success of the farm.

The second case study is of a property in Austria (Bown & Shel, 2000). On this property of 45 hectares, between 1100 – 1500m above sea level, a diverse range of products are grown, many of which are previously unknown to such altitudes. The Farmers have closely observed the relationships between the biological and physical elements in the natural ecosystem and designed their system based upon these observations. They too have implemented a number of design strategies, namely:

- *Energy management and passive solar design:* terraces are placed on a steep south facing slope, large boulders and rocky outcrops are left in place (to trap heat)
- *Optimised ecological relationships*: a diversity of plants are grown – both perennial and annual (agro-forestry, fruit trees, herbs, wildflowers etc) to stabilise the whole eco-system[4]
- *Water conservation techniques*: a large number of ponds and dams have been built (also to trap heat)

[3] *Italics* indicate the design strategy implemented
[4] Species diversity leads to system stability with integrated pest management, less risk of "weed" problems and production

1.8 Chapter Summary

Permaculture, which evolved in the early 1970's, is a 'design-conscious' farming system that has the potential to ameliorate poor environmental and economic conditions, partially brought about by the Green Revolution. Permaculture incorporates strategies such as Zone Analysis and Energy Management to create efficient and productive food systems. Through maximum energy-use efficiency; the inclusion of permanence in the system; and optimised ecological relations Permaculture constitutes an effective farm management strategy that be more successful than current conventional and organic systems in meeting sustainability criteria.

The next chapter includes detailed on-site analyses of the various Permaculture design strategies that were discussed in this literature review.

Chapter 2. Ecological Design of Small Farm Systems in Rural Denmark

Permaculture Approach to Four Case Studies

2.1 General Overview

A close look at existing farm systems is essential to understand the challenges related to the application of Permaculture. A single case study on a Permaculture system could have certainly mobilized the whole project, but we wanted a broader overview of what is currently done in Denmark. On the other hand, time constraints limited the number of farms, as well as the depth of analyses.

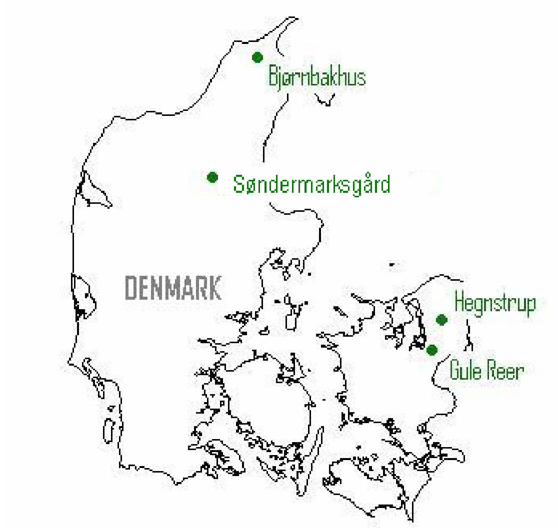


Figure 2.1. Geographical situation of the farm studied.

A balance was found with the choice of four farms scattered around Denmark (Figure 2.1). Two of them are Permaculture farms, and the two others are small organic farms having management practices close to Permaculture.

All of the case studies chosen for the project are indeed very different, and reflect various aspects of the reality faced by small farmers in Denmark.

Bjørnbakhus is a small organic farm in the northern part of Jutland, aiming for self-sufficiency in food and energy. It represents a system that has been established for almost 25 years, but which fulfils the needs of only one family. **Søndermarksgård** is a fairly new system managed by three young enthusiastic farmers sharing a rented piece of land, also in Jutland. It is a site for experiments and application of Permaculture design. **Hegnstrup** is an organic vegetable farm in Zealand, established during the 70's. It is known for its diversity in habitats and cropping systems. **Gule Reer** is a Permaculture project managed by a group of Copenhagen citizens. It has been running successfully for more than a decade.

One reading the following farm analyses must then keep in mind that the systems are at different stages of evolution, have been developed in different geographical and social contexts, and slightly differ in the needs they intend to fulfil. What really links those farms together though is the basic driving force behind them: the desire of creating a food-producing system that can sustain itself, and which is in harmony with the environment.

2.2 Methodology

2.2.1 Farm Visits and Data Collection

The only criterion for choosing the farms was that they would have be somewhat related to Permaculture design. Since Danish Permaculture farms are not numerous, we had to find other farms that would be mimicking the principles. We assumed that small diversified organic farming systems would have more chance to have developed an ecologically functional design which integrates some Permaculture concepts.

The farms were all visited once between March 26th and May 4th. The time spent at each of the farms varied with various circumstances including availability of the farmer and travel constraints. It varied between two hours and two days. For each of the visits, a tour of the farm coupled with a discussion with the farmer was done.

2.2.2 System Analyses and "Permaculture Criteria"

Permaculture is a holistic concept, and assessing the level of its application on a farm is as difficult as assessing the overall sustainability the farm system. Direct and quantitative can be possible in a controlled, experimental system especially designed to achieve a specific goal. However, evaluating the application of Permaculture in commercial and community farms poses some practical problems, due to the complexity and the driving forces behind those systems.

In recent European research about sustainable agriculture, indicators have been used when it is not possible to carry out direct measurements. Indicators synthesize qualitative data, show the current state of a system, and demonstrate the achievement or not of objectives (Bockstaller et al. 1997). According to van der Werf et al. (2002), there are two types of approaches that can be adopted when choosing a set of indicators. The *means-based* *approach* takes into account farmer production practices, and is usually the easiest to conduct through interviews and visits. The *effect-based approach* is focused on the effect these practices have on the state of the farming system and the environment. The latter approach is usually preferred by scientists, since it gives a better view of the farm state, while the choice of means to achieve goals is left to the farmers.

Considering that Permaculture is a practical, applied concept, and considering the resources and time we have to conduct analysis, the mean-based approach is the most suitable in the case of this project. The work from Bill Mollison (1988, 1994) was used to create our own set of indicators.

The following list includes criteria and sub-criteria that have been considered.

1. **System Functionality**
   - The efficiency of functional relationships between components of the system
2. **Respect of Permaculture zoning**
   - The nuclei of activity, and their spatial relation with the different Permaculture zones
3. **Efficiency of energy management**
   - The use of wild energies (wind, sunlight)
   - The energy cycles on the farm, including sources, storages and leakages
   - The use of biological resources and machinery
4. **Efficiency of nutrient management**
   - The nutrient cycling on the farm, including sources, storages and leakages
5. **Establishment of a permanent, self-maintaining food system**
   - The use of perennial plants
   - The continuity of the supply from the system (throughout the year)
   - The adaptability of the system to site conditions
6. **Optimization of ecological relationships**
   - The use of guilds
   - The diversity of species and habitats
   - The shape of edges between habitats

7. **Adoption of an information and imagination-intensive approach in management strategies**
    - The positive use of natural elements of the system
    - A sustainable source of knowledge, and reliability on field experience

Each farm system is first analysed separately. Then, there is an attempt in comparing the farms on a “Permaculture scale”.

2.3. The Farm Systems

2.3.1. Bjørnbakhus

General description

Bjørnbakhus is a 4 ha farm own by Inga and Bent Nielsen. Both are presently over 50 years old, and have been cultivating the land organically for 24 years. They aim at being self-sufficient in energy and food. This farm is a good example of a well-established system that has changed very little during the last years. The farm includes about 5 cows, 2 horses, a few geese and chickens, as well as bees. Energy is produced through the use of a windmill and solar panels. The land is cultivated with horses and manpower. The rotation is over 7 years and includes clover grass, cereals and vegetables.

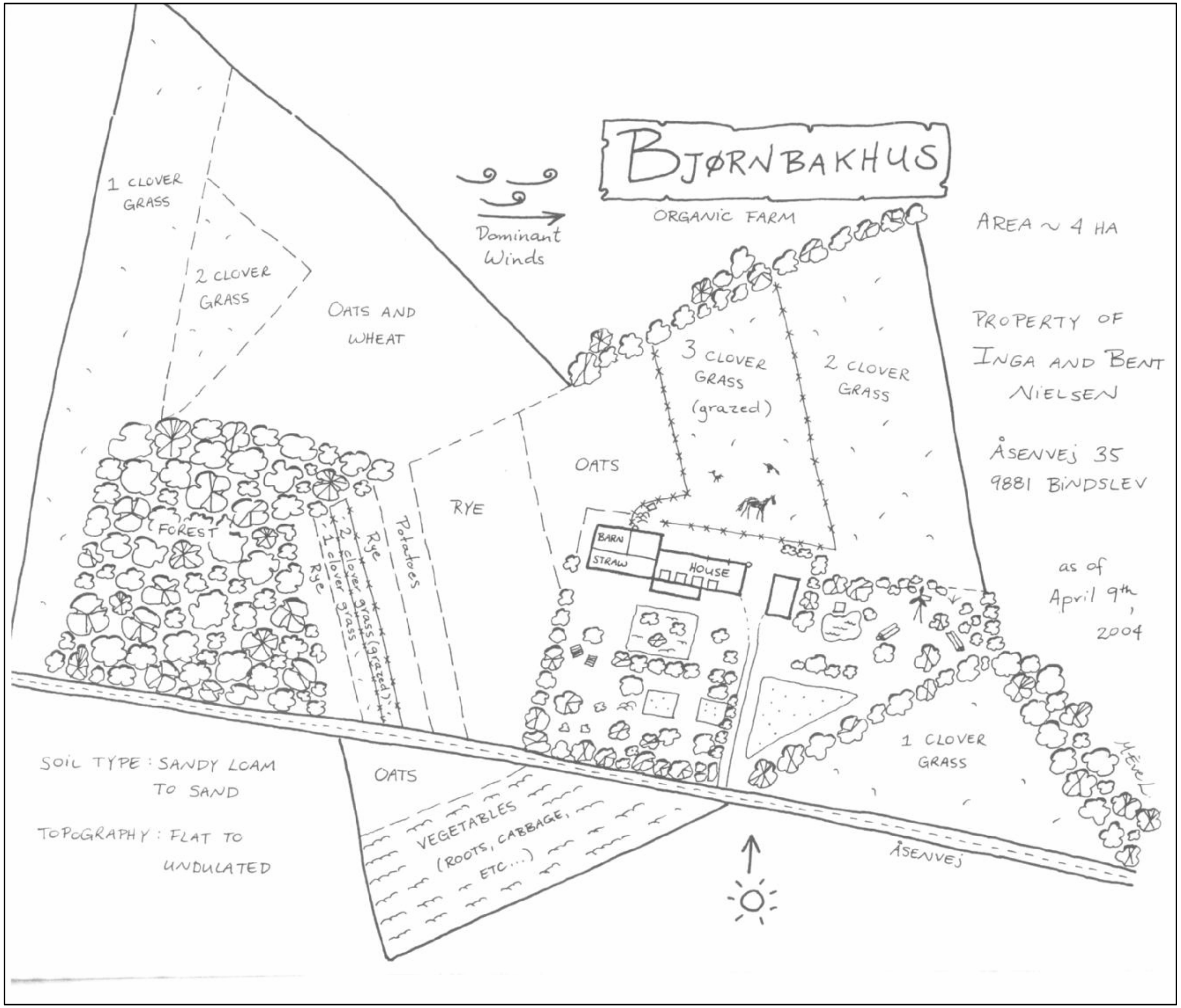
Both Inga and Bent have a part-time job outside the farm. The products of the farm are only consumed inside their family. The geographic location of the farm makes it very difficult for them to find a market for local organic products.

Plan of the farm

Figure 2.2 shows the plan of the farm, drawn from personal observations and an aerial photograph. Some elements require precision, and a look at Figure 2.3 can help in situating some key elements.

1. Windmill
2. Firewood
3. Pond, and shelter for geese
4. Garden, in which annuals and perennials are mixed
5. Storage shed
6. Water barrels, collect water from the gutters
7. Compost toilet within the house
8. Solar panels
9. Greenhouse
10. Orchard
11. Cleaned plot, with scattered shrubs
12. Gardens and trees
13. Bee hives
14. Stable, where cattle are kept during the night and horses during the day
15. Barn with machinery and straw bales
16. Manure heap
17. Water point for animals
18. In the five small fields near the forest, the soil is very sandy and poor
19. The forest is situated on the poorest soil of the land (sand)

Figure 2.2. Plan of Bjørnbakhus



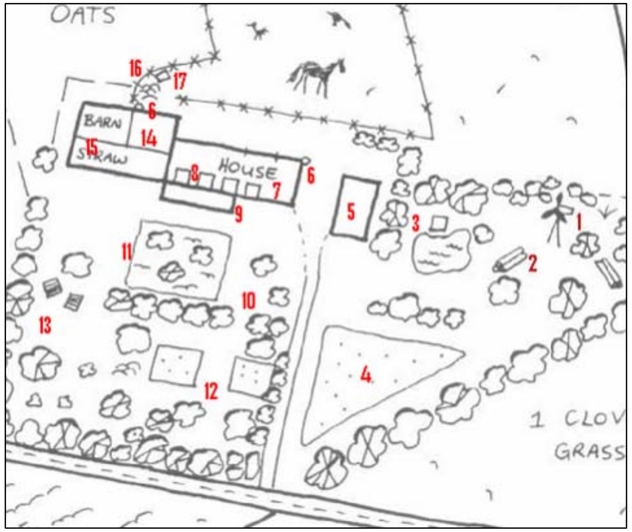


Figure 2.3. Precisions about elements around the House at Bjørnbakhus

Functional analysis of components

Table 2.1 shows the system components, their needs, and what other component fulfil each need. Such functional analysis of the system is important to see if it can maintain itself.

Table 2.1. Functional analysis of Bjørnbakhus

Component of the system	What it needs	What fulfils this need	What could eventually be used
Farmers	Food	Crops, Trees, Animals	
	Shelter	House	
	Waste disposal	Animals, Compost (field and toilet), *Garbage system**	Water treatment ponds
	Clothing etc…	*Various external inputs**	
	Money	*Outside work*	Selling of farm products, agro-tourism
Crops (Clover grass, Cereals, Vegetables)	Soil work	Machinery, Farmers and Horses	
	Fertilization	Compost (Farmers, Animals and Crops)	
	Seeding	Farmers	
	Weeding	Farmers, Animals	
	Pest management	Farmers, Animals, Wild Flora and Fauna	
	Pollination	Bees	
	Harvest	Machinery, Farmers	
	Water	Rain barrels (small scale)	Irrigation ponds
	Sun, Heat	Greenhouse	
	Waste disposal	Compost	
	Storage	Barn and House, Field	
Trees (Fruit trees, Forest)	Weeding	Farmers, Machinery and tools, Animals	
	Pest control	Farmers, Animals	
	Pruning	Farmers, Tools	
	Management	Farmers, Tools	
	Pollination	Bees	
Animals (Cows, Horses, Geese, Chickens, Bees)	Feed	Crops, Wild fauna and flora	
	Shelter	Stable and bird shelters, bee hives	
	Waste disposal	Compost	
	Bedding	Crops (straw)	
	Water	Pond for geese, water barrels	
Structures and Tools (Buildings, Machinery, Windmill, Solar panels, Pond, Electrical fences, Car)	Heating	Wood from Forest Solar Panels	Heat pump from the Stable and the Greenhouse Temperature buffering systems with water in the Greenhouse
	Electrical power	Windmill	
	Fuel (only the car)	*Fossil fuels**	Vegetable oil, electricity or hydrogen
	Maintenance	Farmers	
	Water drainage	Pond	
	Shelter	Barn and storage shed	
Wild Flora and Fauna	Habitat	Forest, hedgerows, fields, pond	

* Good or service not provided by the farm system

Note: the functional analysis includes what is needed to MAINTAIN the system and not to ESTABLISH it (does not include building materials, etc…)

Functionality at Bjørnbakhus is very efficient. Needs of most components are fulfilled by other components on site, showing that the goal of self-sufficiency is not so far from being attained.

Suggestions were made in order to improve the system's functionality. Heat pumps have been observed in Denmark, as well as engines working on oilseed oil, and water-treatment ponds (Appendix B).

Permaculture zoning

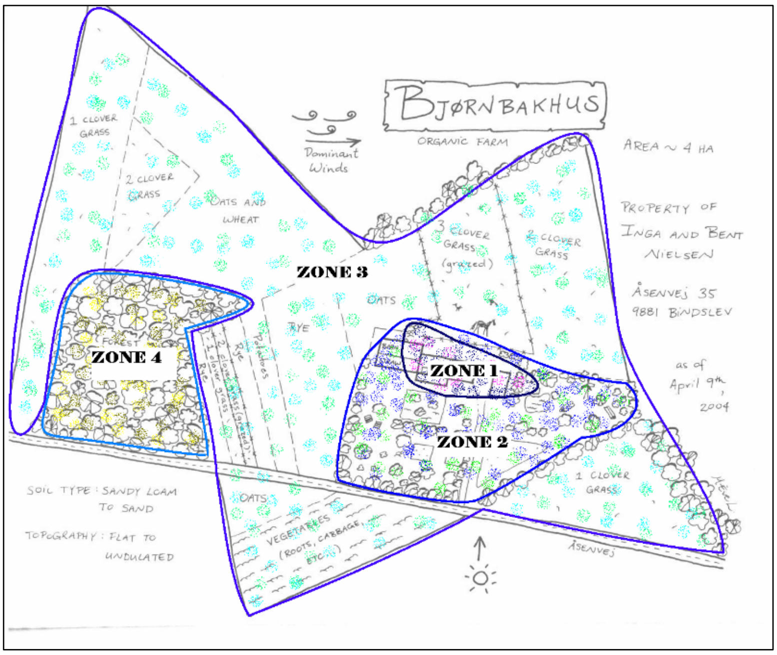


Figure 2.4. Permaculture zoning of Bjørnbakhus

Even if not designed following Permaculture principles at the beginning, this farm is naturally organized in a way that Permaculture zoning applies. Zone 1 includes the house, the greenhouse and immediate surroundings. In Zone 2 are the gardens, the windmill, the pond and the orchards. Main crops are in Zone 3, and Zone 4 includes the semi-managed forest (Figure 2.4).

Energy cycling on the farm

At Bjørnbakhus, the use of wild energies is optimized. Solar panels heat water, and electricity is generated through a windmill. The electricity is sold to the global system, so not directly cycled on the farm, but Bjørnbakhus ends up being a net producer of energy. The farmers invest considerable effort in the maintenance of their one, which had got a respectable lifetime, since the establishment of new windmills is not allowed in the region anymore.

Fossil fuels for the car are the only non-renewable, off-site source of energy used to run the farm system. Fuel has not always been necessary, but technical problems with the electric car and financial constraints had forced the farmers to go back to a conventional vehicle for transportation.

The most interesting feature about energy cycling on the farm is the use of horses to work the land. The horses work the land where plants grow, plants store solar energy into carbohydrates and transfer part of it back to the horses through the food chain. This is a good example of how biological resources can be beneficial in closing energy cycles on farms.

The main leakages of energy on the farm are the losses of heat produced by the metabolic processes of living organisms. Major leaking points that could be improved through Permaculture design are the compost heap and the shelter for large animals. Retention of heat into the system could benefit the greenhouse and the house. Heat pump systems are currently used in Denmark (Appendix B) in dairy production, and composting materials near the greenhouse is a good way to catch heat.

Overall, in the cases studied for this project, Bjørnbakhus is the most efficient at catching and using energy. Leakages are inevitable, but can be controlled up to a certain point through a good system design.

Nutrient cycling on the farm

Nutrient inputs to the system are overall limited to biological nitrogen fixation. The cycling on the farm looks efficient, through the use of on-farm organic matter from animals, crop residues, kitchen residues and also a compost toilet. Leakages from the system are limited. Nitrogen leaching and volatilization are issues like in any other farm system situated on sandy soils, and potential solutions are numerous (e.g. coverage of manure, use of catch crops).

Establishment of a permanent, self-maintaining food system

Bjørnbakhus is situated on a sandy soil, typical of the northern part of Jutland, and the topography is slightly undulated. Conditions for agricultural production are worse than in other areas of Denmark, and sand storms are common on windy days of springtime when the soil has just been plowed. To adapt these conditions, the forest is left on the poorest area, and a rotation on very small fields is established just beside. Thereby, lower yields are then distributed into many different crop types.

The use of perennials, fruit trees and shrubs is significant on the farm, and those are planted all around in Zones 1 and 2 (Figure 2.5).

Figure 2.5. The frontyard garden, where perennials and garden beds are mixed.

Ecological relationships

The diversity of habitats is significant, and what distinguishes this farm from the others is the total size of Zone 4. Even if Gule Reer has a similar proportion of its area allocated to this zone, the size of the forest at Bjørnbakhus creates a more distinct habitat. Also, due to edge effect, the triangular shape of many fields is ecologically more beneficial that square fields.

Management approach to the system

Soil texture, climate, economic opportunities in the region and lack of interest from society about sustainable agriculture are seen as barriers to a complete success. However, when asked if they would establish their farm system somewhere else in the world if they could, Inga and Bent give a clear response: Nej ! We face here a system that has been reflected on for 25 years. It has been constructed not on capital or physical resources, but mainly on knowledge. This is the base for the Permaculture approach to farm management. Also, the fact that the system has been the same for a very long time may mean that it has reached an optimal stable state.

Bjørnbakhus is not labelled as a Permaculture farm, but shows very well how basic Permaculture concepts can be naturally inherent to a Danish farm that has been aiming for sustainable development over decades. Bell (1992) was actually right when saying that some people would follow Permaculture naturally, without using the term “Permaculture”.

2.3.2. Søndermarksgård

General description

Karsten Petersen is renting a piece of land of 1.2 ha with two other young, newly educated organic farmers. The land has been submitted to Permaculture design only during the last six months. They have 2 sheep and 2 lambs, more than 70 rabbits, a couple of ducks, some chickens and they may purchase a pig.

The farm consists mainly of grass paddocks and vegetable crops. Vegetables will be sold at the market in Viborg this summer and in farm-gate sales. All farmers have full-time jobs, or study outside the farm.

Plan of the farm

Figure 2.6 shows the plan of the farm, drawn from personal observations. Figure 2.7 shows some interesting elements that require further precision.

