THE ECO-UNIT: an ecomimetic settlement as a basis for sustainable development. Experiences in Sweden and Brazil.

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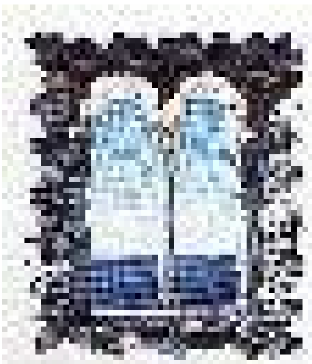

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Introduction

After 350 years of mercantilism, industrial capitalism and neoliberalism, practically all the ecosystems became human-dominated systems.

They became depend on:

1. Fossil fuels,
2. Unfair payments of human work,
3. Very rapid extraction and use of natural resources far away from their recovering time and no concern with bio-stocks losses .
4. Destruction of human values embodied in social structures, as the access to natural resources, (absolutely no concern with social costs).

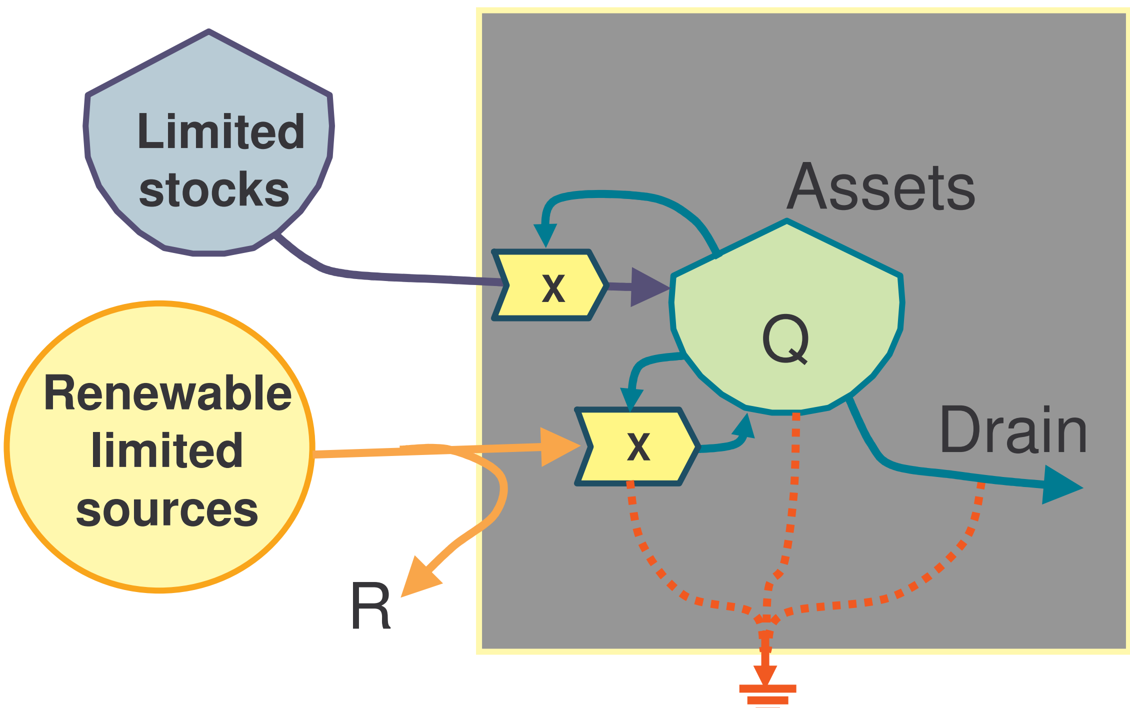
New scenery!

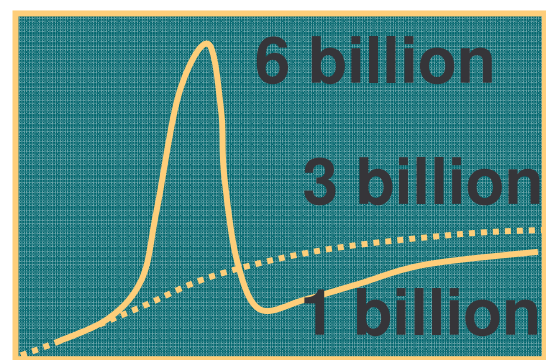
Oil extraction peak:

oil gets more expensive and ecosystems services and social standards decline rapidly.