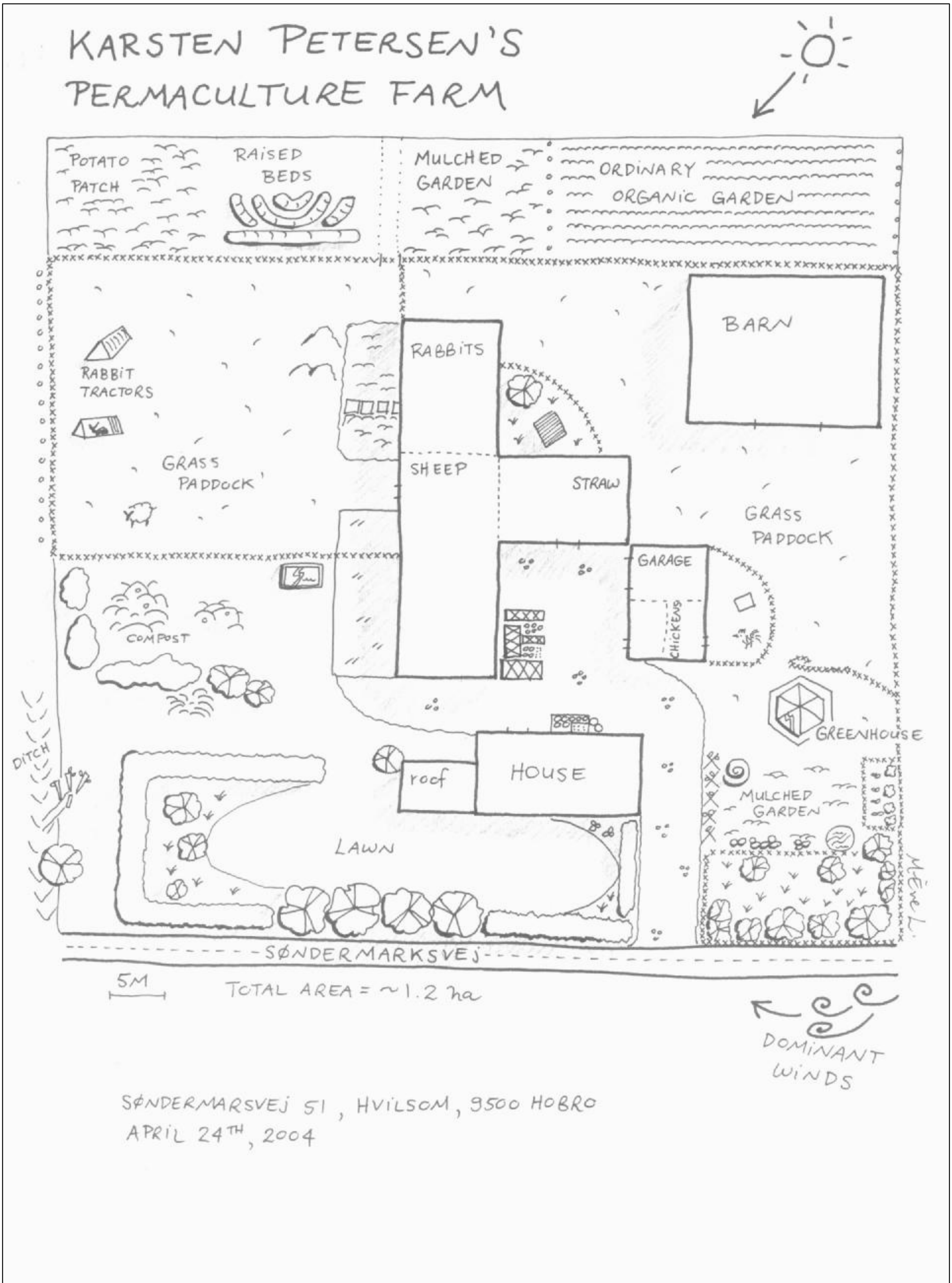


Figure 2.6. Plan of Søndermarksgård

The first four numbers on the map represents an experiment currently conducted by the farmers. The purpose is to see how Permaculture techniques work on the site.

1. **Potato patch**
   Here potatoes are planted with broadbeans, in a sheet mulched garden (Figure 2.8)
2. **Raised beds**
   The raised beds are more than one feet high, and are planted with various vegetables (leeks, carrots, beets, sweet corn, etc; Figure 2.8)
3. **Mulched garden**
   This no-till garden covered with straw will receive cabbages and other vegetables (Figure 2.9)
4. **"Ordinary" organic garden**
   Here the land has been plowed with a tractor and has been seeded with row crops (Figure 2.9)
5. Rabbit tractors are used to grazed the land in a controlled way (Figure 2.10)
6. This area in construction will soon be a outdoor playground for rabbits (Figure 2.11)
7. There is a project of putting a rain barrel there (but gutters have to be installed first; Figure 2.11)
8. Planted willows on the borders serve as windbreaks
9. Those willows were especially planted at the waste water outlet to reduce runoff.
10. Beets are stored here under the straw during winter
11. Young seedlings (Figure 2.12)
12. Herb spiral, typical of Permaculture design (Figure 2.13)
13. This new mulched garden has been covered with imported woodchips and horse manure. It will support the growth of squashes, popcorn and other vegetables (Figure 2.14)
14. This pond is currently under construction
15. In the greenhouse, water barrels are used as temperature buffers (Figure 2.15)
16. Strawberries are planted there with gooseberries (Figure 2.16)
17. Rhubarb has been planted at the edge of the garden to stop weed invasions from the small bush

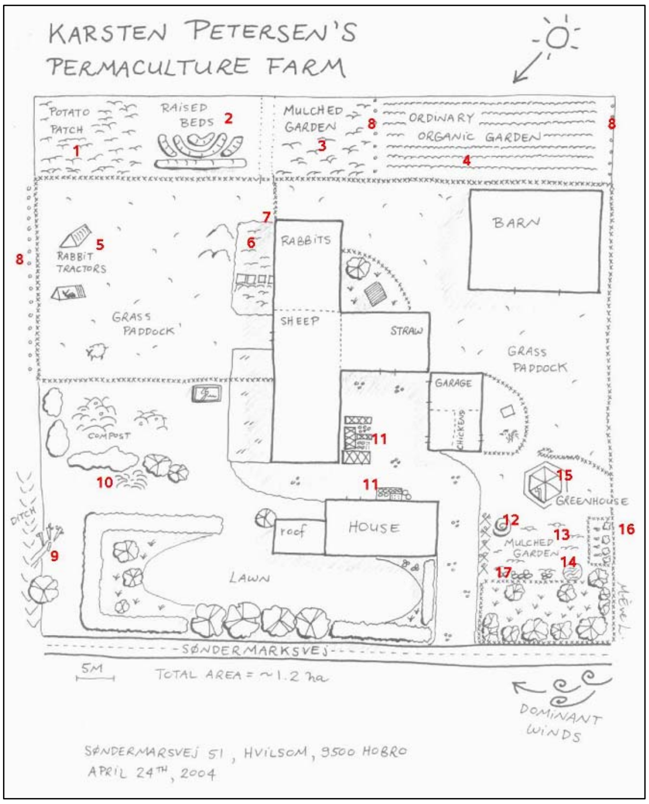


Figure 2.7. Details about some components of the farm system.

Figure 2.8. Raised beds and potato patch

Figure 2.9. Ordinary organic garden and mulched garden

Figure 2.10. Rabbit tractor

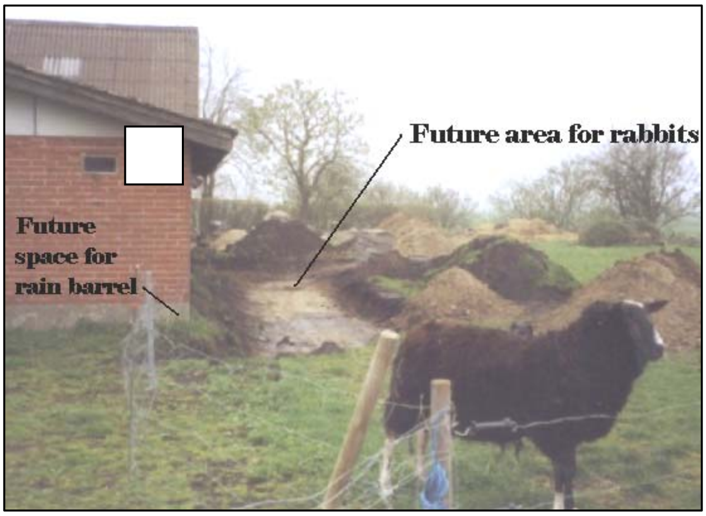


Figure 2.11.Future areas for rabbits and rain barrel

Figure 2.12. Improvised cold frames for seedlings

Figure 2.13. The construction of the herb spiral

Figure 2.14. The second mulch garden,
covered with woodchips and horse manure

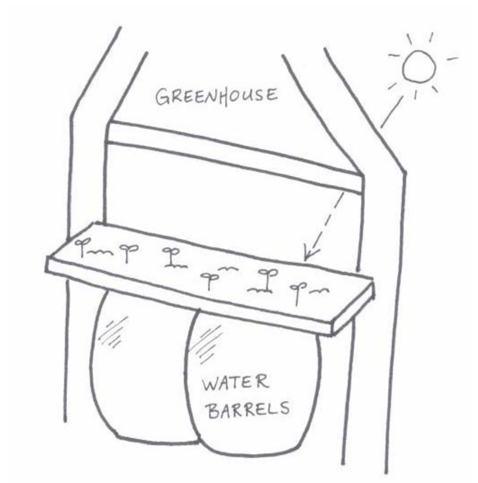


Figure 2.15. Water barrels installation in the greenhouse. Heat is absorbed during the day, and released to the seedlings at night.

Figure 2.16. Gooseberries and strawberries

Functional analysis of components

Table 2.2. Functional analysis of Søndermarksgård

Component of the system	What it needs	What fulfil this need	What could eventually be used
Farmers	Food	Crops, Animals, *Food imports**	
	Shelter	House	
	Waste disposal	Animals, Compost, *Garbage and sewage system**	Water treatment ponds, compost toilet
	Clothing etc…	*Various external inputs**	
	Money	*Work outside*, selling of rabbits and vegetables*	Agro-tourism
Crops (Grass paddocks, Vegetables)	Soil work	Farmers, *Machinery for the ordinary organic garden**	
	Fertilization	Compost from Animals and Crops, *Horse manure**	
	Mulching	*Straw, woodchips, paper**	
	Seeding	Farmers	
	Weeding	Farmers, Animals, Mulch	
	Pest management	Farmers, Chickens	
	Harvest	Farmers	
	Water	Pond, rain barrels	
	Sun, Heat	Greenhouse, cold frames	
	Waste disposal	Compost	
	Storage	Barn and House, *Straw**	
Trees and shrubs (Windbreaks, Hedgerows and fruits)	Weeding	Farmers, Poultry, Mulch	
	Pest control	Farmers, Poultry, Wild Flora and Fauna	
	Pruning	Farmers, Tools	
	Water	Pond, sewage outlet	
Animals (Rabbits, Chickens, Ducks, Sheep, Pig)	Feed	Crops, Wild fauna and flora, Grass, *Cereals and rabbit feed**	
	Shelter	Stable and bird shelters	
	Waste disposal	Compost	
	Bedding	*Straw**	
	Water	Pond for ducks, water barrels	

Structures and Tools (Buildings, Machinery, Pond, Electrical fences, Car)	Heating	*Electricity**	On-farm energy sources (windmills, solar panels, etc)
	Fuel	*Fossil fuels**	Vegetable oil, electricity or hydrogen
	Maintenance	Farmers	
	Shelter	Barn and storage shed	
Wild Flora and Fauna	Habitat	Hedgerows	

*Good or service not provided by the farm system

Note: the functional analysis include what is needed to MAINTAIN the system and not to ESTABLISH it (does not include building materials, etc…)

Functionality is also well-developed here, in the sense that most of the time needs are fulfilled by more than one component, and different components are found at much more than one place in the table. However, a lot of components have their needs fulfilled by inputs from outside the farm, as will be discussed in the following sections.

Permaculture zoning

Delimitations between zones especially at this farm should be seen as being very gradual, and not sharp. Zone 1 includes the house, the herb spiral, the seedlings, the compost pile and part of the other buildings. Chickens and the greenhouse are at the limit between Zone 1 and 2. Zone 2 includes the garden closest to the house, as well as the animals. In Zone 3 are the four main gardens, and part of the grass paddocks. Zone 4 is small and consists in a small bush (Figure 2.17).

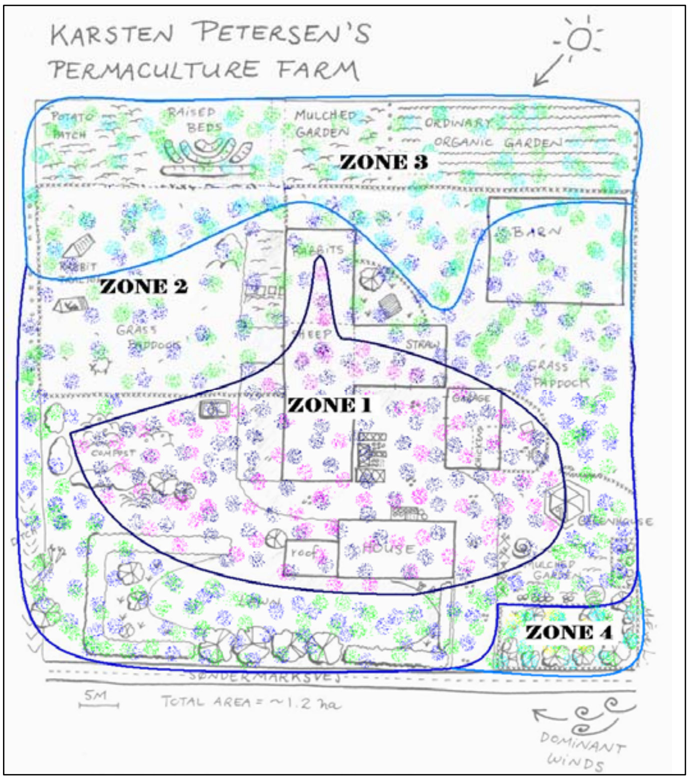


Figure 2.17. Permaculture zones at Søndermarksgård

Since the farm has been submitted to Permaculture only during the last 6 months, the zoning had to adapt existing structures and clear delimitations are still to be determined.

Energy cycling on the farm

All electricity and fuel is of conventional origin (normal electric distribution system and fossil fuels). On the other hand, the farm has adopted many design strategies to improve its energetic efficiency.

One interesting point that is unique to this farm is the use of rainwater barrels to buffer the temperature in the greenhouse (Figure 2.15). The seedlings are grown on top of barrels where water for the garden is stored. During the day, the barrels absorb the heat in the greenhouse, and release it during the night. The herb spiral design is also an efficient way to capture solar energy (Figure 2.13). The large rocks used for its construction have the capacity to store a certain amount of heat and release it for the herbs.

There are also energy savings that can be considered from the use of manual weeding, planting and soil work in the case of the raised beds. The "ordinary organic garden" requires more energy at the base because a tractor is required to plow it (Figure 2.9). Also, mulched gardens and the rhubarb barrier (Figure 2.7, # 17; Figure 2.14) save weeding.

Energy leakages look overall limited and the same comment as for Bjørnbakhus applies with regard to the potential for using heat from the compost pile or the animals.

Nutrient cycling on the farm

The use of legumes is limited on the farm, although beans are grown in the garden. Horse manure had to be imported to prepare the second mulch garden, and animal feed, straw and woodchips for bedding and mulching also have to be brought from outside. If we look at the internal cycling of nutrients, compost and animal manure are used, but human manure escapes. A very good idea has been to plant the willows near the water outlet, so they catch a part of the nutrients that would be lost with the running water (Figure 2.7., #9). The use of mulched gardens is also a good erosion-control technique.

Overall, the needs for energy, straw and nutrient inputs are the main weakness of Søndermarksgård. It is due to the small acreage of the farm, which prevents the production of cereals, necessary for straw, but also to the fact that the system is fairly young and still in an establishment phase. One could also argue that the straw, the woodchips and the manure are obtained from the neighbour, so the "cycle" is still relatively closed.

Establishment of a permanent, self-maintaining food system

Perennials on Karsten's farm are not numerous compared with Bjørnbakhus or Gule Reer, and mostly consist in newly planted gooseberries, strawberries, willows and rhubarb. There are also many trees part of the landscape in front of the house. It is mostly the fact that the property is rented that has led to reluctance for capital investments in the form of perennials.

Continuous supply of products is a challenge in the cold climate of Denmark. One key is to have good and intelligent storage strategies. The farmers succeeded in keeping beets under a heap of straw outside for the whole winter. Carrots left in the ground were also still good to eat when we were there at the end of April.

It is hard to tell if the system is adapted to site conditions now, since it is still in an experimental stage. The four plots at the southern end of the area will probably tell a lot about what is best to use in this area.

Ecological relationships

Plants in the garden are usually regrouped into guilds. Companion planting has been introduced so plants that benefit each other are planted together. For example, leeks are planted with carrots, and potatoes with broadbeans. Patterns within the plots are kept as random as possible (except for the ordinary row garden), to mimic nature.

In an attempt to create more habitat opportunities, a pond has been established this year (Figure 2.7, # 14). The size of the property is again an obstacle to habitat diversity. The shape of edges also needs to be more developed in order to achieve Permaculture goals, since most of the divisions now are square.

Management approach to the system

The main obstacle to the sustainable development of this farm is the uncertainty about the future: none of people at Søndermarksvej 51 knows for how long they will stay there, including Karsten. That really questions the relevance of long-term plans.

The approach adopted is then an experimental one. Since all farmers have a job outside the farm, there is place for small mistakes. Also, as Bill Mollison says in his movie, *The Global Gardener*, "[In Permaculture] we try to do a lot of mistakes, that will tell us what is good to use”. Learning about Permaculture design (reading of books and courses) are also behind management strategies.

2.3.3. *Hegnstrup*

General description

Allan B. Clausen received the farm from his parents in 1976 and converted the land to organic agriculture in 1979. From this time to about 10 years ago, the farm was a commune where up to 20 people have been living. The property is 17 ha large, and produces vegetables for the Saturday market in Helsingør.

Today, as the farmer is aging, the volume of vegetable production is decreasing and more land is converted into clover grass leys. The farm has about 5 cattle, 70 hens, 6 sheep, 3 horses, 150 broiler chickens and 6 pigs. Allan works full-time on the farm, but his wife has full-time job outside.

Hegnstrup has been involved a lot in our course, and another student project covered it into great details in the past (Jakobsen et al. 2000). This Permaculture project gives us the chance to look at this farm with another angle of view.

Plan of the farm

Figure 2.18 shows the plan of the farm, drawn from personal observations and an existing map from last year. Some elements require precision:

- The rotations occurring at the farm are site-dependent.
    - The High Rotation takes place in areas that are upslope, in sandy loam soils. Vegetables that are grown are potatoes, beets, onions, celeries, leeks and Jerusalem artichokes.
    - The Low Rotation takes place in areas that are downslope, in humic soils. Vegetables grown include members of the cabbage family, carrots, pastinac and Hamburg parsley.
    - The “T” Rotation takes place near the house in a sandy soil, and includes early vegetables of the same kind as in the H and L rotations.
- This year, many changes are occurring at the farm:
    - A new neighbour is entering the system, putting new fields into the rotation (labelled into parenthesis)
    - Many fields of Hegnstrup are removed from the vegetable rotations because of lower productivity and water logging (V_7 to V_{10})
    - The L rotation is extended by one year to help control the weeds

Table 2.3. Rotations at Hegnstrup

Year	H-Rotation	L-Rotation	T-Rotation
1	Clover grass	Clover grass	Early vegetables
2	Clover grass	Clover grass	Early vegetables
3	Clover grass	Clover grass	Early vegetables
4	Cereals	Cereals*	Early vegetables
5	Vegetables	Vegetables	Green manure
6	Cereals + clover grass undersown	Cereals + clover grass undersown	

*New from this year

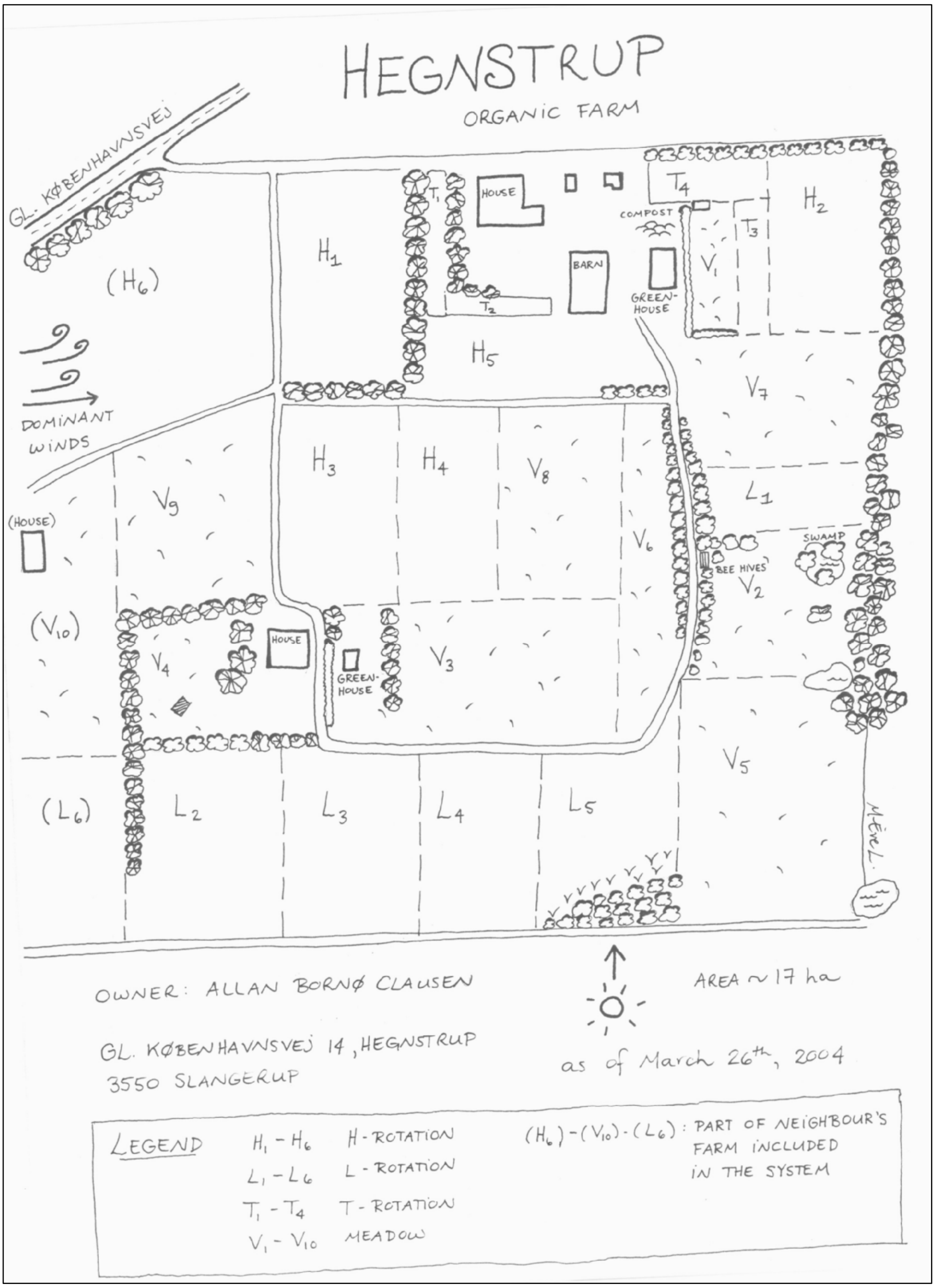


Figure 2.19. Plan of Hegnstrup

Functional analysis of components

Table 2.4. Functional analysis of Hegnstrup

Component of the system	What it needs	What fulfil this need	What could eventually be used
Farmer (and workers)	Food	Crops, Animals, *Food imports**	
	Shelter	House	
	Waste disposal	Animals, Compost, *Garbage and sewage system**	Water treatment ponds, compost toilet
	Clothing etc…	*Various external inputs**	
	Money	Selling of farm products, rent of habitations, *Work outside**	Agro-tourism
Crops	Soil work	Machinery, Pigs	
	Fertilization	Compost from Animals and Crops, *Imported manure**	
(Clover grass, Cereals, Vegetables)	Seeding	Farmer, Machinery	
	Weeding	Farmer, Animals	
	Pest management	Farmer, Animals, Wild Flora and Fauna	
	Harvest	Farmers	
	Water	Ponds	
	Sun, Heat	Greenhouse	
	Waste disposal	Compost	
	Storage	Barn and House	
Trees and shrubs	Weeding	Farmers, Animals, Mulch	
(Windbreaks, Hedgerows and fruits)	Pest control	Farmers, Animals, Wild Flora and Fauna	
	Pruning	Farmers, Tools	
Animals	Feed	Crops, Wild fauna and flora, 3rd year clover grass	
(Cows, Horses, Poultry, Sheep, Pigs, Bees)	Shelter	Stable and bird shelters, pig houses	
	Waste disposal	Compost	
	Bedding	Straw	
	Water	Ponds, water points	
Structures and Tools (Buildings, Machinery, Electrical fences, Car)	Heating	*Electricity**	On-farm energy sources (windmills, solar panels, etc)
	Fuel	*Fossil fuels**	Vegetable oil, electricity or hydrogen
	Maintenance	Farmer	
	Shelter	Barn	
Wild Flora and Fauna	Habitat	Hedgerows, wetland	

*Good or service not provided by the farm system

Note: the functional analysis include what is needed to MAINTAIN the system and not to ESTABLISH it (does not include building materials, etc…)

Hegnstrup can be considered as a fairly multifunctional farm, even if many resources have to be imported. Functions are supported by usually many components, which each appear in the requirements for many functions in general.

Permaculture zoning

This case is special because it has more than one nucleus of activity. The main one, on top of the map, includes the main buildings, animal shelters, gardens for early vegetables and a small grazing area. The second one is a small house surrounded with trees, garden and greenhouse. Then there is a third nuclei where the neighbour lives, although this area was not visited directly. Zone 3, which includes the main crops, hedgerows and meadows, is large and occupy the majority of the property. The band of pine forest on the eastern side is not intensively managed and can be considered as a small Zone 4 (Figure 2.19).

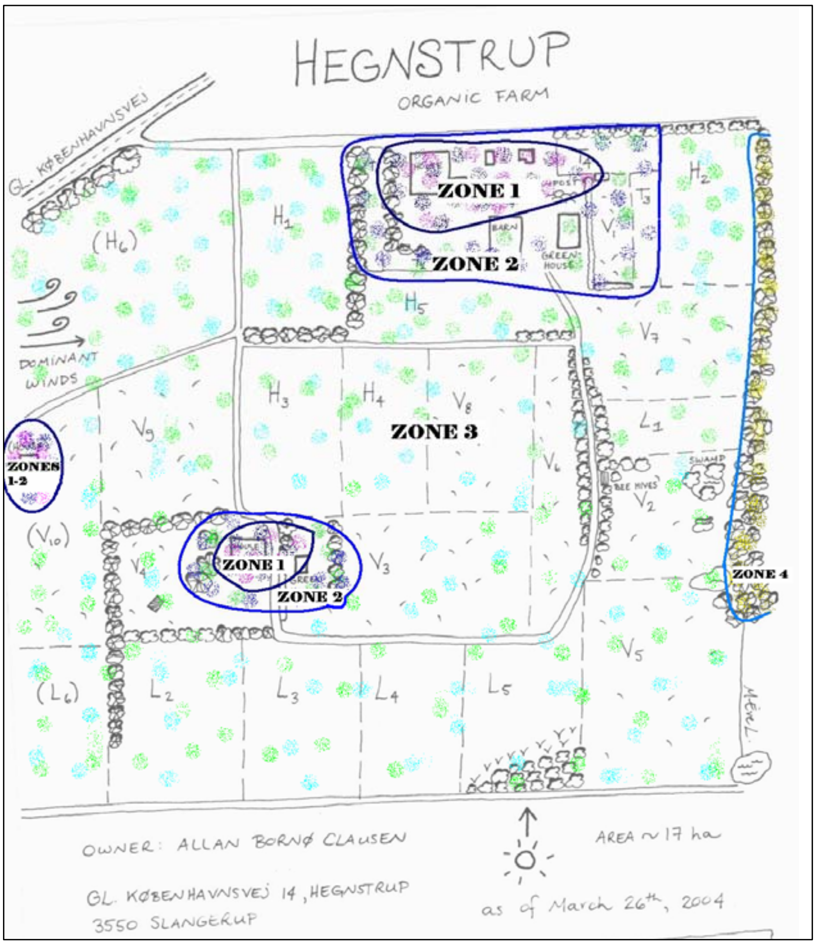


Figure 2.19. Permaculture zones of Hegnstrup

Energy cycling on the farm

The energy cycling at Hegnstrup seems to be characteristic of many organic farms in Denmark. Electricity is bought from the normal distribution system, and fossil fuels are bought to work with the machinery. However, Allan specified to us that energy consumption from oil is reduced to a minimum (400-500 litres of gasoline are bought every year for the tractors). Expected leakages are the same as those mentioned before for the two first farms.

The design around the second house and greenhouse (in the middle of the map; Figure 2.20) is interesting because it creates a micro-climate that eventually reduces the need for heating. The buildings are situated in the middle of a south-facing slope, where solar radiation is maximum, and are protected from dominant winds by coniferous windbreaks.

Figure 2.20. The second house situated between coniferous windbreaks, in a south facing slope.

Nutrient cycling on the farm

By the end of this year, the farm will be self-sufficient in manure, but imports are still necessary for this year. Three years of clover-grass bring also considerable amounts of nitrogen to the system.

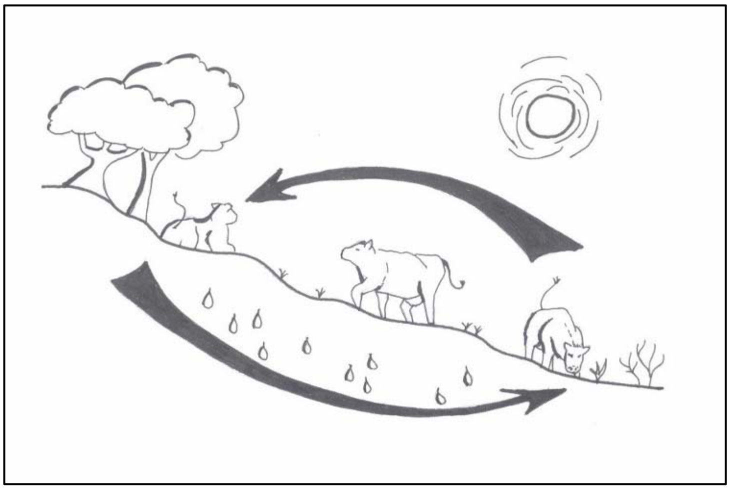


Figure 2.21. Cycling of nutrients in pasture V_2

On the farm, the cycle is closed with the use of on-farm manure and compost. Allan also has an interesting strategy for cycling nutrients efficiently in pasture V_2, while reducing losses. When it rains, the nutrients are drained toward the bottom of the pasture, which becomes more fertile. The animals go there to graze, but when they want to rest, they go up under the trees. There they release the manure, bringing back the nutrients upslope (Figure 2.21, Figure 2.22).

Figure 2.22. Pasture V_2

Leakages of nutrients from the system occur through outgoing products, sewage (human waste), erosion, volatilization and leaching. Volatilization and leaching of nitrogen are increased given that the compost heap is not covered. However, covering leads to drying and complications at spreading (more energy consumption). Also, after the third year of clover-grass in the rotation, pigs graze and work the soil in the late summer. That practice obviously leads to some nutrient losses during the next winter. However, pigs are that way part of the system: they provide manure, weeding, and no fodder needs to be imported.

Hegnstrup does not fulfil the permaculture requirement of being self-sufficient in energy and nutrients, but it shows how some compromises can be made to get close to goals that are not necessarily achievable in the current context of organic farming.

Establishment of a permanent, self-maintaining food system

Perennial crops are definitely not a significant feature at Hegnstrup, although trees are numerous along the edges. Hegnstrup's production has to follow the market demand, and vegetables are almost all annual crops. On the other hand, site-specific rotations are in line with the Permaculture concept of adapting the system to the site. Moreover, Allan has been collecting his own seeds for years from plants that are the most adapted to the site. He believes that plants can only evolve in a strong way by being in constant contact with the local environment they are intended to be grown.

Therefore, the farm system is not self-maintaining nor permanent (i.e. it requires a lot of work from the farmer), but the different strategies related to crop management (rotations, animal grazing, etc) improve considerably its functionality.

Figure 2.23. Multicropping in the greenhouse

Ecological relationships

The plants we saw during the visit of the farm (at the end of March not much is growing) were all planted into guilds inside the greenhouse. Figure 2.23.

shows lettuce growing with garlic. Although the reason for combination is more space allocation than ecological function, it looked very successful.

The diversity of habitats on the farm is large. Biodiversity of wildlife and services it can provide is also visibly considered in the management and the design of the farm. For example, Allan refuses to drain the wetland at the bottom of V_2, since it attracts mosquitoes, which attract birds that eat insect pests (Figure 2.24). Grazing by birds in cropping areas also cleans the ground from grass aggregations, which reduces the amount of wintering pests.

Figure 2.24. Wetland at the bottom of V_2

Unlike in Permaculture design, the shapes of edges are mostly square-like, and in this case it is partly required due to the use of machinery.

Management approach to the system

Allan's approach toward his system is really based on observation and experience accumulated during the last 25 years. When we think about fertilization, pest management and plant propagation, we see that the techniques practiced at Hegnstrup have been developed through the consideration of ecosystem functioning.

Even the pine forest on the eastern border looked a priori useless. But what was a barrier to agriculture is today the hunting ground of Allan's sons, who used to be totally dispassionate about the land of their father. From that the interest might grow… I cannot see any element on the farm that was described negatively by Allan.

Hegnstrup is certainly not an ordinary organic farm, and is definitely oriented toward the use of ecosystem goods and services as the Permaculture philosophy implies. On the other hand, it also shows many limitations with regard to some Permaculture principles, including energy self-sufficiency, use of perennials, and edge shaping.

2.3.4. Gule Reer

General description

The project regroups people of Copenhagen who work on the farm together each weekend. It started in 1989 and the Permaculture garden was established in 1991, in a field that was completely bare at that time. Today, it is impressive to see all the trees and shrubs that have grown there.

The piece of land is used following an agreement with organic farmers. The area, intensively cultivated, also supplies water to the city of Copenhagen. Agricultural pollution is becoming a real problem, and farmers are currently paid not to produce for the next 5 years. The agreement includes 3 ha, but currently 1.5 ha is cultivated.

The purpose of the project is to produce basic food for 50 people, at a relatively low cost (500 dkk/month/person), and in a sustainable and interesting way. The visit was made with one of the initiators of the project, Tony Andersen.

The farm has bees, chickens and rabbits, many fruit and nut trees, and 8 round gardens. There is one windmill (Figure 2.25).

Figure 2.25. Windmill and round field

Plan of the farm

Figure 2.26 shows the plan of the farm, drawn from personal observations and an existing drawing. Some elements require precision:

A simple rotation occurs between the circular gardens. During 4 years, they are covered with clover and alfalfa. After, there are 4 years of various vegetables and beans, with varying designs (Figure 2.27).

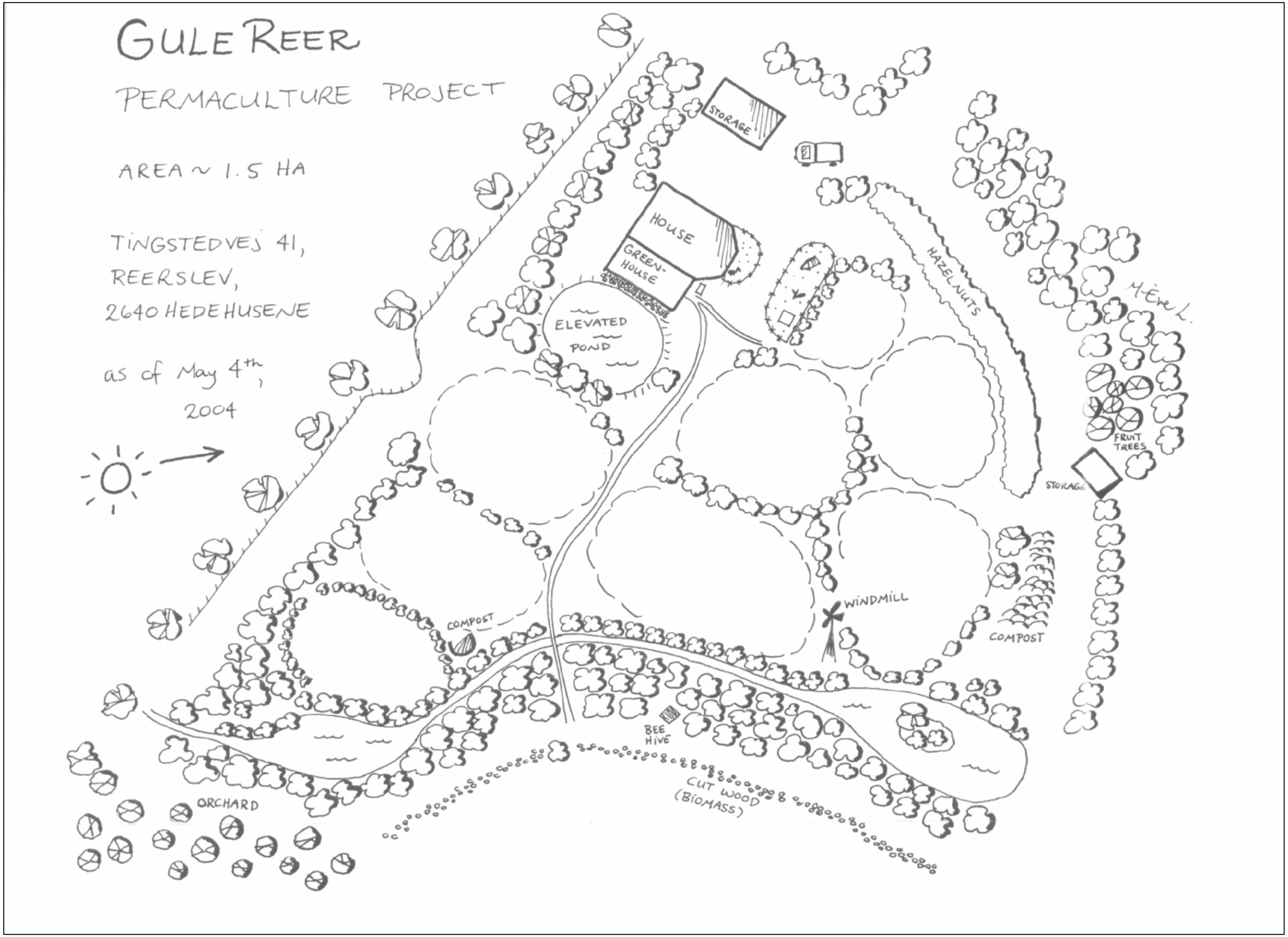


Figure 2.26. Plan of Gule Reer

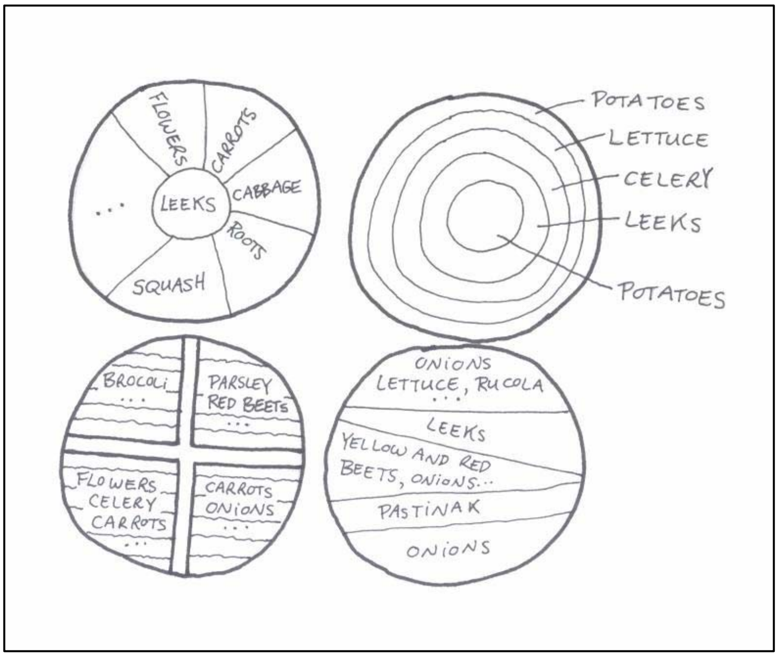


Figure 2.27. Examples of garden plot design used at Gule Reer.

Functional analysis of components

Table 2.5. Functional analysis of Gule Reer

Component of the system	What it needs	What fulfil this need	What could eventually be used
Gardeners (in Copenhagen)	Food	Crops, Animals, *Food imports**	
	Shelter	*House**	House on site
	Waste disposal	Animals, Compost, *Garbage and sewage system**	Water treatment ponds, compost toilet
	Clothing etc…	*Various external inputs**	
	Money	*Outside work**	
Crops *(Clover-alfalfa, Vegetables)*	Mulching	*Straw**	
	Soil work	Gardeners, machinery	
	Fertilization	Compost from Animals and Crops	
	Seeding	Gardeners	
	Weeding	Gardeners, Animals	
	Pest management	Gardeners, Animals, Wild Flora and Fauna	
	Harvest	Gardeners, tools, machinery	
	Water	Ponds	
	Sun, Heat	Greenhouse	
	Waste disposal	Compost	
	Storage	House	
Trees and shrubs *(Windbreaks, Hedgerows and fruits)*	Weeding	Gardeners, Animals, Mulch	
	Pest control	Gardeners, Animals, Wild Flora and Fauna	
	Pruning	Gardeners, Tools	
Animals *(Rabbits, Chickens, Bees)*	Feed	Crops, Wild fauna and flora	
	Shelter	Chicken and rabbit houses	
	Waste disposal	Compost	
	Bedding	Straw	
	Water	Ponds, water points	
Structures and Tools *(Buildings, Machinery, Windmill, Pond, Cars)*	Heating	Wood from hedgerows, electricity from windmill	
	Fuel	*Fossil fuels**	Vegetable oil, electricity or hydrogen

	Maintenance	Gardeners	
	Shelter	Storage shed	
Wild Flora and Fauna	Habitat	Hedgerows, ponds	

*Good or service not provided by the farm system
Note: the functional analysis include what is needed to MAINTAIN the system and not to ESTABLISH it (does not include building materials, etc…)

Functionality at Gule Reer is well-developed. Components are repeated many times along the table, and most functions are fulfilled by more than one component.

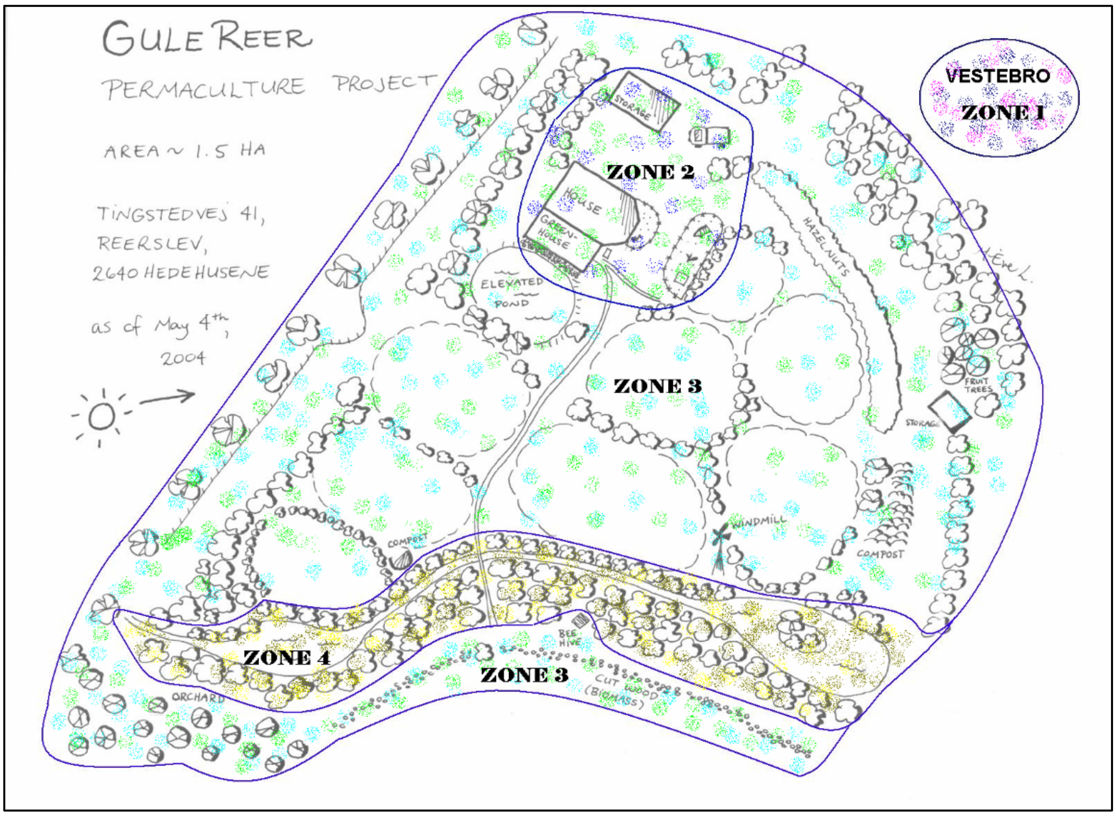


Figure 2.28. Permaculture zones of Gule Reer

Permaculture zoning

Zones at Gule Reer were quite tricky to draw, since nobody lives there for the moment. Therefore, Zone 1 should be extended to Vestebro (Copenhagen), which makes it a bit odd with regard to Permaculture ideology. What should be noticed in this case also is that Zone 4 is closer to the center of activity than a significant part of Zone 3. This shows the compromise that often has to be made between theoretical zoning principles and actual site conditions. It was much more sound to establish the forest close to the stream and ponds, for habitat and water quality (Figure 2.28).

Energy cycling on the farm

Strategies have been developed to catch wild energies, and trees are harvested for firewood. A small windmill is used to pump water. The design around the greenhouse is also in line with Permaculture concepts. The elevated pond catches rainwater and maintains it at a high elevation, so less energy is required to direct the water toward the fields afterward. Moreover, the fact that the pond is situated close to the southern wall of the greenhouse increases total solar radiation through the phenomenon of reflection (Figure 2.29, Figure 2.30).

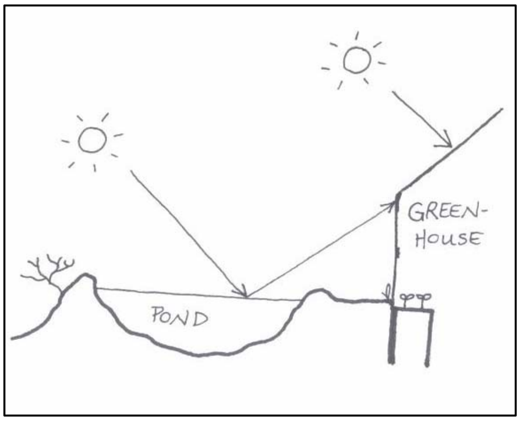


Figure 2.29. Reflection of light toward the greenhouse at Gule Reer

Putting the compost heaps in connection with the house or the greenhouse would increase energy efficiency (heat from microbial activity would not be directly lost), as explained in the case of Bjørnbakhus.

Figure 2.30. The house and greenhouse.

One major problem with this system also is the amount of fossil fuels that has to be used for transportation of gardeners every weekend.