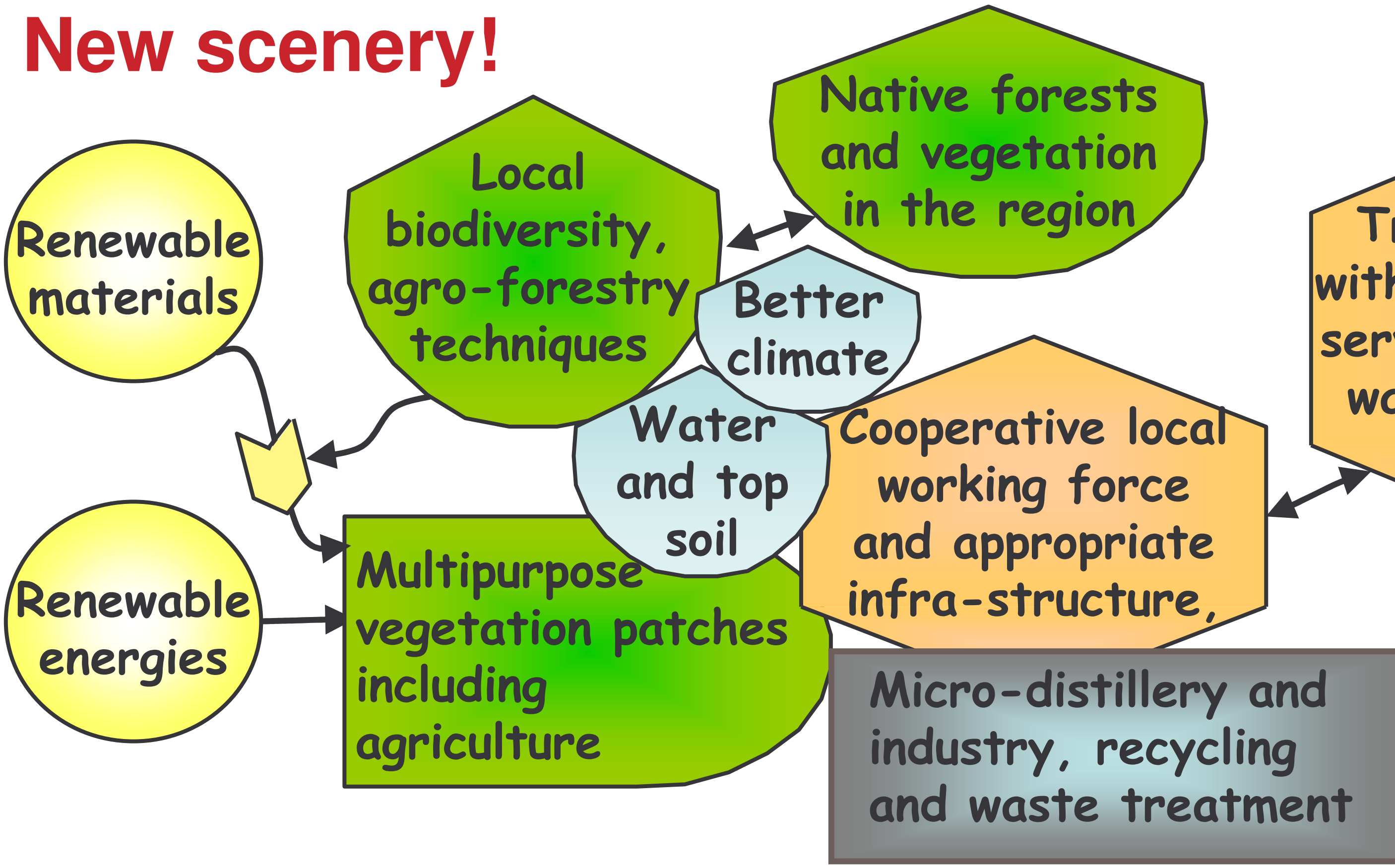
Earth collapse:

The global human system shows signs of possible collapse, which calls for innovative processes.





New scenery!



New models of production and consumption:

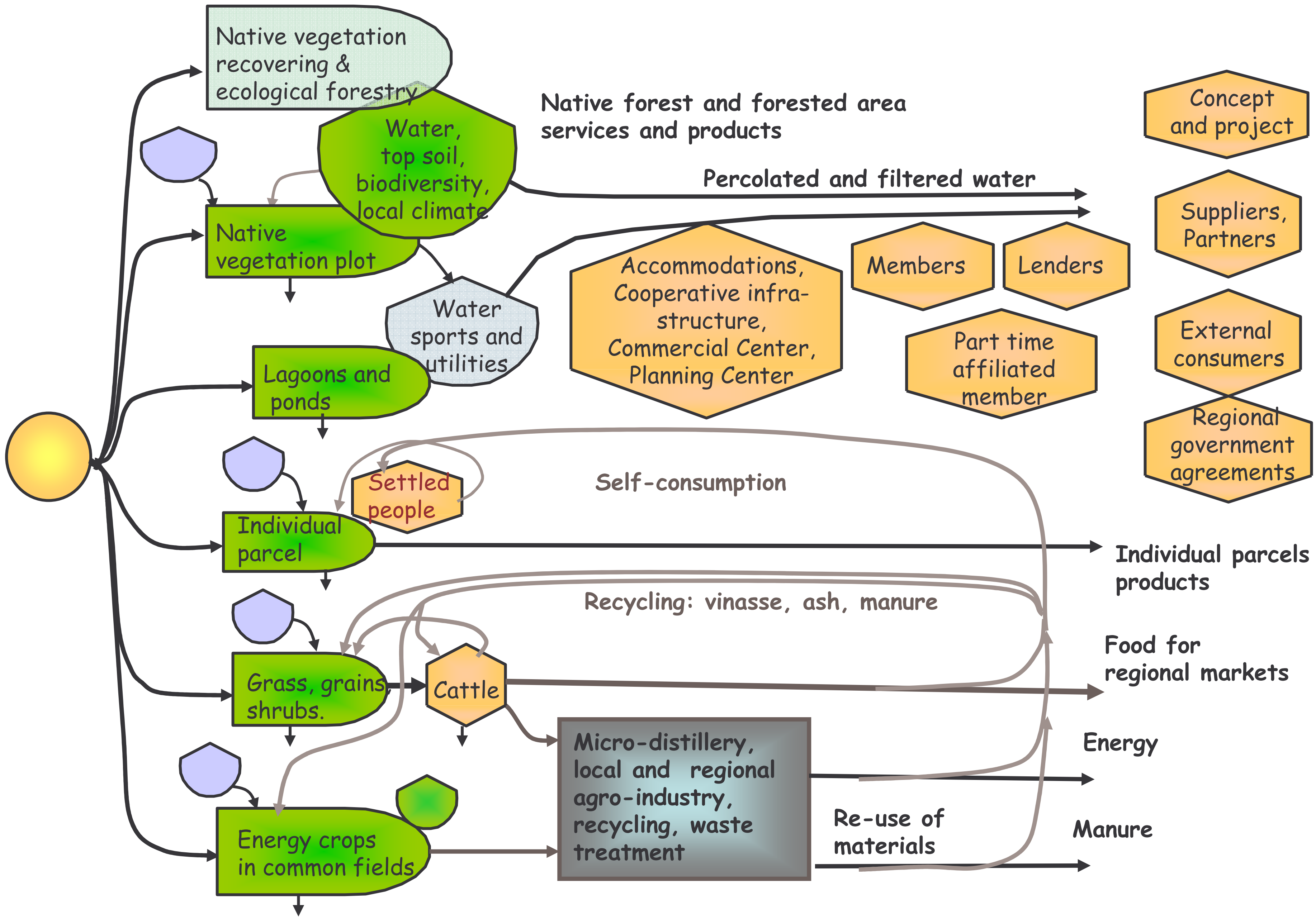
'Eco-units' is a new concept of urban and rural organization. Settlement as this are on development in several countries with different approaches.

Basically, Eco-unit is a rural enterprise that embodies:

complementary ecological and biophysical economy principles and objectives

by establishing a net of local technical and political arrangements

to provide economic feasibility and sustainability through self-sufficiency and regional interactions.



Native vegetation recovering & ecological forestry
Water, top soil, biodiversity, local climate
Native forest and forested area services and products
Percolated and filtered water
Concept and project
Suppliers, Partners
Native vegetation plot
Water sports and utilities
Accommodations, Cooperative infra-structure, Commercial Center, Planning Center
Members
Lenders
Part time affiliated member
External consumers
Regional government agreements
Lagoons and ponds
Settled people
Self-consumption
Individual parcel
Individual parcels products
Recycling: vinasse, ash, manure
Food for regional markets
Grass, grains, shrubs.
Cattle
Micro-distillery, local and regional agro-industry, recycling, waste treatment
Energy
Re-use of materials
Manure
Energy crops in common fields

Main strategies are:

[1] Simultaneous promotion of ecological maturity and human sustainability by establishing local cycles of nutrients and water:

(a) establishing balanced agriculture for local needs using agroecological methods;