Nutrient cycling on the farm

The four years of clover-alfalfa in the rotation allow for a fair amount of nitrogen fixation. Slashed hay and compost are spread on the fields to close the rotation on site. Due to the great amount of residues, patterns and woody plants, erosion is expected to be very limited from those fields. The biggest problem in closing the nutrient cycle is the same as for the energy efficiency: gardeners do not live on the site.

Establishment of a permanent, self-maintaining food system

Figure 2.31. Tony Andersen showing a tree plantation to KVL students in Zone 4.

Since Gule Reer is a Permaculture project, the main effort has been put into establishing perennial plants (Figure 2.31), and this shows very well on the map at first glance. Nuts, fruits, shrubs, trees for biomass and perennials such as rhubarb are plentiful compared to what is found on the other farms. These plants require less work than usual annual crops.

Ecological relationships

Monocultures do not exist at Gule Reer, as shown by the garden plot patterns (Figure 2.27). Some basic order still has to be maintained since about 20 gardeners are involved in the field work. Circle gardens are also an interesting shape since edges between fields are then varying in width, creating different habitat conditions.

The proportion of the design allocated to Zone 4 is also more important than in other cases, as well as the area allocated to ponds. This farm, although one of the smallest, has the greatest habitat diversity.

Management approach to the system

At Gule Reer, decisions are taken following discussions among members of the project, and an action can only be achieved if everybody agrees upon it. The farm has also contributed to the social integration of drug addicts. The management approach to this farm is one that promotes community work and social development, through the evolution of collective knowledge. Production-oriented organic and conventional farms would usually consider group discussions time consuming and rehabilitation of drug addicts too risky to be implemented.

Permaculture design has also been the basic framework for the farm management since the establishment of the system more than 10 years ago. Therefore, ideology has been the driving force for a relatively long time. Even if involves some controversial aspects (should people produce food only where they live?), the farm has reached a state that people can be proud of.

2.4. Classification of Farms With Relation to Each Other

Here is an attempt in comparing the farms on a "Permaculture scale", although such weighing can be very controversial. It has been criticized that aggregation cannot be done without a considerable loss of information, and the output is ultimately dependent on subjective scoring (von Wirén-Lehr, 2001). The objective of this section is then to have a broad picture of the relative strengths and weaknesses of each system with regard to our criteria, rather to assess their absolute sustainability.

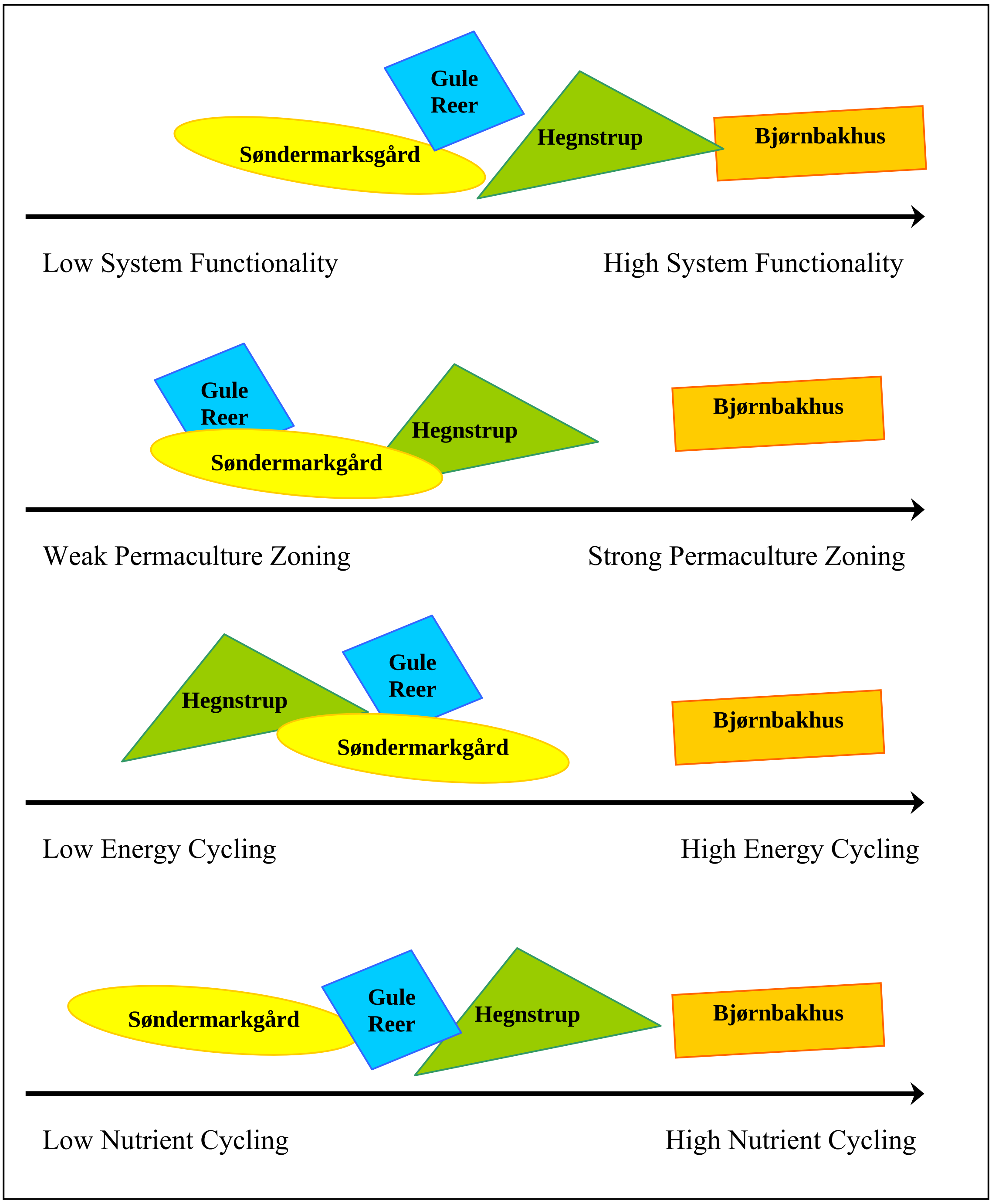


Figure 2.32. Comparison of farms on a Permaculture scale

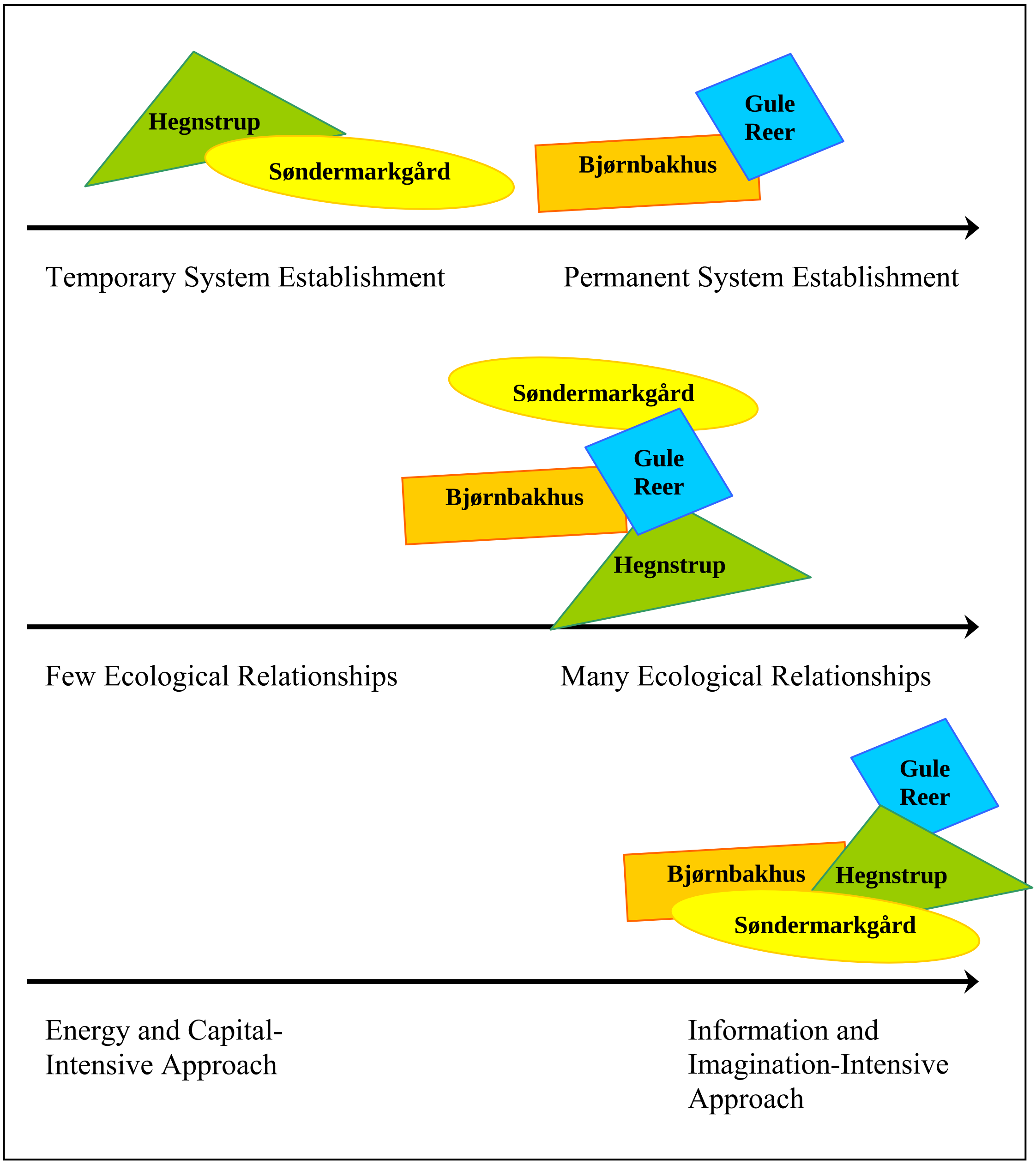


Figure 2.32 (con't). Comparison of farms on a Permaculture scale

From that small analysis, we can notice that organic farms that have been running for a long time can have equal or superior Permaculture application of our criteria compared to newly established Permaculture farms. We can conclude then that Permaculture is naturally applied on farms working towards sustainability in rural Denmark.

One question that could be addressed in more details is also the economic viability of the farms included in the analysis. None of the farmers we met considered productivity and financial returns as a major driving force for the way of life they decided to adopt. Yields, and not economic returns, are the important income of a Permaculture system. Further studies have to be conducted about quantification of yields and services potentially produced by rural Permaculture systems in Denmark.

Another issue can also be raised following those four studies: localization of food production. In all systems, farmers ate their own products. However, in the case of Gule Reer, the Permaculture garden was situated many kilometres from the houses of gardeners. Is rural development sufficient in planning sustainable food supply for Denmark? To what extent city dwellers can produce their own food not too far from their doorstep?

Chapter 3. Permaculture in Urban and Peri-Urban Agriculture

As our cities grow in size and density, problems in waste management and food supply multiply. In some inner cities, landscapes of stark concrete and windowed skyscrapers dominate and stifle greenery. This chapter will discuss Permaculture in the context of Urban and Peri-urban Agriculture (UPA). It links the Permaculture principles (outlined in Chapter One), and gives a synthesis of how Permaculture can help inject life into our cities and bring out the best of what they have to offer as the centres of creativity and culture. An outline of UPA and its functions will be given, followed by a discussion of how urban agriculture in Denmark must be realized within the Permaculture paradigm.

3.1 Urban Food Production

Farming in the city is not a new phenomenon, although it has only recently been recognized in academic circles as a tool for achieving sustainability (Mougeot, 2000). Aztec, Mayan, and Incan cities were found to be self-reliant in fruits and vegetables, and early Javanese cities used the aqua-terra system to produce crops (Smit *et al*, 1996). Many cultures around the world still maintain a tradition of cultivation in the city; about one-seventh of the world's food supply is grown in cities by 800 million urban farmers (*ibid*). Figure 3.1 shows the extent of farming within the city walls of Aachen, Germany more than 300 years ago.

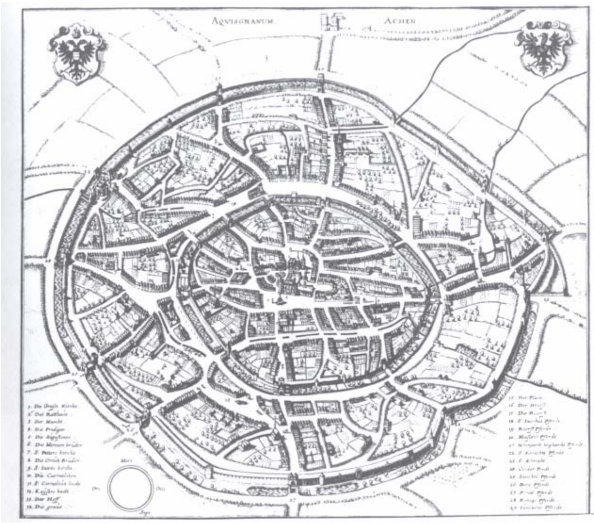


Figure 3.1 Aachen, Germany, 1649 (Taken from Smit et al., 1996)

UPA can take place on the small scale such as a planter on an apartment balcony or it can be as large as several acres of a community farm. Mougeot (2000) defines urban agriculture as

> …an industry located within (intraurban) or on the fringe (peri-urban) of a town, a city or a metropolis, which grows or raises, processes and distributes a diversity of food and non-food products, (re-)using largely human and material resources, products and services found in and around that urban area, and in turn supplying human and material resources, products and services largely to that urban area.

It involves all aspects of food production, processing, marketing, distribution, and consumption, as well as the additional outcomes of this industry that affect society and the environment. This discussion will be limited to food produced in urban or peri-urban areas, that is, areas within and close to city limits, using mainly local resources and supplying mainly local people. UPA is a worldwide movement that aims to help meet the food needs of its residents, improve environmental quality, and aid in community development. A brief overview of its functions, appearing in diverse forms and socio-economic environments, will be given, followed by a discussion on the movement's limitations. One will see that many of the same goals and techniques in UPA are similar to that of Permaculture as described in previous sections.

3.2 Functions of Urban Agriculture

3.2.1 Meeting the Food Needs of its Users

When the conventional production and distribution chain is not sufficient to meet the needs of the urban population, or if poverty makes it difficult to even enter the chain, UPA can help urban-dwellers meet their nutritional needs (Jolly, 2004). This may be the sole source of food for survival, especially in Lesser-Developed Countries if the local infrastructure collapses and alternative sources of food are not available. This was the circumstance recently in the former Yugoslavia, Baghdad, and Kinshasa (Smit *et al*, 1996).

In other cases, the urban garden is able to supplement other food suppliers and increase the nutritional quality of food available (Atkinson, 1995). Edible landscape, such as fruit and nut trees in public areas are a good source of food that needs little maintenance and can be enjoyed by anyone (Mollison, 1994). Affordable fresh fruits and vegetables, recommended for a healthy diet (WHO, 2001), are less likely to be found in regular markets in the city (Smit *et al*, 1996). Produce grown within a closer proximity can be a viable alternative to the highly-processed foods often found in supermarkets.

3.2.2 Improving Environmental Quality

The true cost of industrially-produced food, with its effects on the environment, is not reflected in its price (CFSC, 2003). Excessive transportation and energy consumption are environmentally-destructive linking elements in our food production and distribution chain. UPA simplifies this complex process by keeping both ends – production and consumption – local. With careful planning and design, farming on urban land may actually improve air, water, and soil quality, reduce an urban area's energy consumption, and increase biodiversity.

As our world is becoming more and more urbanized, we are having to deal with importing vast volumes of food into the city and finding ways to export the waste. Local food production for local consumers reduces the need for extensive transport and storage of imported food and thus lowers energy consumption and pollution (Smit *et al*, 1996). Household wastes and sewage can be used on-site for feeding livestock and compost, reducing the need to take the nutrients out of the local system (Deelstra, *et al*, 2001). Thus the nutrient cycle may be tied closer, reversing the direction it has taken post-Industrialization. Figure 3.2 shows the changing nature of the nutrient cycle as urbanization has occurred throughout history. One of UPA's goals is achieving the closed nutrient cycle.

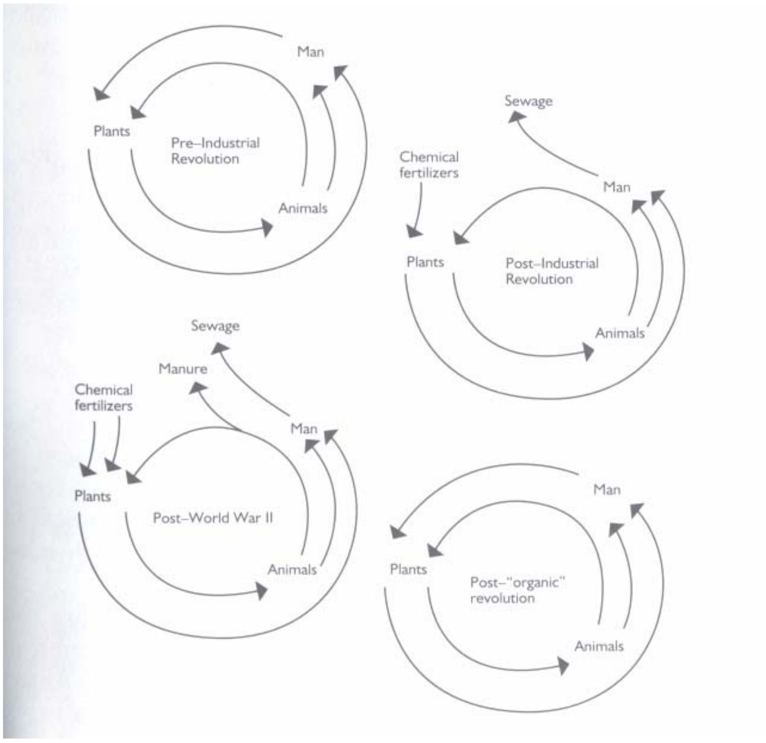


Figure 3.2. The changing nature of the nutrient cycle in urban environments (Taken from Smit et al., 1996)

Introducing more green vegetation in the city may absorb carbon from the air and make it more 'breathable'. Greenery can modify the city's microclimate in a desirable way. For example, shady trees, ground-covering plants, and ponds can help counteract some of the summer heat or winter freeze heightened by concrete and asphalt pavements. Earthed roofs (Stewart, 1986) and vines grown on walls (Gailey and Russell, 1995) provide insulation for buildings.

Water is a valuable commodity, and even more so in urban areas. Urban farms are often more frugal than their rural counterparts because water is usually expensive and in short supply in cities (Sherriff and Howe, 2002). Growers may collect rainwater or reuse greywater in order to save resources (*ibid*). Water percolation to aquifers may also be improved with land that is cultivated rather than built on. This avoids overtaxing nearby rivers and streams during heavy rainfall (Niemczynowicz, 1999).

Urban agriculture can take up unused wasteland and make it useful. It often takes over areas such as old landfill sites or other unwanted vacant spaces in the city, turning something ordinary or unsightly into an attractive landscape. When peri-urban land is cultivated and deemed 'useful' while the city grows, it stands less chance of being taken over by urban sprawl (Ableman, 1998). Among the many issues surrounding growing cities, an important concern is the loss of good farmland and topsoil. Land can be further protected from sudden environmental changes by planting fruit trees on sloping areas or deep-rooted tall grass on flood plains (Smit *et al*, 1996).

3.2.3 Aiding Community Development

> *"The products are sold in public markets, and compete with supermarkets that sell only imported goods. Thus, we support globalization without social exclusion through urban agriculture. Local government loans of a few thousand dollars are being repaid in two, three or four months; the government trains, monitors, promotes. This needs to be recognized by international agencies and supported for replication, as a way to strengthen local food self-reliance with a range of other socio-economic benefits attached to it,"*
>
> Governor Buarque of the Federal District of Brasilia (COAG, 1998)

Urban areas are generally the cultural centres of civilization. They attract and nurture talent and creativity from which countless art movements stem and scientific breakthroughs emerge. They are exciting and full of energy. But they can also be full of poverty, impersonal and void of community support. Community farming can be a way for people to reclaim their 'place' – the sense of rootedness to the land and bonds to the community that they might be hard to find in the city.

Community food security is a movement with its goal as: "all persons obtaining at all times a culturally acceptable, nutritionally adequate diet through local non-emergency sources" (Allen, 1999). It works to build a community-based food system "grounded in regional agriculture and local decision-making", with a focus on how or where food is produced (*ibid*). UPA initiatives may be a part of building that connection between increasing access to food and developing local food systems.

UPA is certainly not the total solution to urban food security problems. The poorest residents still have little access to production possibilities and UPA does not address income distribution (Allen, 1999). However, urban farms may offer opportunities for entrepreneurship and employment, especially in inner city areas where little else in the way of industry exists (Garrett and Ruel, 2000). Many community gardeners start small businesses, selling their produce and/or added-value produce to the community. The Cottonwood Community Gardens in Vancouver, Canada took over a former landfill (Connolly, 1997) and currently employs the Environmental Youth Team. Some of the youth who work there are formerly unemployed and gaining valuable work experience.

Food produced in the city for relatives and neighbours are often cheaper than imported food, because there is less need for longer-distance transport and storage middlemen (Smit *et al*, 1996). This is a significant fungible income, or freeing up of cash, especially when considering the percentage of total household expenditure can be as high as 60 per cent in a city in a developing country (*ibid*). This much-needed cash is able to be used for other household essentials.

Farming in the city can be a comfortingly familiar activity for new immigrants when everything else is foreign and new. They may be able to grow food that they are accustomed to eating while preserving their cultural heritage in their cuisine. In North America and Argentina, many of the urban gardeners are Italian immigrants (Smit *et al*, 1996). After all, being food secure is having access to culturally acceptable food.

People producing their own food may in a way reject the idea of being blind consumers of food. They know exactly what has gone into their food by being a part of the process. This can be important for low-income and other marginalized people, who have little else in their life they are able to control. Instead of buying a prepared meal that they know little about, they can prepare a meal themselves, from ‘seed to plate’. This is power – the ability to control one’s own health and well-being (Gelsi, 2001) and this politicization of ones food choices, however small, has the potential to lead to active involvement in local politics (Allen, 1999). In Decca, India, a Permaculture UPA program is linked to building women's empowerment councils (Gailey and Russell, 1995).

Community gardeners sometimes go further in expressing their citizenship. They choose to farm their own food in defiance of our dependence on large corporations for our food. Of the world's largest one hundred economies, fifty-one are now individual corporations (Allen, 1999). Because they have no control over the ethical decisions of these corporations other than through their choices as consumers, growers are able to act on their morals (Gelsi, 2001). However, gardening could simply be a leisure activity without any other objective. Many people choose to garden in the city for recreation and general health and well-being.

School children can learn about biology and the food system by working with soil (Gailey and Russell, 1995). A recent survey in Great Britain revealed that many children are more familiar with video games than their food.

Table 3.1 Young people's skills: 'Which of these can you do for yourself?'(Adapted from MORI, 1993)

Activity	Percentage with these skills
Play computer games	93%
Programme a video to record something on TV	77%
Use a music centre or CD	61%
Heat up a pizza in a microwave	60%
Make a cake	54%
Cook a jacket potato in the oven	38%

Many urban gardens are set up near or within school property in order to teach children the value of knowing where their food comes from. Perhaps, if they grow up with this knowledge, they are more likely to be thoughtful in their food choices when they are older.

Urban gardens can be a way of "using nature to save culture" (Payne, 1991). Nature in the city context can give inspiration to art while creativity is let loose in gardening and cooking. Gardens can be gathering places to sing, dance, and develop friendships (Gelsi, 1999).

3.2.4 Constraints in Developing Urban and Peri-Urban Agriculture

Local governments are often hesitant to approve UPA start-ups. UPA is sometimes perceived to take up land meant for housing or create a polluting eyesore in the city. It can be challenging for aspiring city farmers to secure and hold tenure without usufruct agreements that give growers the legal right to use public or private land as long as they do not degrade it (CFSC, 2003).

These concerns are not unfounded. Like any form of agriculture, UPA has the potential to harm the environment. Chemical pesticides and fertilizers could be leached into the water supply, fossil fuel energy overused, and topsoil further degraded (Smit *et al*, 1996). With poor management, UPA stands an even greater risk of causing these problems because of its often high intensity of production (Dubbeling, 1997).

If they are heavy users of chemical inputs, farmers are highly dependent on their suppliers and other external factors (*ibid*). These instances of UPA hardly address poverty issues in sustainable development, as they does not promise greater access to food or economic stability.

UPA's potential damaging effect on human health is enhanced because of its proximity to settlements (Dubbeling, 1997). Chemicals found in the soil and air can contaminate food produced on urban land. That can be the biggest challenge to urban farmers. If the only space available to farm is by the side of the road, the produce absorbs the pollution from passers-by (Smit *et al*, 1996). Eggs produced on urban land in Western Australia were found to contain high levels of dioxins (Gaynor, 2001).

An urban farm can sometimes be a source of conflict between neighbours, especially if resources are shared. Ableman (1998), who operated an organic farm in a Californian suburb, was caught in a debate over his crowing roosters. This is but one example of the many challenges faced by anyone wishing to cooperate with others.

As outlined above, urban agriculture is far from easy to manage, but it is by no means a reason not to have it. With research and planning, implementing an effective urban agriculture system is a manageable goal. Therefore, the need for low-input systems such as Permaculture is all the more vital.

3.3 Ecological Impact of Denmark's Cities: Why Urban Permaculture?

Denmark produces 660 kg per capita of municipal waste per year (OECD, 2004), while its cities still are growing. The major towns in Denmark grew 4.8 per cent between 1990 and 2000, while the overall population growth of the country was 3.8 per cent (Bach *et al*, 2002). Moreover, as Figure 3.4 shows, there has been an increase in building space-taking detached housing (*ibid*). As urban areas expand and intensify, the challenge to supply food for the growing populations and manage their wastes increases. The Annual cost for waste management in Denmark today is 250 Euro (Magid, 2003).

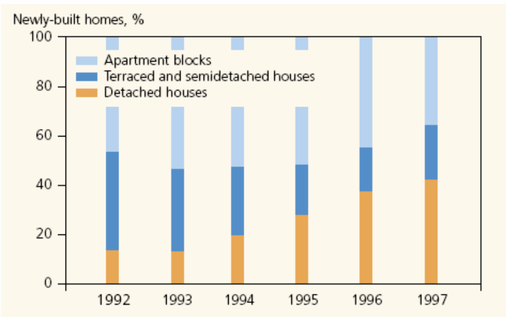


Figure 3.3. Detached houses account for an increasing percentage of newly built homes. (Taken from Bach *et al*, 2002)

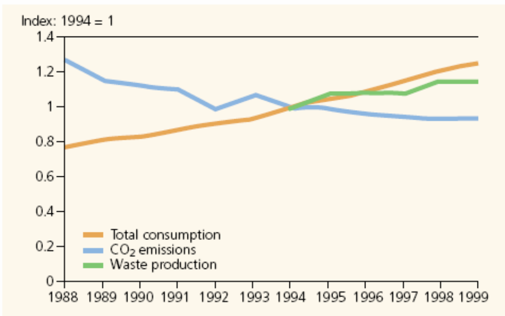


Figure 3.4. Development in consumption and two indicators of pollution: Waste production and CO_2 emission. (Taken from Bach *et al*, 2002)

The quality of life in Copenhagen is considered to be on average 5 per cent lower than in the countryside or in villages (Bach *et al*, 2002). "Green spaces seem to be an important positive factor as regards well-being in the towns" (*ibid*). Perhaps this is the reason why city planners have increased the number of urban green spaces over the last 25 years, usually in mid-sized cities (populations of 8 000 to 30 000) (*ibid*) and many urbanites own summer houses in the countryside. Figures 3.6 and 3.7 show the availability of green spaces in Copenhagen, Frederiksberg, and Aalborg. The question remains, people have recognized the need for green spaces in the cities, but has this contributed to overall sustainability in the cities? The next section will look at the role of Permaculture philosophy in the urban context and an evaluation of Permaculture adoption, and its potential for expansion in Denmark.

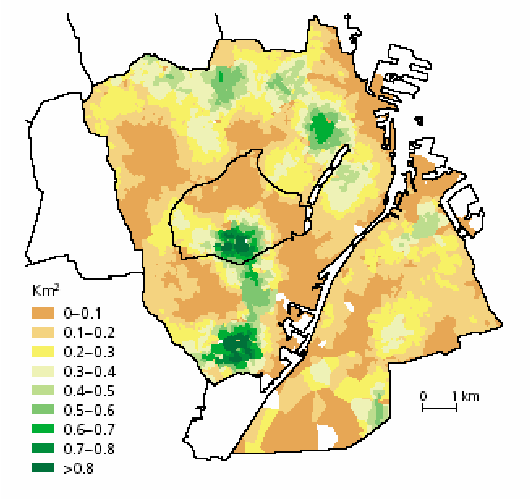


Figure 3.5 Map of the availability of green spaces in Copenhagen and Frederiksberg Municipalities. The map shows the number of km^2 green space available within approx. 15 minutes walking distance from a random point in the municipality. (Taken from Bach *et al*, 2002)

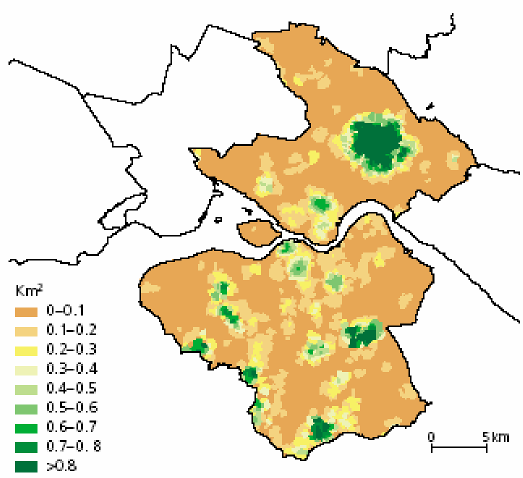


Figure 3.6 Map of the availability of green spaces in Aalborg Municipality. The map shows the number of km^2 green space available within approx. 15 minutes walking distance from a random point in the municipality. (Taken from Bach *et al*, 2002)

3.4 Permaculture in Denmark's Urban and Peri-Urban Areas: Existing and potential applications

As mentioned in Chapter One, many people have "never even heard of the word [Permaculture] yet practise it every day through common sense" (Bell, 1992). It is within the Permaculture philosophy that producing food in the city contributes to its overall sustainability, and many urban farms employ Permaculture principles out of pure necessity. This section will discuss the place of Permaculture-influenced systems in Danish cities. While Chapter Two focussed on Permaculture as a design strategy in the rural context, the following analysis will focus more on the impact Permaculture can have on urban life as a whole and how it plays a role in reconnecting urban people with their food. Urban Agriculture exists on many levels and has many different functions, but in Denmark, perhaps the most effective way that Urban Agriculture can be realized is within the Permaculture paradigm.

A cost-benefit analysis is beyond the scope of this paper, due to the lack of data specifically related to Denmark's cities. Examples of UPA and urban ecological design are far too diverse to compare within our time frame (Munkstrup and Lindberg, 1996). However, a surface analysis follows, with the aim to give an overall picture rather than in-depth analyses of a few examples of UPA.

Table 3.2. Forms of Urban and Peri-Urban Agriculture in Denmark: Examples, evaluation, and potential contribution to the growth of Permaculture in Denmark

Form of UPA	**Examples**	**Evaluation**	**Potential contribution to the growth of Permaculture in Denmark**
Allotments and Summer Houses	• Virtually no instances of Permaculture design	• Distance to Zone 1 • Not so likely to have nutrient, water cycling (because of distance to Zone 1) • Laws protect its permanence	• Less likely to get into community gardening at Zone 1 • Allotment Societies and their conflict with the Permaculture aesthetic
City farms and community gardens	• Enghave Plads	• Challenges integrating the marginalized • Able to incorporate many Permaculture concepts such as zoning (especially at Zone 1) and community sharing	• Problem of funding • Cooperation with LA21 initiatives
School gardens	• Kapalvej • Jagtvej	• Some moving in the Permaculture direction, some are not • Positive effect on children	• Problem of funding • Temporal – teachers and students move in and out
Private gardens in and around the home	• Thomas Lauds Gade 16	• Able to incorporate many pc concepts such as zoning, water and nutrient cycling	• Need education, funding, open-minded people
Ecovillage farms	• Munkesoegaard	• Self-sufficiency in food is not a goal	• Requires sufficient funds to join
	• Beboerforening	• Involvement of immigrants	• Facing termination
Urban-rural interaction	• Gule Reer	• Distance to Zone 1 • Able to incorporate many pc concepts such as zoning, water and nutrient cycling	• Requires sufficient funds to join
	• @stiderne	• Distance to Zone 1 • Possible negative impact on small farmers in the community	• High potential for growth due to marketing

Refer to Appendix C for a description of each example.

Table 3.3. Brief Summary of Permaculture Design Implementation

Case	Energy Management and Passive Solar Design	Optimized Ecological Relationships	Nutrient and Waste Management	Water Conservation Techniques
Høje-Taastrup Municipality	• None noted – conventional energy use	• None noted – conventional landscape design	• None noted	• None noted
Enghave Plads/Thomas Lauds Gade/Jagtvej	• None noted	• Wide plant diversity	• None noted	• Collected rainwater cleaned in pond and used in the garden
Munkesoegaard Eco-village	• Variety of renewable energy sources such as solar panels, corn and wood (surplus from industry) as fuel to heat buildings • Energy-efficient building design	• Plant and animal diversity – herbs, fruit trees, corn, wheat, sheep, and pigs	• Composting of human waste • Used article exchange	• Collected rainwater stored in barrels and used in the garden

A word of caution: The above is not a comparison of Permaculture Design strategies. The focus of the study was to get an overall picture of the urban Danish societal attitude towards Permaculture options or alternatives. Therefore the data are qualitative and should not be considered as quantitative.

Permaculture principles are manifested in Urban Agriculture on three expanding levels of function: as a practical system for supplementing the food supply, as efficient garden design, and as a way of living.

3.4.1 Practical System for Supplementing the Food Supply

The most basic reason to adopt Permaculture is its practicality in being able to supplement the food supply. It emphasizes producing people producing food for themselves, minimizing our food-shed.

The food-shed of a city is the theoretical bioregion that includes the origins and destinations of food (Smit *et al*, 1996). A large food-shed implies more of the intermediary processes such as transportation, processing, and storage. Most of the food that is available at the large supermarket chains, where most people shop, is imported from abroad (Iverson, *pers. comm.*). If food is grown in the city, it is able to be shared or sold among community members, decreasing the size of the city's food-shed.

Beehive- and henhouse-sharing are programs that have been set up in Høje-Taastrup (Communication with Iverson, 2004) that introduce families to producing their own eggs and honey. Munkesoegaard Eco-village has a Permaculture-inspired landscape design in the 'youth' section, but self-sufficiency in food is not a stated goal of the community (Pedersen, *pers. comm*).

3.4.2 Efficient Design for a Garden

In adopting the Permaculture design principles, Urban Agriculture can be taken one step further. Space and resources are more limited in the city, accentuating the importance of efficient design. The advantage is that when two or more elements are brought together with thoughtful consideration, an 'extra' yield of energy, or synergy, can develop. This is what occurs in natural ecosystems – the whole is more than the sum of its parts – and this phenomenon can be imitated in Permaculture system. A garden can combine the benefit of chickens for weeding without the need for more energy input, gain an extra energy yield of eggs, and save the need for pesticides (de Waard, 1994). Similar beneficial interactions are found all over a Permaculture system.

While conventional design is to use space in two dimensions, Permaculture design calls for the use vertical space. For example, urban forest gardens make use of vertical layers of sunlight penetration, imitating the layers found in the natural forest. Canopy layers catch the first layer of sunlight, with smaller trees below them catching the second, shrubs, herbs, creepers on the forest floor, roots below the ground, and climbers (de Waard, 1994). This diverse system not only minimizes energy requirements, but once it is established, it requires very low maintenance because it is self-fertilizing, self-watering, self-mulching, self-weed-suppressing, self-pollinating, self-healing, and highly resistant to pests (*ibid*). This model is appropriate for fitting a highly-productive system into a small space without requiring high levels of external inputs.

The infrastructure for implementing Permaculture design into gardens does exist in Denmark. Table 3.7 shows the distribution and coverage of allotment gardens. There are a large number of allotment gardens that are designated as permanent by government approval (Attwell and Jensen, 2002). Time is important in establishing and developing a functional Permaculture design, and protected allotment gardens give the incentive to make long-term plans. There are also a number of Permaculture gardens in schools and neighbourhoods that have the opportunity to adopt new designs, allowing children to play in a garden-like setting instead of concrete and metal jungle gyms (*ibid*).

Table 3.4. Geographical distribution of allotment gardens (2000) and coverage. (Number of allotment gardens expressed in percent of the number of flats in apartment blocks). (Adapted from Spatial Planning Development, 2001)

Area	Allotment Gardens Total	Coverage
Greater Copenhagen	30 687	6%
Aarhus municipality	3 388	5%
Odense municipality	3 718	9%
Aalborg municipality	2 426	6%
Other municipalities	20 931	7%
Whole country	62 150	

3.4.3 A Way of Living

Permaculture ideas shift the focus of urban agriculture from the utility of it as a food production system to the perception of food production as a part of life. The health of the human community is linked to the health of the greater biological community, implying that sustainability means more than simply meeting food demands. This is the broadest goal of Permaculture. It encompasses the functions discussed above, but moves beyond that to a way of living.

In Western Europe, urban agriculture is often seen more as an environmental sustainability strategy than an instrument for poverty amelioration (Dubbeling, 1997). In reality, the

Permaculture concepts of multifunctionality and zoning are often applied to an urban farm. The space used to produce vegetables can be used as a recreational park, a green space for local biodiversity to thrive, and a place for teaching people about the nature and the food system (Mollison, 1994).

There are many ways that people in Denmark work together to ensure a good and stable food supply. Cooperation, especially for people with busy lives, is essential for a well connected food system. Chicken and cattle co-operatives have been set up in the cities of Alberstlund (Dubbeling, 1997) and Høje-Taastrup (Iverson, 2004). Local windfall fruit- and seed-sharing programs (*ibid*) have had some success. After all, according to Iverson, "exchanging is not so far from the Danish way of thinking" (*pers. comm.*.). As in the natural ecosystem, great things happen when people help and support each other with a common goal. An 'information and imagination intense' (Mollison, 1994) interaction between people will surely create synergy.

Urban-rural interaction is important for changing a common urban view of the farmer as quaint and irrelevant. The Permaculture farm at Gule Reer is an example of city folk making a conscious effort to get out of the city once in a while and producing enough food to feed themselves while building community between themselves. Its members are not dependent on Gule Reer as their sole source of food, but they chose to grow food themselves because they feel its importance (Anderson, 2004).

Box schemes, such as @stiderne are another method of connecting city people to their food source. Boxes of selected produce are delivered weekly to households in the city. The idea is that transportation costs and emissions are saved because there is less need for each household to drive to the grocery store for food. Instead, fruits and vegetables are delivered in bulk at the sorting plant and in turn delivered to all the customers at the same time.

3.4.4 Limitations in Developing Urban Permaculture in Denmark

In the urban areas (populations of more than 1000) of Denmark, the average population density is 133 persons per km^2 (Attwell and Jensen, 2002). This presents challenges in developing further greenspace and intensifying production, if UPA is to expand.

However, there is still very much vacant space that has yet to be developed for food production, such as rooftops and walls.

A much greater challenge in creating self-sufficient communities is public interest. Even if they access to gardening space, gardening may not be a priority in peoples' lives. They may have busy lives, or they may perceive gardening as something meant for old and poor people. "It is not in the Danish tradition to grow vegetables for themselves" (Zwaan, *pers. comm.*.). If they do garden, some people prefer to grow flowers and grass instead of 'useful vegetation' because there is no urgent need for it. Access to food is not as great a problem in Denmark as in many other countries and gardening may simply be a hobby (Iverson, *pers. comm.*.).

There currently only one existing urban community Permaculture garden on public Danish property and that is in Enghave Plads in Copenhagen. Permaculture is a movement that is growing slowly in Denmark (Zwaan, *pers. comm.*.). Perhaps because people are able to garden and enjoy the greenery at their allotments and summer houses, they may not feel the need to create and share it in the city.

There should be more programs set up to try to integrate the marginalized into an urban garden setting. Permaculture-designed school gardens and playgrounds are made for children who attend that school. The Permaculture garden in Enghave Plads experimented with integrating passers-by, some of whom had quite a bit of knowledge about ecology, but that resulted in conflict with the gardeners (Zwaan, *pers. comm.*.). However, there have been some successes in integrating Turkish and Cambodian immigrants in Beboergaarden, Svenborg (Slumstrup, *pers. comm.*.) and drug addicts at Gule Reer (Anderson, *pers. comm.*.) into their respective farming systems.

3.5 Chapter Summary

All around the world, Urban Agriculture is contributing to food security, environmental quality, and community development. However, it is a movement that faces challenges. Permaculture, on the other hand, is a useful perspective with which Urban Agriculturalists can work. There are several Danish examples which demonstrate the ways in which urban Permaculture can work, or not work. Permaculture can be interpreted as a commitment to produce one’s own food, a set of guidelines for constructing a garden, or a guiding principle for an alternative lifestyle.

It is often said that healthy communities lead to healthy societies. Chapter Four will discuss the relevance of Permaculture in our society.

Chapter 4. Permaculture at Global Societal Level

In the context of a holistic, Permaculture project, we feel that the analysis cannot be isolated from a cultural, global historical analysis of agro-ecosystems. This chapter looks at the theories, philosophies and principles addressed in the previous chapters and elevates them to the global and societal level.

4.1 Permaculture Ethics and Philosophy

4.1.1 An Ethical Foundation for a Permanent Society

Permaculture is much more than a strategy for environmentally friendly agriculture. Its creator Bill Mollison mentions that "*without permanent agriculture there is no possibility of a stable social order.*" So, Permaculture is a strategy for achieving a permanent agriculture that permits a stable social order amongst other goals. The practices it promotes and suggests are therefore based on considerations about many other areas than just farm management. It attacks certain aspects of modern culture and defines 'immoral materialism': "*To accumulate wealth, power or land beyond one's needs in a limited world is to be truly immoral.*" (Mollison, 1996)

In fact, Mollison developed a set of ethics and then built his agricultural system on top of that, because he believes that any culture is based on ethics. Inspiration mentioned for his ethical framework includes research in 'co-operating societies', such as the Aboriginals of Australia, and Taoism. And indirectly by the Gaia Hypothesis developed and proposed by James Lovelock at about the same time Mollison came up with Permaculture – in the sense that this hypothesis suggests a much wider application of 'co-operating ecosystems' rather than the previously thought to be dominant theory of 'competitive ecosystems' which on the other hand has influenced theories across a wide array of societal issues, particularly economy. Mollison derived what he believes are the 'universal principles' of an ethical foundation for a permanent society:

- Care for the Earth (including other species)
- Care for fellow humans
- Fair Shares: Limiting population and consumption

Mollison defends putting Earth over people in this list by stating that all life has the same source, and what benefits the ecosystem will also benefit the human race. (Mollison, 1996)

This can easily be described as a radical ethics; it is to this day completely inconsistent with a large number of people's views, and consequently very provocative, that on a list of three concerns, the human race comes in at a second place and also has to cope with the moral dilemmas of having to consider putting constraints on it's own population. But actually, it isn't hard to present the one child policy of China as one of the most important environmental actions ever taken by Man (Møller, 2004).

From these three concerns Mollison formulates a five-part ethical foundation for his Permaculture idea that addresses various current issues (Mollison, 1979, 1996):

- Mans responsibility towards nature is equal to the responsibility towards his fellow Man.
- One cannot claim recognition of one ethical belief and live by another.
- Learn and study as an integrated network. Reductionism leads to ignorance.
- Build conserving societies; a mosaic of small, well administrated and efficient systems.
- Adopt collectivism everywhere.

4.1.2 Permaculture and the 'Who Must Die?' Question

There is a general perception that conversion from conventional to organic agriculture implies a drop in yields. As a result, the possible productivity of various 'alternative' strategies is often questioned. A radical example hereof is the Danish politician, writer and self-acclaimed anti-environmentalist, Helga Moos, who has put forth the question “Who must die?” for the environmentalists to answer. (Moos, 1997)

For some people, it can be hard to imagine a world designed on Permaculture principles as being sufficiently productive. This too is approached at a fundamental and ethical level as Permaculture claims both agriculture and industry *could* be sustainable given our current scientific knowledge. In stead, it places responsibility of productivity constraints on the narrow definition of productivity used in conventional thought which is in general just a number – i.e. how many kilos of a given crop can be harvested in a given area etc. Permaculture points at many 'invisible harvests': Better population health and nutrition, social and physical security and contexts, happy life styles and abstract human values. The yield of any harvest is considered less important than the insurance that another harvest will be made next season. (Whitefield, 1996 and Mollison 1979, 1992)

4.2 The Gaia Hypothesis

Bill Mollison developed the Permaculture concept concurrently with James Lovelock's work on the Gaia Hypothesis, a source of inspiration that is both obvious and explicitly mentioned. So, what is this Gaia Hypothesis and what exactly does it have to do with Permaculture?