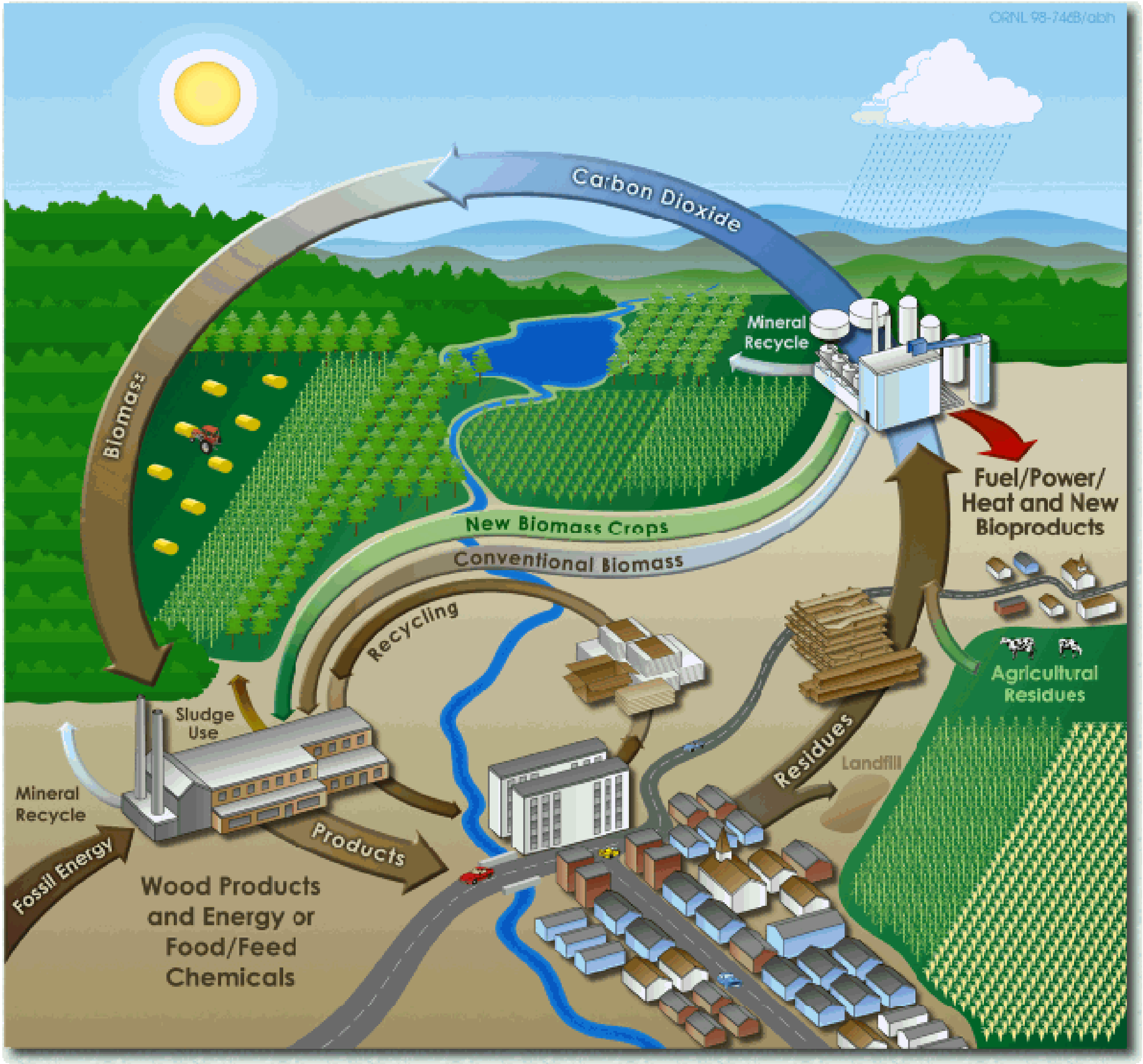
(b) water purification and recycling, using ecological engineering methods;

(c) promoting maturation of ecosystems;

[2] Establishing local, self-sufficient units to reduce vulnerability for crashes induced by shortage of cheap energy:

(a) agriculture for energy purposes (oil, ethanol) as well as for food, feed and fiber production;
(b) local production of forestry products for building, energy, nutritional and other purposes;
(c) direct capture of incoming solar radiation for heating, drying and other purposes;
(d) use of solar energy derivatives (as local water power, photovoltaics, animal draft) to replace dwindling energy resources from fossil fuels

[3] Participation in watershed planning, agrarian reform and Agenda 21 programs.



This study is aimed to relate cases and discuss methods for establishing of eco-units in **Sweden** and **Brazil**.

Bio-energy is a turning point but not the unique concern, **ecological design** will consider many factors. The raw-material for bio-fuels production will depend on local climate, soil and water resources.

It is important to study **innovative experiences** from many countries with a **common methodology** **exergy-emergy-local monetary numeraire-social indicators** to be able to compare cases and discusse estategies and policy with broad concerns (social, ecological, economical, political, cultural).