4.2.1 What is Gaia?

The name 'Gaia' is taken from Greek mythology – she was/is the goddess of the earth, who bore and married Uranus and became the mother of the Titans and the Cyclopes (dictionary.com, 2004). It is a holistic theory strictly based on natural science, atmospheric chemistry in particular, that suggests the perception of Earth as a living organism. The basic assumption is that life or the biosphere regulates or sustains a climate and atmospheric composition most suitable for life. Lovelock came upon this idea while working for NASA on a method to establish if other

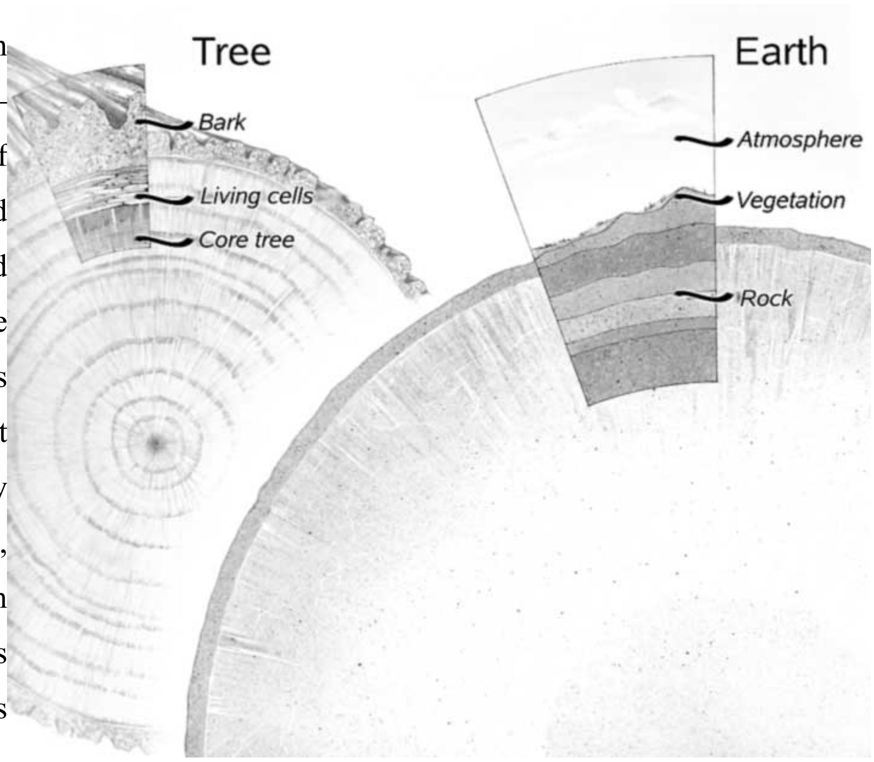


Figure 5.1. The comparison between Earth and a tree - both only has a thin layer of living cells yet it is controversial to regard one of them an organism. (Mollison, 1992)

planets in the solar system contained life. He then realized that the atmospheric composition on Earth is highly improbable and must depend on some regulative mechanism. (Lovelock, 1979, 1992) In other words, it suggests some sort of 'interspecies cooperation' – a concept willingly adopted by Mollison.

This theory has met a tremendous amount of opposition as it is extremely alien to the prevailing belief in reductionism. One of the first and strongest objections Lovelock had to answer, was that most of Earth is just a dead stone drifting in space – but in this respect Lovelock compares Earth to a tree: whereas a tree can be 97% dead material, since only cambium and leaves are alive, everyone considers it to be an organism. However, Lovelock emphasises that he does not wish to attribute feelings or free will to either trees or Earth; his Gaia Hypothesis is not animistic. (Lovelock, 1979, 1992)

4.2.2 Implications of Gaia

It does however provide a construct of substantial critique to our industrialized society and to conventional agriculture and even compares the life form of Man to that of a parasitic species. (Lovelock, 1979, 1992) This is another very provocative point to make and it is also a point of junction to Permaculture in accordance to which Man cannot claim to be a conscious and moral creature if we permit ourselves and others to go extinct due to plain stupidity. (Mollison, 1979, 1996)

Permaculture preaches that a cultivated ecosystem should have as many species it can support. Not just from blind belief in an importance of high biodiversity, but from a consideration of ensuring high ecosystem stability by maintaining, creating and encouraging many beneficial connections between elements of the ecosystem, including species (Mollison, 1979, 1996). However, high biodiversity as a goal is in accordance with the implications of the Gaia Hypothesis and related research. In example, (Pujol, 2002) models Gaia and from the results support the obvious idea that greater species diversity better helps support the narrow range of an acceptable climate.

4.3 Agro-ecosystems and Permaculture

4.3.1 Cybernetic and other properties of Gaia

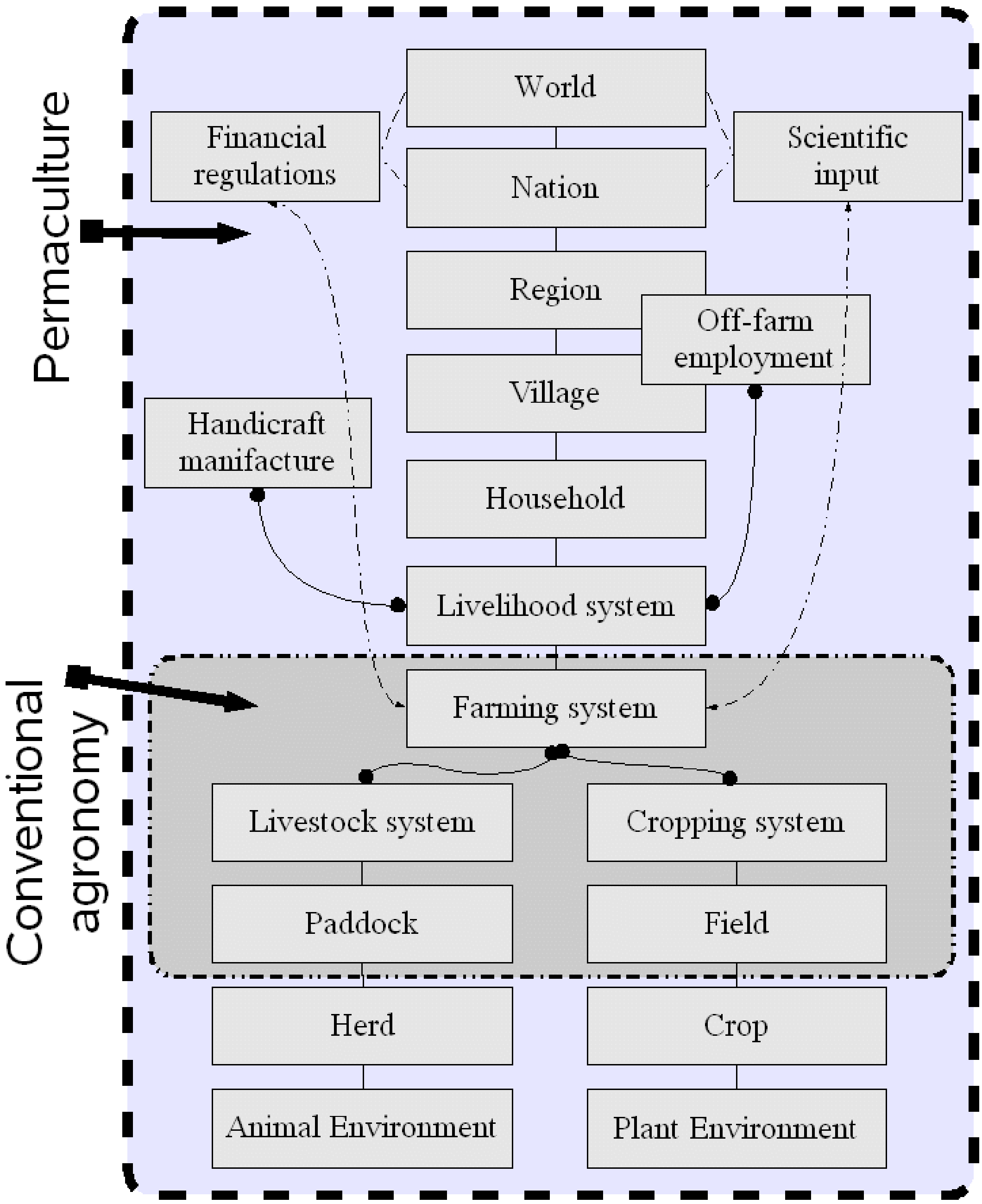


Figure 5.2: The hierarchy of agro-ecosystems and the interest spheres of conventional and Permaculture farmers respectively. This is of course very arbitrary – i.e. most farmers care for their individual animals to some extent regardless of professional ideology. (After Conway, 1987)

The controversy surrounding the Gaia Hypothesis and the notion of Earth being a super-organism is interesting but it is not central to an evaluation of Permaculture as such. We need to work on a scale somewhere in between field and globe anyway, as Permaculture is addressing issues beyond the farmer's everyday. It is however interesting to see how (Conway, 1987) describes agro-ecosystems as 'true cybernetic systems' – as cybernetic abilities are usually only associated with higher, intelligent organisms. The word 'cybernetic' means the science of communication and control, as done by nervous systems and brain functioning (Lawrence, 2000). Whether or not cybernetic abilities should be attributed to Earth is about as controversial an academic debate as the one regarding it's organism or not debate, but agro-ecosystems are well defined entities with defined goals that are steered towards these by feedback control and communication networks and thus to be regarded as 'cybernetic'. Therefore, in order to analyse an agro-ecosystem, systems theory holds that one must not only analyse separate pieces - but instead look at all levels above and below in the total hierarchy. (Conway, 1987)

Within the total system, the goals and properties of each level varies. The traditional basic ecological unit, 'the organism' or 'an individual', has fitness for a goal and achieves it though high values of growth, reproduction, maintenance and survival. The highest goal of an agro-ecosystem must be social value, which is sought through productivity, stability, sustainability and equitability. The three first properties of agro-ecosystems are equivalents to properties of organisms, but equitability is harder to validate in theoretical ecological relations. Social value is then measured in current productivity, likely future productivity and the distribution of the productivity amongst the population – taking into account not only the amounts of goods and services produced, but also their relation to the actual human needs and the allocation among the population. *Productivity* is defined as the valued output per unit of input – which units to use includes a very large number of possibilities, but land, labour and capital are very basic. The *stability* of a system is related to its capacity to maintain constant productivity given disturbances arising from natural fluctuations and cycles. Whereas *sustainability* may be defined as the same ability regarding major disturbances. These properties are intimately linked – when doing an input of pesticides, for example, the (conventional) farmer is at the same time applying a shock to the ecosystem in which his crops live. Finally, equitability is the evenness of distribution of the outputs of the agro-ecosystem among its human inhabitants – a concept impossible to describe in purely objective and positive terms as all measures of it includes highly subjective value judgements. (Conway, 1987)

Permaculture Literature very often uses examples and arguments from current politics, ancient philosophies and other areas far from what is traditionally seen as a farmer's main concerns. It is a central theme that the politics of democracy are not relied upon; these are often described as 'dictatorship of the majority' etc. This is listed as a direct reason for designing a strategy for how the people themselves can change the world. The Permaculture gardener cares for the world through their care for their own gardens - i.e. autonomy is Permaculture’s ideal social order among humans. In this shared assets, variability and multifunctionalism are the sought ideals for equitability (Andersen, 2000).

At whatever level ecological units are studied, they all hold certain characteristics (Kryazhimskii *et al.*, 2001):

- Non-static: Ever changing, dynamic systems of varying productivity, stability etc.
- Open: Cannot exist without an ongoing flow of both energy and matter.
- Complex: Multidimensional hyper structures with overlapping partitions.
- Nonlinear: Doesn't follow certain rules of evolving; complexity (number and relevance of variables in our models) related to nonlinearity.
- Remembrance: Partially irreversible development; behaviour depends on previous development.

With this in mind we'll now dive into the 'memory' of Earth's agro-ecosystem 'cognitive apparatus' and take a look at previous considerations and decisions done.

4.3.2 Previous dispositions of agro-ecosystems

This part is a short walk through time with regard to changes in human dominated and utilised ecosystems. From "slash'n'burn” agriculture to the medieval feudal system - to industrialisation to globalised corporate governing. How useful will the agro-ecosystem approach be? What was Earth thinking!?

Early agriculture

Agriculture appeared from out of nowhere in at least six widely dispersed areas around the world eight to twelve thousand years ago. Intriguing, but hard to say why. Theories include agriculture as a response to pressure of an adverse period of climate or to population growth. Yet stability may have been a more important achievement than productivity – hunter-gathering can be very productive, but always fluctuate. Archaeological evidence suggests agriculture remained a minor contribution to food supplies for many years. But as people migrated into temperate regions the benefits of cultivating crops and herding animals relatively increased. (Conway, 1987) The first Danes were following reindeer flocks, but they became farmers long before the Viking Age. Perhaps the most important change was the physical and conceptual separation of Man from nature and the from then and onwards progressing institutionalization of production and distribution systems (Dahlberg, 2001)

Sustainability and equitability were quick to suffer: there is geological evidence of salinity stress, erosion turning arable lands into wasteland and equitability may have declined when agriculture became associated with family ownership of land (Conway, 1987). Much early agriculture was dependent on the burning of vegetation to release and make available phosphorous – the prolonged existence of simple agriculture in Egypt was only made possible by the erosion of Ethiopia – putting a major restraint on the human population relative to the rest of the biosphere (Newman, 2000).

Manorial agriculture

From the 7th to the 14th Century the so called manorial system ruled. Its ecological basis for sustainability was a two or three course rotation of open fields (preventing pest, weed and disease build-up), and the use of marling and manure. In particular, the collection of nutrients by grazing herds returning to cultivated areas to leave their droppings may have been crucial to the sustainability of the system (Newman, 2000). Strict control over cultivation dates, stocking rates and land allocation was enforced by village councils to ensure the sustainability of the system. (Conway, 1987)

The power of the church was at the time so great, it even extended itself into the environmental sphere. In two cases from the 16th century, farmers of the French village of Saint-Julien were sentenced to daily prayers and denied permission to destroy a colony of bugs. Many such cases are known from medieval Europe. They were settled on a judgement of whether the pests were to be considered creatures of God merely abiding the laws of nature, if they were a 'plague sent from heaven to punish Man for his sins' or if they were 'tools of the devil'. (Ferry, 1994)

Equitability among the landholders was ensured by allocating each family fair shares of both good and bad lands for cultivation and sharing of grazing lands. Productivity was relatively low, however, having increased little in thousands of years. Crops were preferred on the basis of the stability of their yields rather than their peak performance. (Conway, 1987) The sustainability of the system, however, was dubious: Three times as much phosphorous was removed in grain harvests as was added through natural weathering of rocks – but the problem was solved by the spread of plague – the sharp population decrease suffered from the Black Death – in Europe and the invention of fertilizer in China. The agro-ecosystem managers of China later went on to learn a painful lesson when the use of human faeces as manure resulted in the spread of dysentery, typhoid and cholera. (Newman, 2000) When the manorial system finally broke down, which it did at least in part to decreasing productivity and monetary development, previously open fields were enclosed in individual estates and farms: productivity went up measured per unit of land and labour, but at the expense of the peasantry who suffered a social degradation in the process, decreasing agro-ecosystem equitability (Conway, 1987).

Colonial culture

Colonialism is the term for one state taking advantage of another weaker state (dictionary.com, 2004). It is named after a historical period in which European countries practised this policy extensively. It began in the middle ages or even earlier and in fact some would argue it never really ceased – although the classical slavery-alcohol-goods linkage is gone or completely changed, one fourth of Earth's population is still consuming about three fourths of it's resources in accordance with the notion of the period that a colony is useful only if it supplies resources (Sachs, 2003).

It is a period often described as a sad display of European dominator-culture. Patriarchy, monotheism and materialism all prevailed. Europe was expanding its values on the rest of the world which in turn were similarly subjectively described as 'virgin' and 'harmonious'. It certainly was a historical period that changed the world – some cultures were crushed into oblivion, new goods were imported to Europe, diseases were spread, forests were burned, wars were fought etc. A good example of this time is coffee. “Third world” agro-ecosystems were changed into plantations and the farmers were made dependent on the exporting coffee beans. The Europeans were doped by the stimulant in the brew, in turn making a whole population dependent on importing it. Another may be opium, for which reason alone England more or less fought a war. A good example of anti-colonial counter-culture literature is (McKenna, 1992). In Europe, intrinsic fashions of garden design were developed to symbolise Man's domination over nature (Andersen, *pers. comm.*).

This period was detrimental to all properties of the global agro-ecosystem except <u>productivity</u>. Perhaps not immediately, even though local problems some times made environmental managers out of colony governors (Sachs, 2003), but the foundation for an <u>unequal</u> and <u>unstable</u> culture was built.

It was not only a time for conquest as exploration went alongside it. The travels of the scientists of the time led to many discoveries and new theories. For example, those of the German geographer Alexander von Humboldt (1769-1859) and British Charles Darwin (1809-1882). It is interesting that the former is considered a 'classical' scientist and the latter a 'modern pioneer' (Meadows, 1987). Darwin's hypothesis went very well along with those of Adam Smith (1723-1790) presented in his *Wealth of Nations* (1776), the epitome of capitalist literature and theory, the influence of which cannot be underestimated to our modern day society. But actually, Smith clearly stated that his proposal for an economical layout of a nation, was indeed a proposal for a nation only – not a globalised world (Andersen, *pers. comm.*). And von Humboldt coined the theory of such terms as ecology and biodiversity – years before they were established. A review of his work shows parallels to Permaculture.

Critical literature, such as (McKenna, 1992) often blame many things on these white, males 'penetrating' other cultures on their travels. Again, von Humboldt seems to have been somewhat ahead of his time, as he always carefully described his own role in the observations he did. Perhaps the most important travel he did was the South American expedition which was partly sponsored by the Spanish colonial power. Humboldt was an intrepid, reductionist worker, classifying many new species in the Linnaean system, but he also witnessed the implications of colonialism which truly disgusted him. In many passages of his journals he rallies against Spain's hoarding of agricultural land, the destruction of nature, violence against native people and in particular the brutality of the massive slavery. In one book he explicitly states that "*the very idea of a Colony is immoral*". In stead of keeping his sociological and natural observations separate he went on to make the ground work for a humane ecology – a socially conscious and humanistic yet non-anthropocentric science.

Reductionism in it self even had to take a few blows from him, for example indirectly in down playing the importance of his many new species discoveries: "*The discovery of an unknown genus [...] seemed to me far less interesting than an observation on [...] the eternal ties which link the phenomena of life, and those of inanimate nature*" because "*all natural forces are linked together, and made mutually dependant on each other*"; or directly when he writes that "*no generation of men will ever have cause to boast of having comprehended the total aggregation of phenomena"* and that this very reductionist assumption is a "*mad notion.*" When asked to investigate a drop in the water level of a lake, he pointed at nearby deforestation arguing that without roots in the soil around the lake the springs leading water to the lake would never sufficiently recharge – but was dismissed as too improbable and in stead the sudden appearance of an imaginary underground sink was used for an explanation. Humboldt did believe in Man's right to use the products of nature, but he wished to achieve a sustainable use - "*a more enlightened employment of the products and forces of nature*" – and through his writings sought to raise the consciousness of his fellow Westerners regarding the impact of their actions on far-off places. But when he had the use of guano for fertilizer demonstrated in Peru and brought some with him home it resulted in a massive import of this resource which in turn shaped Peruvian economy of the time and led to a war with Chile. And when he passionately described the destructiveness of the Mexican silver mining industry to its own country and people it just caused a rash of investment in it. Humboldt attacked the colonial elites for pursuing personal profit rather than welfare of the countries: "*Whenever the soil can produce both [a cash crop] and [a food crop], the former prevails over the latter, although the general interest requires that a preference be given to those vegetables that supply nourishment to man over those which are merely objects of exchange with strangers*" and praised those indigenous peoples who'd remained "*free*" and "*self-governing*". (Sachs, 2003)

Globalised, industrialized, monopolized Green Revolution agriculture

Modern times have added substantial physical separation of humans from nature, as we dwell in larger and larger cities, to the cosmological separation begun with the first domestication of animals and cultivating of crops. Actually, the Green Revolution has been much more effective in spreading Western institutionalization of food systems than the colonial period was – only the rationale has changed from religious and civilized to plain economic. A global decrease in natural and cultural diversity has been directly correlated with this expansion. (Dahlberg, 2001)

A dominating factor in western agriculture has ever since the financial hardships in the 1930s been subsidies and protectionism, guaranteeing a certain income to every farmer. Protected from the fluctuations of the world market European and other privileged farmers have increased productivity beyond any previous levels even resulting in gigantic surpluses of goods – some of which have been stored although in grave demand elsewhere, others of which have been 'dumped' on the world market to cause much hardship for those who also produce them. Yet it is only possible due to massive imports of nutrients and use of energy so its actual sustainability is an ongoing debate. The productivity of the so called 'Least Developed Countries' (LDCs) was dramatically increased during the so called 'Green Revolution' of the latter half of the 20th Century, during which new high-yielding species were bred and the use of fertilizer expanded. At the expense of decreased equitability, stability and sustainability however, as this development has been accompanied by numerous problems – such as the spread of pests and diseases and loss of local autonomy. (Conway, 1987)

The rise of the multinational corporations have caused many conflicts and debates in the western countries internally – in respect to their influence on public health, financial morals and business methods and many other issues. A good example is the North American fast food industry. When McDonald's and Burger King started expanding across USA, they took their strategy of targeting high-way motorists so seriously, they paid for some politicians' election campaigns and then had them move state subsidies from public transportation initiatives and railroad building to the construction of many new roads. In USA at least they use the same strategy for creating and exploiting subsidies for their franchising sub-contractors, who by the way run the financial risks anyway. The fast food industry has surpassed the oil companies in the public's notion of being the main antagonists – leading to vandalism against McDonald's restaurants world wide (including Denmark, China, France, India and many other countries). (Schlosser, 2001) Such threats to democracies were predicted as "industrial aristocracies" already in writings by a de Tocqueville in 1835, and later by Marx (Dahlberg, 2001).

The centres of power have moved upwards in the hierarchy of agro-ecosystems (Illustration 2) during these years. Companies in all sectors, including the agricultural industry, have grown beyond the average size of a country, and do increasingly exploit their options for policy influence – ensuring profits through construction of dependency is not a secret scheme anymore, it's a part of business college curriculum termed 'encapsulation' and it includes offensive strategies on how to subdue consumers, farmers and nations alike. Consequently, our leaders have begun meeting on even higher levels to discuss such issues as international trade and policy, increasing the relative importance of such power constructs as the International Monetary Fund (IMF) and the World Trade Organization (WTO), but the actual roles of these are still being settled on various levels and the multinational corporations do influence them a lot and use them for restructuring whole societies for their own benefit. Corporate power is on the rise, no doubt, even culturally as they now claim the rights and privileges of persons and national economies are no longer judged by the health of their citizens but by the health of their big businesses. New research increasingly comes from these huge corporations, and is aggressively promoted by these companies for fast profits - who are well aware and protective of technology's strong position in the general public as morally neutral. They claim no responsibility for feeding the world yet blame anyone who questions their rather naïve optimism for exactly the opposite. (Kneen, 1999)

The company strategy of Monsanto is expressed down to the genetic level in the "Terminator Technology" which consists of crops who's seeds cannot germinate, ensuring annual purchases of new seeds straight from the company – a strategy that together with Monsanto's strict copyright claims have coined the new word 'bio serfdom' to describe the new situation of farmers. One of Monsanto's claims in defence of commercial use of genetically modified organisms is that the technology behind them is 'quick and precise' – but that is a highly subjective statement. That it's precise is mainly an assumption people tend to accept because the technology deals with things too small to see with the naked eye. And the speed of it also brings with it a philosophical dilemma as the full consequences of applying it will never be evident before it is much too late to try and correct it. Up until 1996 when Monsanto inserted a *Bacillus thuringiensis* gene into cotton, Chinese newspapers enjoyed their readers by following the annual body count of field workers during the spraying season; by having the plant produce some of the pesticides, many Chinese workers have already been kept alive – but the pesticide itself hasn't gone away (Manning, 2004). And when inserting the same gene into potatoes, how will the large-scale consumption of *Bt* affect us? Furthermore, *Bt*-resistant pests are bound to evolve, just like penicillin-resistant bacteria now haunt the industrialized husbandry. In fact, it is expected to take no more than five years. (Kneen, 1999)

Concurrently with the development of corporate world domination counter-measures have evolved from below. Permaculture is just one such an idea. Given certain conditions, organizations such as Greenpeace and the Worldwatch Institute, potentially wields tremendous power, because they very directly influence a fundamental part of the corporate power: the consumer, without whom there is no company at all. Today we're in many ways in a stand-off situation, neither side willing to give in. Now there's even a counter-environmental idea spreading, suggesting that the environmentalist organizations are an 'industry of fear' preying on naïve westerners, preventing new uses of the world's natural resources to the benefit of all Mankind (Lomborg, 2001 & Moos, 1997). How will our common agro-ecosystem move on?

4.3.3 Current challenges of agro-ecosystems

Human approaches to environmental issues

Kryazhimskii *et al.* (2001) divide people's points of views on environmental issues in three:

- Narrow – medical and physiological (associated with strict anthropocentrism, animal organisms serve as experimental models for humans)
- Broad – interdisciplinary (population ecology may have relevance to humans although analogies from knowledge of other species may be difficult to use)
- Traditionally ecological – *Homo sapiens* is one species among others in the ecosystem

The science of ecology has grown from being a niche within biology into a science of its own incorporating also the interaction with abiotic elements. Kryazhimskii *et al.* (2001) welcomes a shift in attitudes from the narrow anthropocentric approach to the more ecologically based, whether it's actually bio-centric or not. However, even traditional ecologists who fail to acknowledge the relevance of a holistic, bio-centric view at things, often also fail to identify important feedback mechanisms between natural systems and human society. He (and his co-authors) then leaves two main paths open for us humans to follow towards a world with fewer environmental problems:

- Attain harmony between Man and nature
- Create a super-ecosystem with desirable characteristics

In many ways, people are already swearing their allegiances to one or the other approach, yet realistically they are both utopian ideas. (Kryazhimskii *et al.*, 2001)

Permaculture is certainly following the first of the two paths. Its obvious weakness would include the 'who must die question' but to Permaculture the current over-population issue is not the responsibility of individuals, whereas the contribution to our society of tomorrow is (Mollison, 1996). The latter of the two paths would include such overtly optimistic ideas such as reversing the green house effect by adding iron to the oceans thereby fertilizing Fe^{2+}-deficient photosynthesis and growth of phytoplankton indirectly increasing their CO_2-capacity as dead organic matter sinks to the bottom and stays there (Newman, 2000).

Environmental concerns influence decisions made on all levels in society. Many large companies have moved away from the “traditional customer centered” way of acting and onto a more socially responsible orientation, so environmental concern may be just one more step? (Stone *et al.*, 2004) Just a few years ago there was reasonable public concern that large companies would take over most land and leave the farmers in a position equal to a factory worker. However, land investment has proven far too risky for these companies and today they own relatively little land and property – this goes for McDonalds and Monsanto and others alike. They have turned to other methods for swaying their influence. (Kneen, 1999)

Goals

Dahlberg (2001) provided a synthesis of how to help further democratize the food systems of human societies from a historical review – somewhat similar to this chapter. One quite central issue is that we inevitably move towards a post fossil fuel society, and that any vision should address this. He also wish for a reconsideration of our high hopes for technological progress, for the very idea that such are always value neutral and for our beliefs in the efficiency of ever larger infrastructures. According to him the two most important initiatives to take if we are to lighten our tread upon Earth is to...

- slow the growth of human and livestock populations and

- Move away from dependence on stored forms of solar energy and on to a more traditional, but technologically enhanced dependence on daily and seasonal solar income. And, in general, strategies based on regenerative processes.

Which is surely something Mollison do agree with, and which is addressed quite directly by Permaculture – in fact, the non-fossil energy strategy is an underlying principle in it (Holmgren 2003). Four main goals are specified and some strategies for reaching them:

- Diversify and decentralize agro-ecosystems by re-embedding culture and society in nature: I.e. counter the industry's redefinitions of food in narrow nutritional and commercialized terms by reviving regional cuisines; and protect the remaining 'wild' areas of the world and their indigenous peoples.

- Re-embed science and technology in society and nature. I.e. expand focus on 'food safety' to 'agro-ecosystem risk'.

- Re-embed economics in society and in nature. "Today, the main content of politics is economics, and the main content of economics is technology. If politics cannot be left to the experts, neither can economics and technology" (Schumacher, 1973; after Dahlberg, 2001).

- Re-embed governance and politics in society. Representative democracies are loosing grasp of power as the influences of corporations grow. Many a call for better 'food democracy' has already been made.

All of which we believe Mollison and other Permaculture thinkers would agree with. (Dahlberg, 2001)

4.4 Current polemics

After this remembrance of the agro-ecosystem – what is Gaia thinking now? We only know what we're thinking ourselves, so finally a few examples.

4.4.1 Genetics – but how?

A good example of the followers of the two paths clashing is the ongoing debate on whether to use genetically modified organisms or not – organic farmers of all sorts more or less agree fully on a total boycott of such crops, whereas most conventional farmers have chosen to embrace them. In Denmark, the organic farmers' association run a website explaining their reasons for rejecting genetically engineered crops (http://gmo.okoland.dk/) while the conventional organization rejoice at the news of the European Union imposing on it's member countries a law that allows the cultivation of genetically engineered crops (Høegh, 2004). Monsanto's agricultural advisors have advised american farmers not to bother growing GMO and non-GMO crops seperately, assuring them that Europe would have GMOs allowed by harvest time (Kneen, 1999) – and when the farmers then had to accept a lower payment for their entire harvest, now considered GMO, European media blamed consumers for being evil to the american farmes! The suspicious mind would see a conspiracy right here. There are many stories like this one, but will this continue?

A good example of the followers of the two paths clashing is the ongoing debate on whether to use genetically modified organisms or not – organic farmers of all sorts more or less agree fully on a total boycott of such crops, whereas most conventional farmers have chosen to embrace them. Remember Flavr Savr – the tomato whose creators sought to solve a fundamental problem in modern society with? In industrialized tomato cultivation the fruit is taken off the vine before it's actually mature, a process which is – even chemically – finished later in the food chain (the supermarket); a procedure that has led to less culinary interesting and less healthy tomatoes. Flavr Savr was a genetically modified tomato that supposedly solved this problem – only the plant had very poor yields, poor disease resistance and other problems so growers soon went back to more reliable strains. Now, the company behind Flavr Savr, Calgene, has been bought up by Monsanto who later abandoned the tomato project. In the mean time new tomato strains have conquered the market – bred using the knowledge of the genes in the many varieties, yet without the use of transgenic methods. Science has in this case succeeded to move on without hitting the pitfall. Richard Jefferson is one biotechnologist who takes a directly anti-Monsanto approach to his work. Citing the open source ethos of Richard Stallman and Linus Torvalds he reverses an analogy from software programming to genetic engineering – most often used by the technology optimistic advocates – he instead highlights that where computer programmers operate 0's and 1's, genetic engineers have to juggle both A's, C's, T's and G's making the task fundamentally much more complex. So, in stead of going along the mainstream of hopefully inserting genes across species, he's developed a method called 'homologous allelic recombination technique ' (HART) which breed new varieties by activating of deactivating certain genes already present in the plant. In comparison, he taunts transgenic research as 'hammer and tong science'. (Manning, 2004)

4.4.2 Certified organic agriculture vs. conventional agriculture

Moos (1997) assessed the potential global production of food from agriculture run organically, and concluded that the vast majority of Earth's population would have to starve to death, in the case of total convertion. Her calculation however, was an extrapolation from yields in North Korea, which she claim is 'truly organic' as they cannot afford neither fertilizers nor pesticides. More than anything this exemplifies the disturbingly low level at which the debate has been waged at times.

It is also far from uncommon to see certified organic farmers being blamed for 'spiritualism' by conventional farmers, who on the other hand feel they are unjustifiably blamed for the environmental problems at hand. This is a topic frequently discussed at KVL – not least at the student's bar!

Most farmers agree subsidies are if not bad, then at least something they'd rather be able to

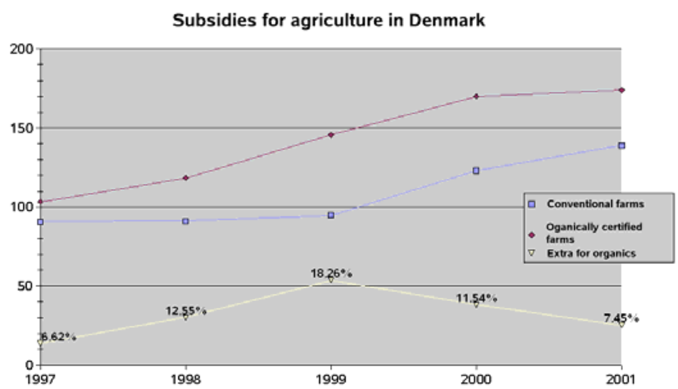


Figure 5.3. Subsidies for both conventional and certified organic farms in Denmark 1997-2001. Tremendous discussions underly the fluctuations on this graph. (source: Danmarks Statistik, www.danmarksstatistik.dk)

do without. But they all have their associations and various political parties clawing for them.

4.4.3 Sceptical environmentalism

The previously mentioned 'counter-environmentalism' of personas such as Lomborg and Moos was perhaps best expressed in the world wide success of *The Skeptical Environmentalist* (Lomborg, 2001). Both Lomborg and Moss (whether they are aware of it themselves or not) rest heavily upon the works of Luc Ferry (1994), the North American economist Julian Simon and others, but they are probably the best Danish representatives of this notion.

Lomborg somehow represents a 'conventional retreat' in the sense that he rejects all 'improvements' to plain financial-statistical analysis and does all his environmental assessments with basic cost-benefit analysis. Therefore, most modern thinkers have a hard time arguing with him. Where Permaculture and Bill Mollison is implementing 'scientific subjectivism' by adding smiling or frowning little faces to his graphs, Lomborg solely measures in numbers of human lives and money. They are simply trying to pull the same strings in different directions and with incommensurable methods. (Lomborg, 2001; Mollison, 1996)

When the Danish government was last replaced, and a shift to the right side of the political spectrum took place, many existing councils were shut down and an institute of environmental assessment put in their place – with Bjørn Lomborg as a director. The debate is in other words heavily influenced by politics. At the same time subsidies for sustainable energy production has been removed, then partially replaced at the loss of consumer protection – and, not least, Denmark has joined a Middle Eastern war in which fossil fuel plays some role. All of this should explain why Permaculture has abandoned political fora as a platform for expansion. Conventional politicians may claim to be environmentalists merely sceptical, but Permaculturists are certainly sceptical politicians.

4.5 Summary

Permaculture is a biocentric paradigm for agricultural science; a central concern is the wellbeing of planet Earth. But first and foremost reasoning – rather than just wishful. We believe the recognition of ‘agro-ecosystem Earth’s memories’ is quite interesting and inspiring indeed; but it is an *analogy*, of course, in which all organisms of the super-organism constitutes one ‘brain cell’. The summary of Homo sapiens’ population history also found very early signs of Permacultural thoughts in the shape of von Humboldt who was doing ethical, holistic agro-ecosystem science, and sought to raise his fellow specimens' awareness of the need for sustainable and fair social order and rationale. The decision making of 'Gaia' is as hard as ever: Questions of drastically increasing complexity are being raised by some and hidden from public view by others.

Chapter 5. Discussion

In this project, we have defined Permaculture, and seen many examples of how it applies in both Danish rural and urban areas. Of course, there was no “perfect” Permaculture system – each had its strengths and weaknesses. We also discussed the necessary societal context for sustainable food production systems.

In this chapter, we attempt to synthesize our thinking process and merge what we have discussed previously, in order to assess 1) the theoretical sustainability of Permaculture, 2) the applicability of Permaculture in Denmark, and 3) the sustainability of Permaculture practices in Denmark. The chapter ends with a set of recommendations and a short discussion about our personal worldviews and biases.

5.1. Is Permaculture the Solution to Sustainability?

Bell (1992) states that Permaculture is “a way of arranging your life to be happy and abundant.” So how can it produce enough food to feed us all? An issue that came out quite often through the project is the potential for Permaculture to give sufficient yields. All farms visited seemed to have relatively low levels of production. Also, there exists a perception in the society that non-conventional farm management systems, such as organic farming, lead to decreased yields which are compensated for with niche market price premiums, reduction in input costs, or government subsidies. Studies about comparing yields are numerous and contradictory, but the capacity of organic (or alternative) farming, to meet or exceed conventional yields, has been demonstrated many times (Lockeretz, 1989; NRC, 1989; Whitefield, 1997; Deria, 2000). We think the most relevant answer is provided by Jeavons (1995): by implementing much more ecological and intensive methods of production, yields can be dramatically increased from much less land.

From our study, we learned that Permaculture leads to energy efficiency, closed nutrient cycling, ecological balance, reduced work and disturbance, and community development. Considering that it has the potential to increase yields on a small scale, and considering that the world is an aggregation of small systems making up the Gaia organism, we then think that Permaculture has the potential to be a successful strategy for global sustainability.

5.2. Is Permaculture Applicable in Denmark?

5.2.1. Physical Potential and Limitations

The variety of plants to be grown in Denmark is limited compared to tropical countries, and the climatic limitations for growing crops year-round makes harvests very sporadic on farms. However, as shown by the two case studies included in Chapter 1, it is very possible to apply Permaculture in cold climates, if the design used is appropriate. Denmark also has a great potential for the production of electricity from renewable sources of energy, especially wind.

5.2.2. Traditions in Danish Farming

Farming in Denmark traditionally reflects what is done in the other developed countries in the world, following the green revolution that was discussed in Chapters 1 and 4. Having an agriculture based on annual crops and dependent on the use of machinery is obviously an obstacle for the adoption of Permaculture design. We have seen in Chapter 2 that perennials and edge shaping are key elements to achieve permanence and useful ecological relationships, but these were neglected on more mechanized farms (e.g. Hegnstrup). Moreover, it requires a lot of effort and thinking to establish Permaculture systems in Denmark, since the landscape has been domesticated for so long. For example, at Søndermarksgård, Karsten has to deal with the existing buildings and structure of the installations, even if the zoning and is not accurate.

5.2.3. Economic Issues

Various economic issues in Denmark can be an obstacle for the thriving of farms adopting Permaculture principles. First of all, almost all farmers told us about how the pressure on the land is currently increasing. Pig producers are moving from the most densely populated areas of Europe, seeking for cheaper land. Farms in Denmark have basically three basic reactions: 1) increase in size to stay competitive, 2) move to Eastern Europe where the land is cheaper

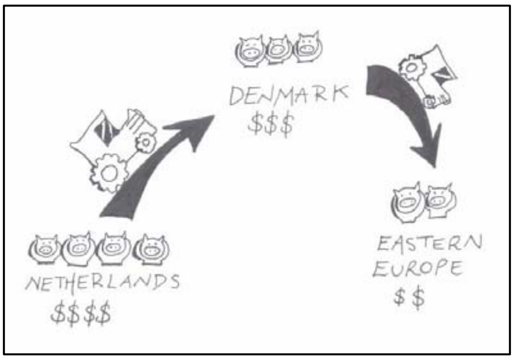


Figure 5.1. Movement of farmers toward cheap lands, and farm size

(creating a domino effect) or 3) disappear (Figure 5.1). Permaculture and small organic farms do not seem to have a place in this scheme.

Another problem encountered by the farms, especially those in Jutland, is the commercialisation of their products. Moreover, as pointed out by one of the farmers, the growth of @rstiderne is creating serious competition on the Danish organic market, which is not favourable for small producers who want to sell their products independently. @rstiderne is good for bringing organic food to Copenhagen, but is an obstacle for the development of Permaculture in Denmark.

5.2.4. Cultural Barriers

Organic food implies a change in choice of consumption. Permaculture, in contrast, implies a change in the way of life. Is it too radical? The progression of the Green Revolution was straightforward and rapid, because it went hand in hand with industrial development. Although Permaculture seems popular among a portion of Danish urban dwellers, and although the principles seem to be applied naturally on some farms, a national shift is unlikely to happen easily. In community gardens and eco-villages, people are still reluctant about common plots and prefer to have their own little square (equal to everyone else), which reduces the possibilities for interesting design compared to places like Gule Reer. The Danes are recognized for having a relatively strong sense of community solidarity because their social welfare system seems to make sure people are well taken care of. On the other hand, we may say that the social system allows people to be asocial. People do not seem to feel the urgency to form strong community bonds for local action. Structural problems within Danish Permaculture organizations also make it difficult to develop an efficient network. We could also add a long discussion of the effect summer houses have on Permaculture development. They could encourage food growth, but at the same time reduce the need for local, community-based urban agriculture.

5.3. Is Permaculture a Sustainable Alternative for Denmark?

That is a very difficult question to answer. Danish Permaculture is not developed enough for us to have a clear idea of the consequences of its broad scale adoption. What Permaculture can obviously bring to Denmark is food and energy autonomy, rural and urban sustainable development, and a healthy environment. Moreover, Permaculture could have the impact of increasing people's interest about ecology through gardening, since

Permaculture is holistic and more accessible to non-scientists than many other pieces of literature on agro-ecology. As mentioned by Julie Firth (International Permaculture Conference, Perth, Western Australia, 1996) Permaculture is not about "going back to the past, it's about looking to the future." On the other hand, considering the state of current Danish agriculture, Permaculture establishment could bring lower incomes if new market opportunities and adequate policies are not developed.

5.4 Recommendations to increase Permaculture in Denmark

Here are some direct actions we recommend following our work:

- Start to include Permaculture design (social and environmental) in community planning (towns and cities)
- Integrate different Permaculture organizations and increase activity
- Open Permaculture farms to visitation
- Increase Permaculture "campaigns" in schools to set up school gardens
- Increase accessibility to Permaculture design courses (i.e. Reduce costs)
- Develop Permaculture structures and techniques adapted to Denmark, and make them available to people (water treatment, energy production and storage, …)

Indirect actions are also recommended:

- Increase consumers awareness of food and technology democracy (give the choice)
- Promote agricultural policies related to ecosystem goods and services
- Develop opportunities for local markets in the countryside
- Develop the potential for the use of renewable energies

"We can return to managing our massive knowledge and capability for construction, not destruction, in a way which accords with natural processes. I do not suppose any previous golden era to which we should all return, nor that we should reject out of hand modern technology. However, there are plenty of old ideas worth assimilating into our lives, alongside current useful discoveries." (Bell, 1992)

5.5 Our Worldviews and Biases

At this point, we have to recognize that our worldviews have greatly influenced the content of this project as well as the direction of the analyses. We are all from developed countries (Denmark, the “host” country, Australia, the “source” country, and Canada), and also we all have a biocentric paradigm. Most of us had a base in Permaculture before starting the project, meaning that we were considering it already as an interesting tool for sustainable development. We were also greatly influenced by all the people we met along the way.

It is sometimes hard to be totally objective when talking about organic farming and it becomes impossible when we try to assess sustainability of Permaculture systems. The traditional scientific approach is often not sufficient to traduce how human communities function. Individual judgement is implicit in any assessment.

Conclusion

Permaculture is theoretically feasible, theoretically applicable, and theoretically sustainable in Denmark at the farm, city and society levels. However, limitations to its practical, broad scale application are numerous, although on the local level some principles are naturally adopted. Permaculture farms in Denmark are engaged a tough battle against the restraints of years of moulding the country in the 'conventional' frame of thought.

Asking the question ‘can Permaculture feed the world?’ is asking a biased question because it assumes conventional farming can. One can easily see this when considering the equivalent postulate - 'conventional agriculture cannot sustain our agro-ecosystem' – and the fact that Permaculture isn't a set of techniques but a paradigm for evaluating and improving whatever practices one is currently applying.

The illustration on the cover of this report lends heavily from Australian aboriginal culture, but we could just as well use symbolism from Scandinavian mythology: the Vikings believed in principles keeping the world from falling apart (The Midgaard Worm), the humans challenging it (thunder god Thor trying to lift it), and the inevitable doomsday conflict (Ragnarok).

Literature Cited

Ableman, M. (1998). *On Good Land*. Chronicle Books. San Francisco, USA

Allen, P. (1999). Reweaving the food security safety net: Mediating entitlement and entrepreneurship. *Agriculture and Human Values* **Vol:16** pp117-129

Andersen, T. (2000). Permakultur – økologiske helhedsløsninger i praksis. In: *Permakultur – Nordisk Årsskrift 2000*. Permakultur foreningen Danmark, Copenhagen.

Andersen. T. (2004). Personal communication, May 2004. Phone: +45 3331 5694; email: permakultur@post.cybercity.dk

Anon. (2004). Definitions of Sustainability. Website. http://encyclopedia.thefreedictionary.com/Sustainability

Atkinson, S. (1995). Approaches and Actors in Urban Food Security in Developing Countries. *Habitat International.* Vol: 19(2) pp 151-163.

Attwell, K. & Jensen, O. (2002). "Spatial Planning in Denmark." *Greenstructures and Urban Planning.* Taken from: http://www.map21ltd.com/COSTC11/dk-planning.htm

Community Food Security Coalition (CFSC)'s North American Urban Agriculture Committee. (2003). *Urban Agriculture and Community Food Security in the United States: Farming from the City Center to the Urban Fringe.* Taken from: http://www.foodsecurity.org/PrimerCFSCUAC.pdf

Bach, H., Christensen, N. & Kristensen, P. (ed). (2001). *State of the Environment in Denmark, 2001.* National Environmental Research Institute, Ministry of the Environment. Copenhagen, Denmark.

Baldwin, M (1997). *Permaculture in Practice (video).* Permanent Publications, UK.

Bansal, M. R. (1992). *Cost Benefit Analysis in Agriculture*. Friends Publications, Meerut, India

Bell, G. (1992). *The Permaculture Way – Practical steps to creating a self-sustaining world*. Thorsans Publishers. London, UK.

Bockstaller, C., Girardin, P., & van der Werf, H.M.G. (1997). Use of agro-ecological indicators for the evaluation of farming systems. *European Journal of Agronomy* Vol 7: 261-270.

Bown, M. & Shel, H. (producers). (2000). *Farming with Nature* [video]. Crystal Lake Video, UK.

Burnett, G. (2000). *Permaculture – a Beginners Guide*. Land and Liberty Press, Essex, UK.

Committee on Agriculture (COAG). (1998). *Urban and Peri-Urban Agriculture.* Food and Agriculture Organization. http://www.fao.org/unfao/bodies/COAG/COAG15/X0076e.htm

Connolly, N. (1997). "Report on Community and Allotment Gardening in the Greater Vancouver Region." *Urban Agriculture Notes*. Taken from: http://www.cityfarmer.org/normstats.html

Conway, G. R. (1987). The properties of Agro-ecosystems. *Agricultural Systems* **Vol: 24**, pp. 95-117.

Dahlberg, K. A. (2001). Democratize society and food systems: Or how do we transform modern structures of power? *Agriculture and Human Values* **Vol:18**, pp. 135-151.

Danish Research Center for Organic Farming (DARCOF). (2000). *Principles of Organic Farming*. http://www.darcof.dk/discuss/Princip.pdf

Deelstra, T., Boyd D. & van den Biggelaar, M. (2001). *Multifunctional Land Use: an Opportunity for promoting urban agriculture in Europe*. Taken from: www.ruaf.org/newslgen_fr.html

Deria, A. M. (2000). *A Comparison of Organic and Conventional Farming Systems with Particular Reference to Wheat Production and Soil Fertility in Western Australia*. PhD Thesis. Murdoch University, Western Australia

de Waard, Fransje. (1994). "Permaculture design, or edible landscaping: hands and feet to sustainability." *Sustainable land use planning,* pp243-252. Van Lier, H. N. *et al.* (ed.) Elsevier, Amsterdam.

Dictionary.com (2004). [http://dictionary.reference.com/] cited May 2004.