Commercial and social dimensions of Eco-Units

The Eco Unit concept addresses the challenge of maintaining quality of life and living standard for present and coming generations.

Traditional measurements like GDP and average income per person should indicate life quality is rising as the present world economy expands.

However, whilst most accept economic measures as ONE dimension of **living standard**, there is growing awareness that our present **life style** is actually eroding **quality of life**.

Several alternative value frameworks shed light on this new development.

These frameworks are made up of criteria such as:

(a) social cohesiveness,

(b) control over one's destiny and sustainable development, for coming generations as well as our own.

Max Neef's framework is a good example.

http://www.rainforestinfo.org.au/background/maxneef.htm.

These more balanced approaches to assessing progress show the downsides of maintaining our present standard of living; for every day our industrialized lifestyle continues, a more and more troublesome legacy awaits coming generations.

Populations are growing whilst signs of resource depletion point to much as half of the Earths' legacy of oil has already been used[i], water is becoming scarce[ii], and even the quality of air in cities is threatening to reduce life expectancy.

[i] Association for the study of peak oil & gas.
http://www.peakoil.net/
[ii] BBC's Planet under pressure
http://news.bbc.co.uk/2/hi/in_depth/sci_tech/2004/planet/default.stm

Natural ecosystems spontaneously change logistically towards ecological maturity

by their fundamental capacity of increasing their exergy consumption capacity.

A disturbed, or ‘young’ ecosystem fundamentally from a ‘mature’ ecosystem differ in several ways.

Those **factors** are depicted in next table.

Structural changes during the maturation of an ecosystem.

Immature ecosystems properties	Mature ecosystems properties
• Low diversity (Shannon)	• High diversity (Shannon)
• Annual plants	• Perennial plants
• Interspecific competition	• Interspecific co-operation
• Parasitism typical	• Mutualism typical
• Nutrient leakage from ecosystem	• Nutrient circulation within ecosystem
• Export (loss) of organic and inorganic material	• On-site storage and consumption of organic material
• Fast structural change	• Slow stuctural change
• Water export by drainage	• Water export by evaporation

Human societies tend to disturb the ecosystems they inhabit and thereby making them more immature.

Decreasing the maturity of a ecosystem will almost always decrease the support capacity of the system, why this is an unwise survival strategy.

However, this has not always been the case. History shows that in many societies, cultural and/or religious traditions provided people with a supportive attitude towards the ecosystem that supported them. Such **mutuality** behaviour is typical of many species in mature ecosystems.

During industrialization, fossil energy based systems have prevailed, why the solar based ecosystem support societies have been neglected, and also forgotten or misunderstood.

Fossil-fuel based industrialized cultural system differ from solar based system in that it is based on ***stocks of non-renewable materials*** (stored fossil fuels, minerals etc.). ***Bio-stocks*** (forests, animal population etc.) are treated as non renewable stocks in this context, with the resulting degradation.

Sustainable societies understands ***Bio-stocks*** as part of support ***flows*** from the ecosystems.

By developing the carrying capacity of the supporting ecosystem long-time wealth and a sense of belonging and understanding in the Max-Neef sense could be attained.

The eco-unit as part of the ecosystem

By using ecosystem development as guidelines for small scale societal development, a sustainable type of development might be attained.

Examples of ***societal developments*** that mimick mature ecosystem characteristics at a societal level are depicted in next tables.

Ecosystem mimicking characteristics in an eco-unit.

Mature ecosystems	Properties of eco-units
High diversity (Shannon)	draft animals, chicken for complementing the compost process
Perennial plants	fruit and nut trees perennial grasses for fodder pond-shores or living walls for water purification
Inter-specific cooperation	cow-pig-human horse-human human-chicken chicken-compost worm-fertile soil-human food tree - fruit- fungi - human - tree

Mutualism typical	medical plants milk production brewing bee-keeping grey water purification by plants and micro-organisms in pond or wall systems: purified water returned
Nutrient circulation within ecosystem	balanced agriculture (animal living of plants produced with their manure) urine and faeces returned to agriculture

On-site storage and consumption of organic material	plant biomass returned as soil ***terra preta*** formation with charcoal production from gas generators food production for local use
Slow stuctural change	incremental changes, traditions
Water export by evaporation	“living-wall” systems for food and water purification continuous plant shield avoidance of naked soil soil shielding crops

The system that produces our **way of life** is characterized by a linear, industrial approach [i], it needs a continuous economic growth in order to survive.

It demands a huge one-time consumption of basic resources and it stresses ecosystems [ii].