Dubbeling, M. (1997). "First Bulletin on Urban Agriculture in Europe." *Urban Agriculture Notes.* Taken from: http://www.cityfarmer.org/etcbulletin2.html

Dubbeling, M. (1997). "Second Bulletin on Urban Agriculture in Europe." *Urban Agriculture Notes.* Taken from: http://www.cityfarmer.org/etcbulletin2.html#bul2

EA. (2002), *State of the Environmental Report – Agriculture*. Environment Australia, Commonwealth Government of Australia, Canberra.

Ferry, L. (1994): *Den nye økologiske orden – træet, dyret, mennesket.* Munksgaard/Rosinante, Copenhagen. Original title: "Le nouvel ordre écologique".

Fukuoka, M. (1978). *The One-Straw Revolution: An Introduction to Natural Farming.* Rodale Press Inc, USA.

Gailey, T. & Russell, J. (producers). (1995). *Global Gardener with Bill Mollison* [video]. Australian Broadcasting Corporation, Australia.

Garnett, T. (2000). "Urban Agriculture in London: Rethinking our Food Economy." *Growing Cities Growing Food: Urban agriculture on the Policy Agenda.* Bakker, N. (ed.) Consultants in Development Programmes (ETC). Taken from: http://www.ruaf.org/reader/growing_cities/Theme1.PDF

Garrett, J. & Ruel, M (ed). (2000). *Achieving Urban Food and Nutrition Security in the Developing World.* International Food Policy Research Institute, Washington.

Gaynor, A. (2001). "Pesticide Soil Contamination: a Case Study from Perth, Western Australia." *Urban Agriculture Magazine: Health Impacts of Urban Agriculture.* March 2001. http://www.ruaf.org/1-3/12-14.html

Gelsi, E. (2001). *Gardening in the Street: Sociality, Production and Consumption in Northey Street City Farm.* Urban Agriculture Notes. http://www.cityfarmer.org/brisbane.html

Holmgren, D. (1992). "Uncommon Sense". *In Permaculture International Journal: Green Economics.* Issue **No: 44** Sept-Nov 1992.

Holmgren, D. (2003). *Permaculture: principles and pathways beyond sustainability*. Holmgren Design Services, Victoria, Australia.

Hooper S., Barrett D., & Martin P. (2003). *Australian Grains Industry 2003: Performance and outlook.* Australian Bureau Agricultural and Resource Economics (ABARE). http://www.abare.gov.au

Høegh, H. (2004): *Grønt lys for GMO på vej*. [Internet: http://www.landbo.dk/minimain.jsp?o_id=16867, cited 17th of May 2004]

IFOAMa. (2004). *The Principles of Organic Agriculture*. IFOAM Website. http://www.ifoam.org/

IFOAMb. (2004). IFOAM Basic Standards for Organic Production and Processing. IFOAM Website. http://www.ifoam.org/standard/norms/ibs.pdf

Iverson, K. (2002) *Self-Sufficiency Plan for Copenhagen Suburb*. Urban Agriculture Notes. Taken from: http://www.cityfarmer.org/CopenhagenSuburb.html

Iversen, K. Personal Communication. 6 May 2004. Contact: Miljo- og Energi Centret i Hoje-Taastrup. Hoje-Taastrup Boulevard 60, Taastrup

Jakobsen, M., Amhrein, M., & Jensen, A.B. (2000). *Evaluating Hegnstrup as a Farming System*. Report for the Thematic Course "Ecological Agriculture I." The Royal Veterinary and Agricultural University, Denmark.

Jeavons, J. (1995). *How to Grow More Vegetables – than you ever thought possible on less land than you can imagine*. Ten Speed Press, California, USA.

Jolly, D. (2004). "Urban Agriculture as Food-access Policy." *For Hunger-Proof Cities: Sustainable Urban Food Systems.* Koc, M. *et al.*, (ed). Taken from: http://web.idrc.ca/en/ev-30579-201-1-DO_TOPIC.html

Kneen, B. (1999). Restructuring food for corporate profit: The corporate genetics of Cargill and Monsanto. *Agriculture and Human Values* **Vol: 16**, pp. 161-167.

Lambeck R. (2003). Farming for the Future: designing agricultural landscapes for conservation and production. *Pacific Conservation Biology*, **Vol: 9**. pp68-82.

Lawrence, E. (2000). *Henderson's Dictionary of Biological Terms*. 12th edition. Pearson Education Limited, England.

Lomborg, B. (2001). *The Skeptical Environmentalist: Measuring the Real State of the World.* Cambridge University Press, UK.

Lovelock, J. E. (1979). *Gaia: A New Look at Life on Earth*. Oxford University Press, UK.

Lovelock, J. E. (1992). *Jordens overlevelse. Den hidtil mest udfordrende bog om Gaia-teorien*. Politikens Forlag, Copenhagen, Denmark.

Madeley J. (2002). *Food For All: The Need for a New Agriculture*. Zed Books Ltd., London, UK.

Mader P., Flieβbach A., Dubois D., Gunst L., Fried P. & Niggli U. (2002). Soil Fertility and Biodiversity in Organic Farming. *Science* **Vol: 296** (5573) pp 1694-1697.

Magid, J. (2004). "Recycling of nutrients – a prerequisite for sustainability. *Journal of the Royal Swedish Academy of Agriculture and Forestry.* **Vol: 143**.

Manning, R. (2004). *Super Organics*. Wired Magazine (cited 11 May 2004) http://www.wired.com/wired/archive/12.05/food.html

Matson P. A., Parton W. J., Power A. G. & Swift M. J. (1997). Agricultural Intensification and Ecosystem Properties. *Science* **Vol: 277** (5325) pp504-509.

McKenna, T. (1992). *Food of the Gods*. Bantam Books, New York, USA.

Meadows, J. (1987). *The Great Scientists*. Equinox, England.

Mollison, B. (1988). *Permaculture, A Designers' Manual*. Tagari Publications. NSW, Australia.

Mollison, B. (1991). *Introduction to Permaculture*. Tagari Publications. NSW, Australia.

Mollison, B. (1994). *Introduction to Permaculture 2nd ed*. Tagari Publications. NSW, Australia.

Mollison, B. (1996). *Permaculture - A Designer's Manual 2nd ed*. Tagari Publication, Australia.

Mollison B. (1999). *Permaculture Two: Practical Design for Town and Country in Permanent Agriculture* (First published 1979). Tagari Publications. NSW, Australia

Moos, H. (1997). *ØKO-ideologi NEJ TAK*. Borgen, Copenhagen.

Mougeot, L. (2000). "Urban Agriculture: Definition, Presence, Potentials and Risks." *Growing Cities Growing Food; Urban agriculture on the Policy Agenda.* Consultants in Development Programmes (ETC) Taken from: http://www.ruaf.org/reader/growing_cities/Theme1.PDF

Møller, B. L. (2004). *Hvordan bevarer vi romantikken*? Orally presented at KVL conference 'Rigtige forskere har respekt for naturen – men kan de formidle den?', 21st of April 2004. Unpublished. Email for correspondence: <blm@kvl.dk>.

Munkstrup, N. & Lindberg, J. (1996). *Urban Ecology Guide.* Danish Town Planning Institute. Copenhagen, Denmark.

Munro T., Cook H. & Lee H. (2002). Sustainability Indicators Used to Compare Properties of Organic and Conventionally Managed Topsoils. *Biological Agriculture and Horticulture*, **Vol: 20**. pp 201-214.

Newman, E. I. (2000). *Applied Ecology & Environmental Management*. 2nd edition. Blackwell Science, Oxford, UK.

Niemczynowicz, J. (1999). Urban hydrology and water management – present and future challenges. *Urban Water 1.* pp1-14.

NRC. (1989). *Alternative Agriculture*. National Research Council – Committee on the Role of Alternative Farming Methods in Modern Production Agriculture, Board on Agriculture. National Academy Press, Washington DC, USA.

Organization for Economic Co-operation and Development (OECD). (2004) *Selected Environmental Data.* OECD Environmental Data Compedium. Taken from: http://www.oecd.org/dataoecd/11/15/24111692.PDF

Payne, S. (1991). "Ecology in the City". *Permaculture International Journal*. Issue: 40 pp16-19.

Payne, S. (1998) "Save the Backyard." *Permaculture International Journal.* Issue: 66 pp8-9, 24.

Pedersen, S. Personal Communication. 10 May 2004. Munkesoegaard 50, Himmelev, Roskilde

Penfold C. & Miyan M. (1998). *Organic Farming - Now and the Future*. University of Adelaide, Roseworthy. *In* Proceedings of the 9th Australian Agronomy Conference, Wagga Wagga.

PIJ. (1992). Jerome Osentowskis' Organic Farm, *in Permaculture International Journal.* Issue No: 44 June-Aug 1992.

PIJ. (1999). *Permaculture International Journal: 21st Birthday Edition - Sustainable solutions from the city to the wilderness*. Issue **No: 72** Sept-Nov 1999.

Pujol, T. (2002). The consequence of Maximum Thermodynamic Efficiency in Daisyworld. *Journal of theoretical biology* **Vol: 217**, pp. 53-60.

Schlosser, E. (2001). *Fast Food Nation – the dark side of the all-american meal*. 1st edition. HarperCollins, USA.

Schumacher, E. F. (1973): *Small is beautiful: Economics as if People Mattered.* Harper Torchbooks, New York.

Sherriff, G. & Howe, J. (2002). "Tackling Permaculture in the U.K." *Urban Agriculture Magazine* March 2002. Taken from: www.ruaf.org/newslgen_fr.html

Slumstrup, C. Personal Communication. 4 May 2004. E-mail: beboergaard@hotmail.com

Smit, J., Ratta, A. & Nasr, J. (1996). *Urban Agriculture: Food, Jobs and Sustainable Cities.* United Nations Development Programme. New York, USA.

Stein & Steward (1989). *Permakultur*. NOAH, **no. 118**, pp. 19-23.

Stewart, H. (1986). *Sustainable Agriculture for Urban Areas*. Danish Organization for Renewable Energy. Hurup Thy, Denmark.

Stone, G. *et al.* (2004). Toward the creation of an eco-oriented corporate culture: a proposed model of internal and external antecedents leading to industrial firm eco-orientation. *Journal of Business & Industrial Marketing* **Vol: 19**, no. 1, pp. 68-84.

Tilman D., Fargione J., Wolff B., D'Antonio C., Dobson A., Howarth R., Schindler D., Schlesinger W., Simberloff D. & Swackhamer D. (2001). Forecasting Agriculturally Driven Global Environmental Change. *Science,* **Vol: 292**. pp 281-284.

Tilman D., Cassman K., Matsons P., Naylor R. & Polasky S. (2002). Agricultural Sustainability and Intensive Production Practices. *Nature*, **Vol: 418**. pp 671-677.

Van der Werf, H.M.G. & Petit, J. (2002). Evaluation of the environmental impact of agriculture at the farm level: a comparison and analysis of 12 indicator-based methods. *Agriculture, Ecosystems and Environment* **Vol 93**: 131-145.

Von Wirén-Lehr, S. (2001). Sustainability in agriculture – an evaluation of principal goal-oriented concepts to close the gap between theory and practice. *Agriculture, Ecosystems and Environment* **Vol 84**: 115-119.

Whitefield, P. (1996). *Permakultur i en nøddeskal. 1st edition*. Permakultur foreningen Danmark, Copenhagen.

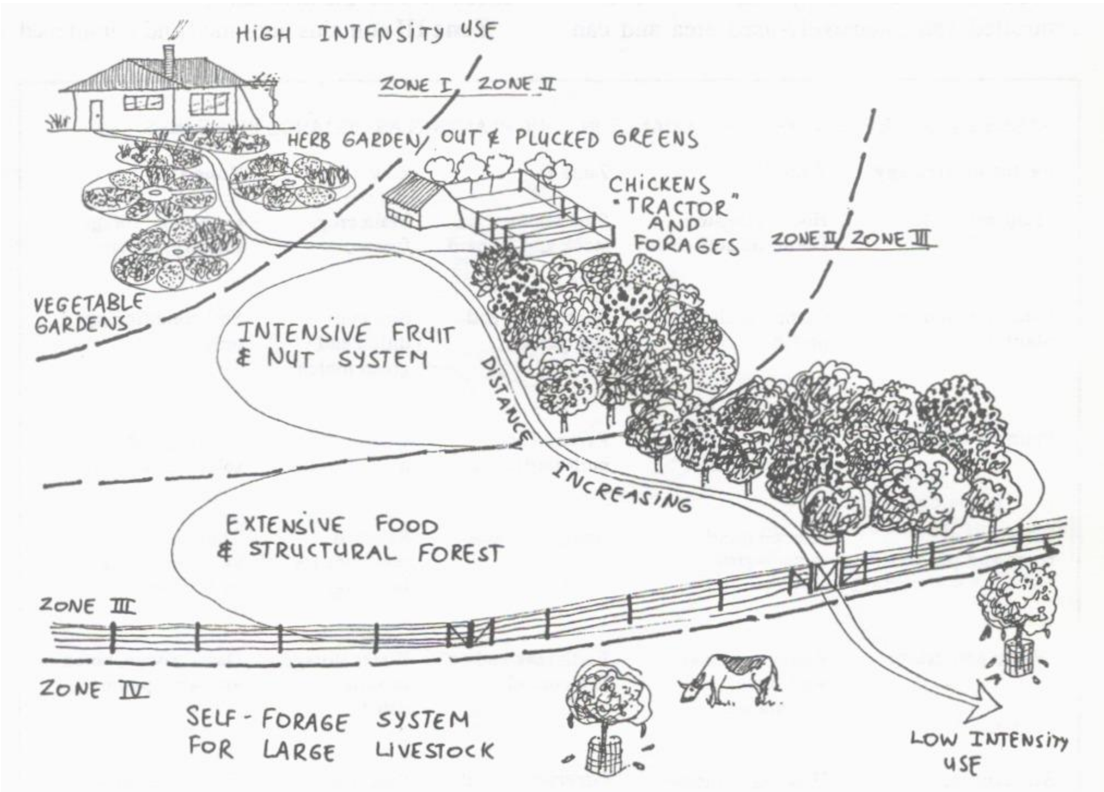
Whitefield, P. (1997). *Permaculture in a Nutshell*. Permanent Publications, Hampshire, England.

WHO Regional Office for Europe Programme for Nutrition and Food Security. (2001). *Urban and Peri-Urban Food and Nutrition Action Plan.* http://www.who.dk/document/e72949.pdf

Zwaan, M. Personal Communication. 17 May 2004. Telephone number: +45 33 31 30 48. Website: http://www.byhavenetvaerket.dk

Appendix A. Permaculture design for a farm

(from Introduction to Permaculture, Mollison, 1994)



Appendix B. Small breakthroughs into Danish Sustainable Agriculture

1. The green wastewater treatment system of the *Folkecenter for Renewable Energy*

The Folkecenter for Renewable Energy is situated in Hurup Thy, Jutland. It aims at diffusing information about renewable energies and the environment, and has some demonstration infrastructures. One interesting structure was the wastewater treatment system, which has not been observed on Permaculture farms, but could eventually be implemented to improve water conservation and nutrient cycling (Figure A-1).

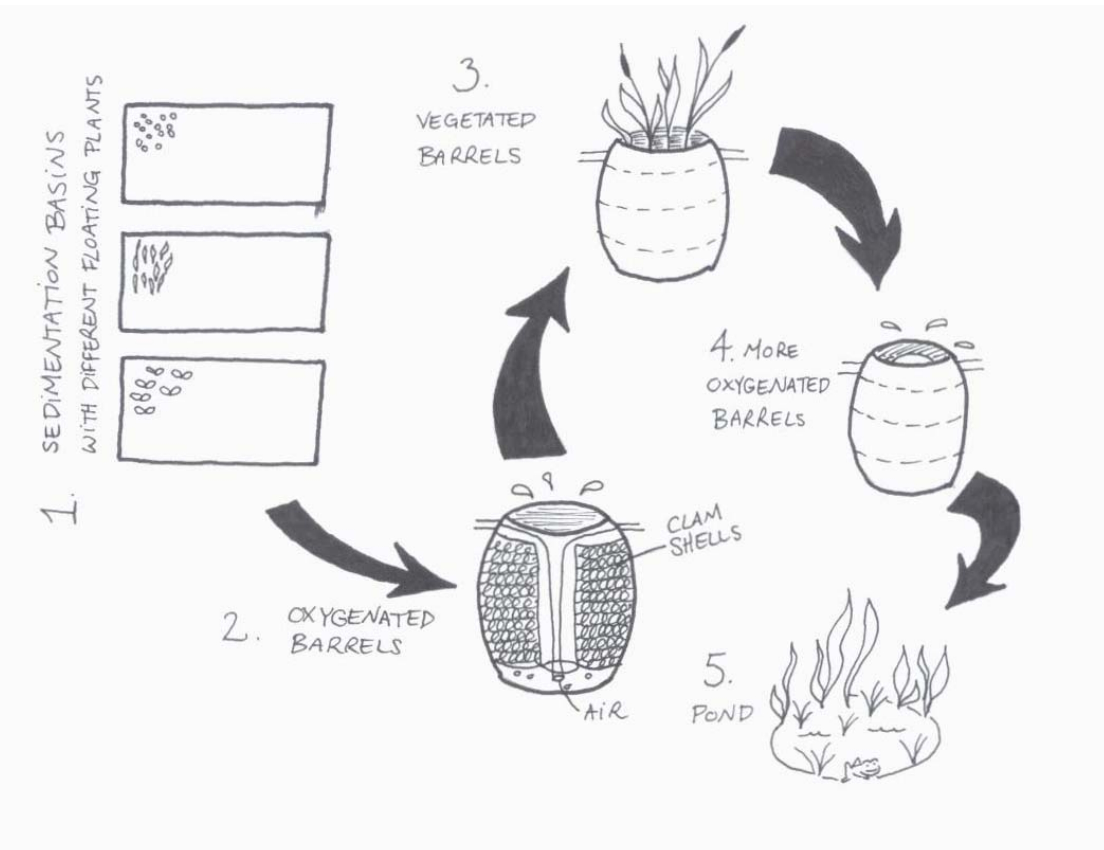


Figure A-1. One of the green wastewater system observed at the *Folkecenter for Renewable Energy* in Jutland.

The water is pumped into the system, where it gets cleaner as it goes through the different steps. The last pond with the frogs shows that the water is ready to be drained into the immediate environment.

The center also has demonstration structures for engines working on rapeseed oil.

2. The heat pump system of Jørgen Larsen, organic cattle producer

Jørgen Larsen is a small organic cattle producer near Holstebro, Jutland. He has an interesting system for heating his house, which could be a relevant option with regard to Permaculture design of farm with many large animals.

Basically, the cold water is pumped into pipes situated inside the cow shed, above the animals. The plumbing is made so that the water circulates for a long time inside the building. The heat released by the animals is transferred to the water, which is then directed toward the house for heating (Figure A-2 and A-3).

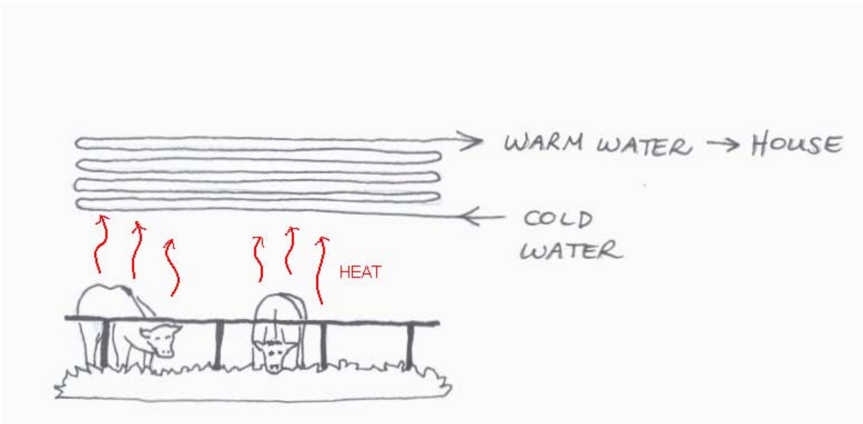


Figure A-2. Heat pump system principle.

Figure A-3. Jørgen Larsen's cow shed.

The pipes for water can also be installed in the concrete under the straw bedding. The heat from the composting (microbial activity) is transferred to the water. Another group of students in our have gone further in studying the use of renewable energies on farms (Breton *et al.*, non-submitted project).

Appendix C. Examples of Urban Permaculture in Denmark

Figure AC-1

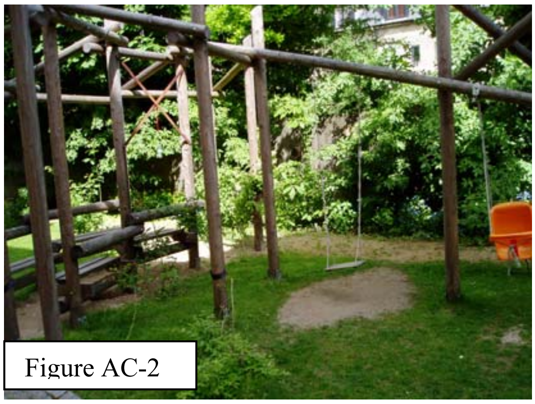


Figure AC-2

Figures AC-1 and AC-2: Permaculture garden in the courtyard of a Thomas Lauds Gade apartment complex in Copenhagen.

Note the use of piping to direct water from the roof troughs to the pond in Figure AC-1 and the jungle gym for children in Figure AC-2.

Figure AC-7: The community garden at Enghave Plads in Copenhagen gives locals the opportunity to garden in a Permaculture-designed setting

Figure AC-8: The garden at a school on Kapalvej is forced to evolve (away from the Permaculture ethic?) because of changing management.

Figures AC-3, AC-4, AC-5, and AC-6: Munkesoegaard Eco-village in Himmelev, Roskilde.

Figure AC-3: Solar panels provide energy for heating one of the common buildings.

Figure AC-4: A wetland on-site provides a habitat for diverse species.

Figure AC-5: A sculpture based on Nordic mythology reflects the Eco-village's culture.

Figure AC-6: A windmill pumps water for the gardens.

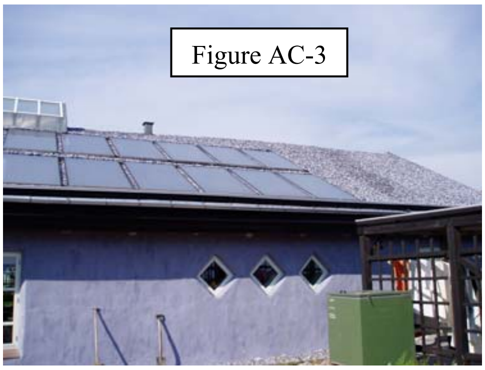


Figure AC-3

Figure AC-4

Figure AC-5

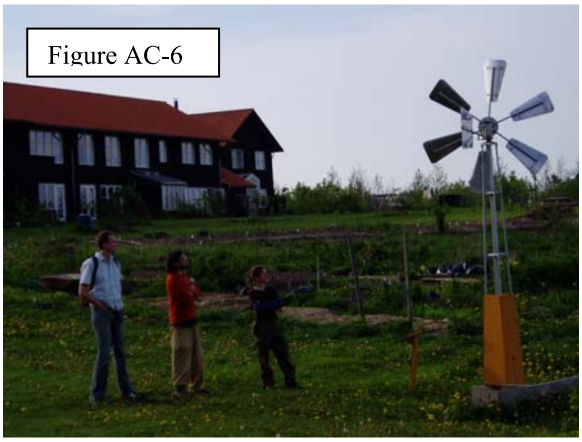


Figure AC-6