[i] The linear approach is described by Folke Günther. Specially the flow of phosphorus, essential for agriculture. http://www.holon.se/folke/kurs/Distans/Ekofys/Recirk/Eng/phosphorus.shtml

[ii] Millennium Assessment of the state of ecological systems http://www.millenniumassessment.org/en/index.aspx

Future generations may find themselves in a densely populated world, with ecosystems in such a state that food and water will be hard to produce and lacking easily available energy resources to address these issues.

This capitalist system is reinforced by the choices we made as individuals about where we work - what kind of business we commute to and work in - about the kind of house we invest in and where we regularly get our food and shopping.

All of these choices cement the current infrastructure and put the individual’s own livelihood at risk when energy depletion means supply can no longer meet demand [i].

As urbanization continues, other downsides become apparent, as lifestyles give rise to more stress related illnesses and loss of feeling of closeness to nature.

[i] Richard Heinberg. Powerdown
http://www.museletter.com/Powerdown.html

In this light, conventional investments can only be seen at best as short term.

For example, few would want to invest in a petroleum refinery against the background of dwindling oil supplies.

Likewise, investment in nuclear power seems dubious when it takes 20 years to reach break even, and there may only be 30 years of uranium left of the Earth’s endowment.

There is, therefore, a need for alternatives, which

1. Increase resilience towards rising energy costs
2. Estimulate the development of ecological maturity in the geographic area that the investment encompasses.
3. Offer to each individual the possibility to be involved in readdressing the direction of development towards a sustainable way of life.
4. Reduce stress, and offer a experience close to nature.

Operational models for Eco-units can be evaluated against these criteria.

SWEDISH CASE

One possible model for Eco Units is cooperative ownership, based loosely on the **Swedish Tenant owner cooperative housing model** [i] (fig 1).

Here an economic association is set up with the purpose of promoting the economic interests of its members by providing housing, food and business framework in a setting giving an experience of closeness to nature.

[i] EU refers to models like this as Social Economy.
http://europa.eu.int/comm/enterprise/entrepreneurship/coop/index.htm

The cooperative owns a plot of land which includes farmland, the farm and housing as well as areas for water recycling and energy capture.

Members join the cooperative by purchasing a share. Then, food and housing are provided in return for a monthly service charge.

Extra services are available, like the use of business premises or other resources for leisure activities like boats, canoes, bicycles.

Members can either work on food growing or in other areas of the cooperatives activities, for example in running a child day-care centre.

The work in the cooperative would result in a reduction of the service fee.

Members are expected to offer 120 hours a year [i] in participating in the running of the cooperative by working on the board or with common activities like spring and autumn clean ups or on the farm.

[i] This represents just 7.5% of a normal working year, an estimated 50% of the average number of leisure hours per year.

The attractiveness of investing in this way is that the better the energy capture and farm work, the more food and energy produced, the more resilient the investment is against rising energy costs.

The share in the cooperative should be worth more as the unit is able to reduce reliance on the electricity and water grid.

The same for food. As the farm section is developed, and less and less food needs to be bought from outside, the more valuable the return on investment becomes.

In terms of the ecological maturity of the area, the less leakage of nitrogen and phosphorus from the area, the more is retained for food growing, and less artificial fertilizer is needed.

The advantage of this kind of ownership model is that the individual's involvement in the running and management of the cooperative will directly affect both the financial performance and its ecological maturing.

The model was presented to the Cooperative Development Assistance Bureau in Stockholm for evaluation and preliminary evaluation was carried out.

Preliminary results:

- A cooperative producing and consuming its own food and housing fits in with current models of cooperative ownership where the purpose of the organization is to further the members' economic status by providing low cost housing and food.

- There were some concerns about the contribution of the eco unit to the municipality, as the unit would not need to pay taxes for garbage removal and water rates. On the other hand, the unit would contribute tax via each individual's taxation and property tax.

- That members’ food was slightly cheaper than buying at the local supermarket is regarded as providing healthy free market competition.
- On the question of being employed in one’s own business, employed by the cooperative or simply part of a system that shared the products of the cooperative among its members, it was unresolved what the tax status would be. More voluntary activities would result in the rights to more service from the cooperative, perhaps in the form of reduced monthly fee. In a tenant cooperative the reduction in service fee is seen as remuneration for employment and liable for both employer’s tax and personal taxes.

- In principle a points system could facilitate a fair distribution of the cooperatives resources. For example, each owner could receive a certain number of points a year, and these could be used on common shared resources like a car pool, leisure activity equipment like piscina, sauna, canoe, bicycle, and gym. Some voluntary work behind the obligatory 120 hours per year (for example, growing flowers for communal use, or making jam from locally picked berries) could give a larger entitlement.

- The main advantage of sharing resources is that they are used much more effectively and a far higher level of eco efficiency is reached along with utility. By sharing the resources, residents can enjoy a higher standard of living without having the investment if they were to try to own each individually.

- Where the points system meets possible barriers is when, say, working in the farm could reduce the monthly fee to zero. At this point, the market value of housing and food should be seen as wages and the recipient expected to pay social costs and personal taxes.

The model was also explored from the point of view of pensions and housing association. One possibility is for a pension fund to invest in the unit in return for providing housing for pensioners.

The fund investor would, on retirement either “cash in” to move into special accommodation in the eco unit or sell their entitlement on the open market. In the same way, saving in the “building society” could entitle the saver to rented accommodation on the unit, and when they had saved enough, could buy a share in the cooperative.

The cooperative model also presents challenges:

Governance:

By definition, the cooperative is democratically governed. At the same time it has several different areas of activities.

To get all of these different interests to work together may prove difficult. One suggestion is to set up separate cooperatives for the various functions so that members can be actively involved in the areas that best fit their situation and interest.

Balancing the purpose envisioned by founders and the day to day concerns of the residents.

Defining the Eco Unit too closely would subject residents to a strict regime.

Defining it too loosely, either the purpose is not achieved or the concept does not work.

Balancing this fine line is not easy.

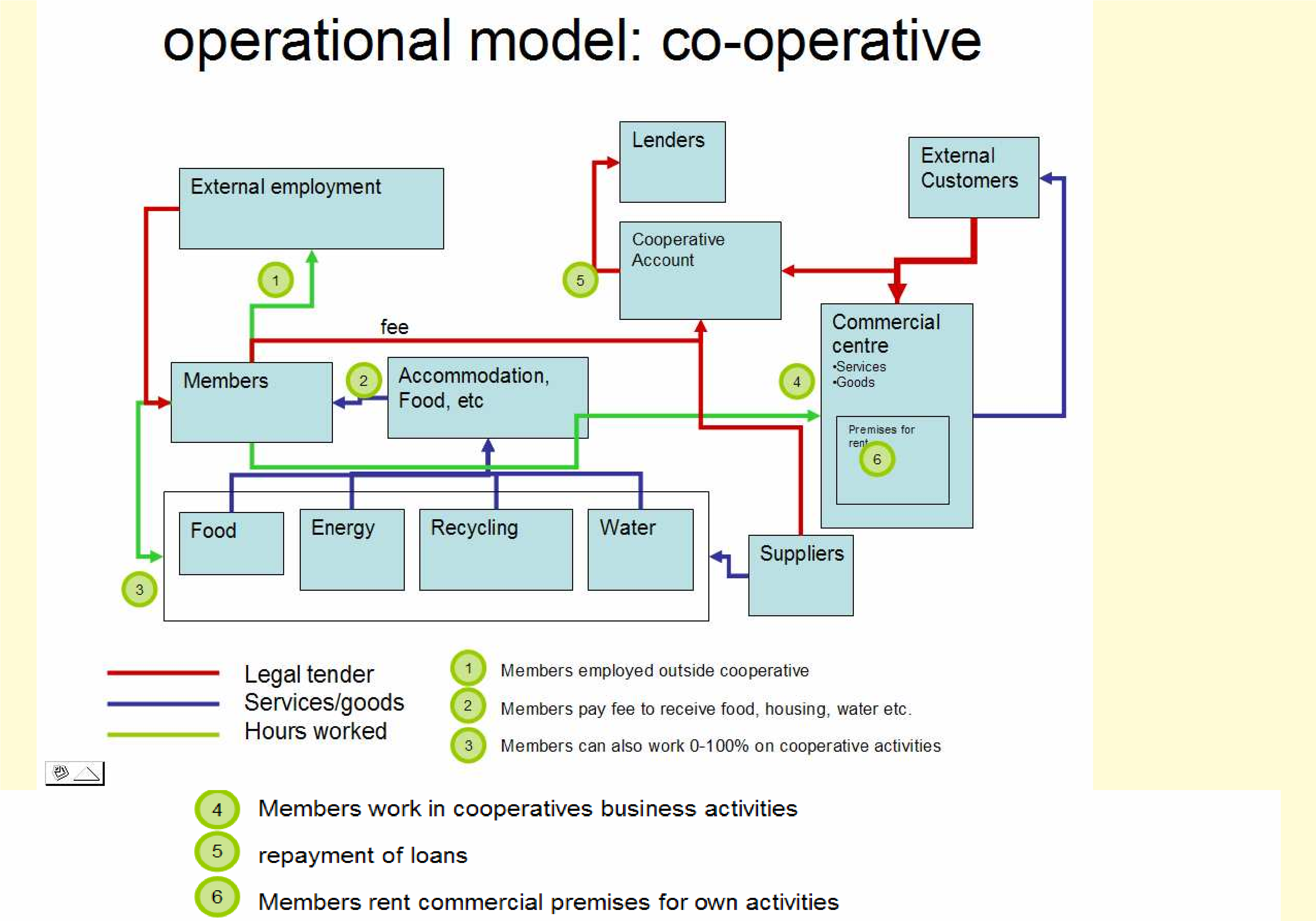


Figure 1. Swedish Eco Unit Model.

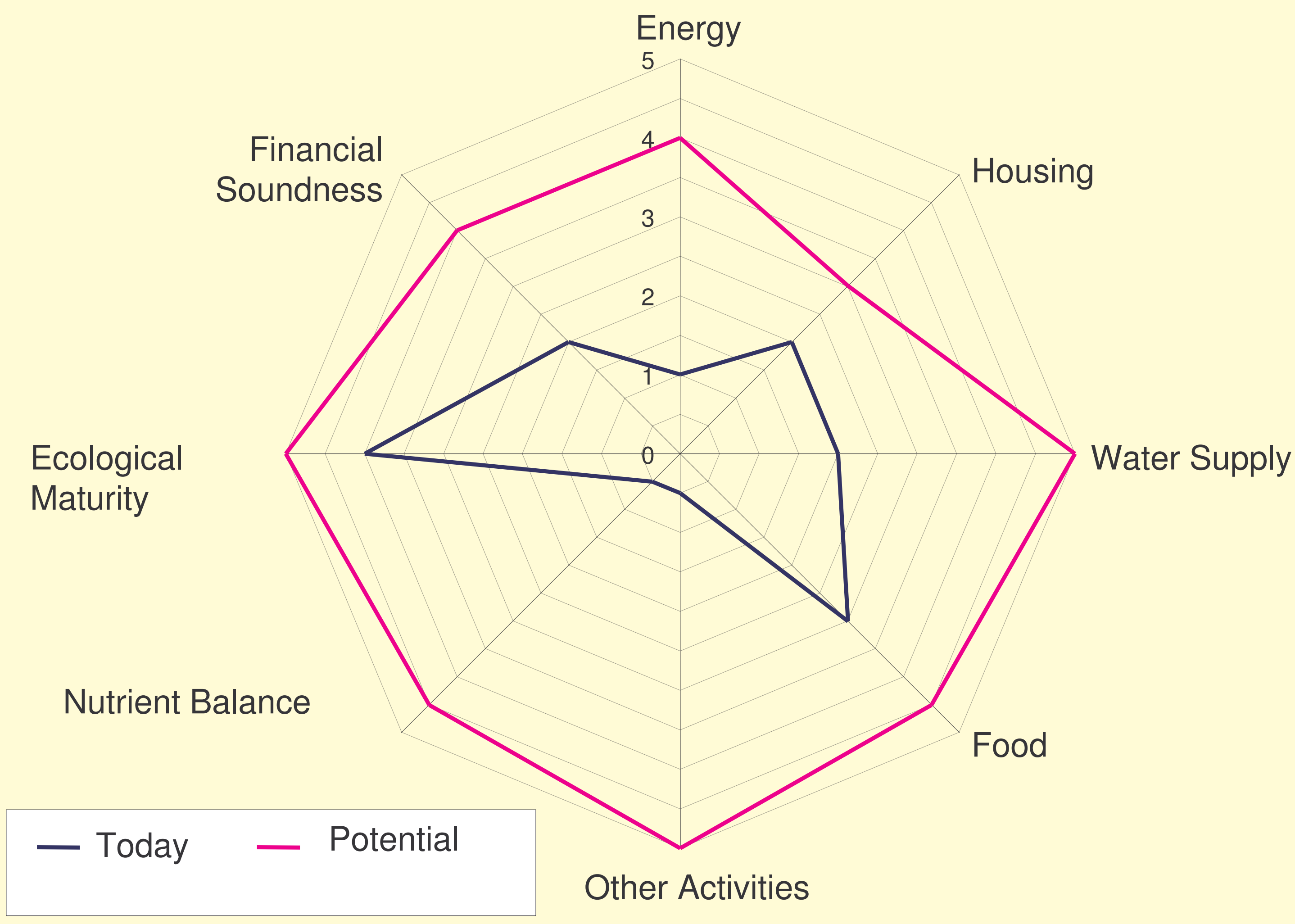
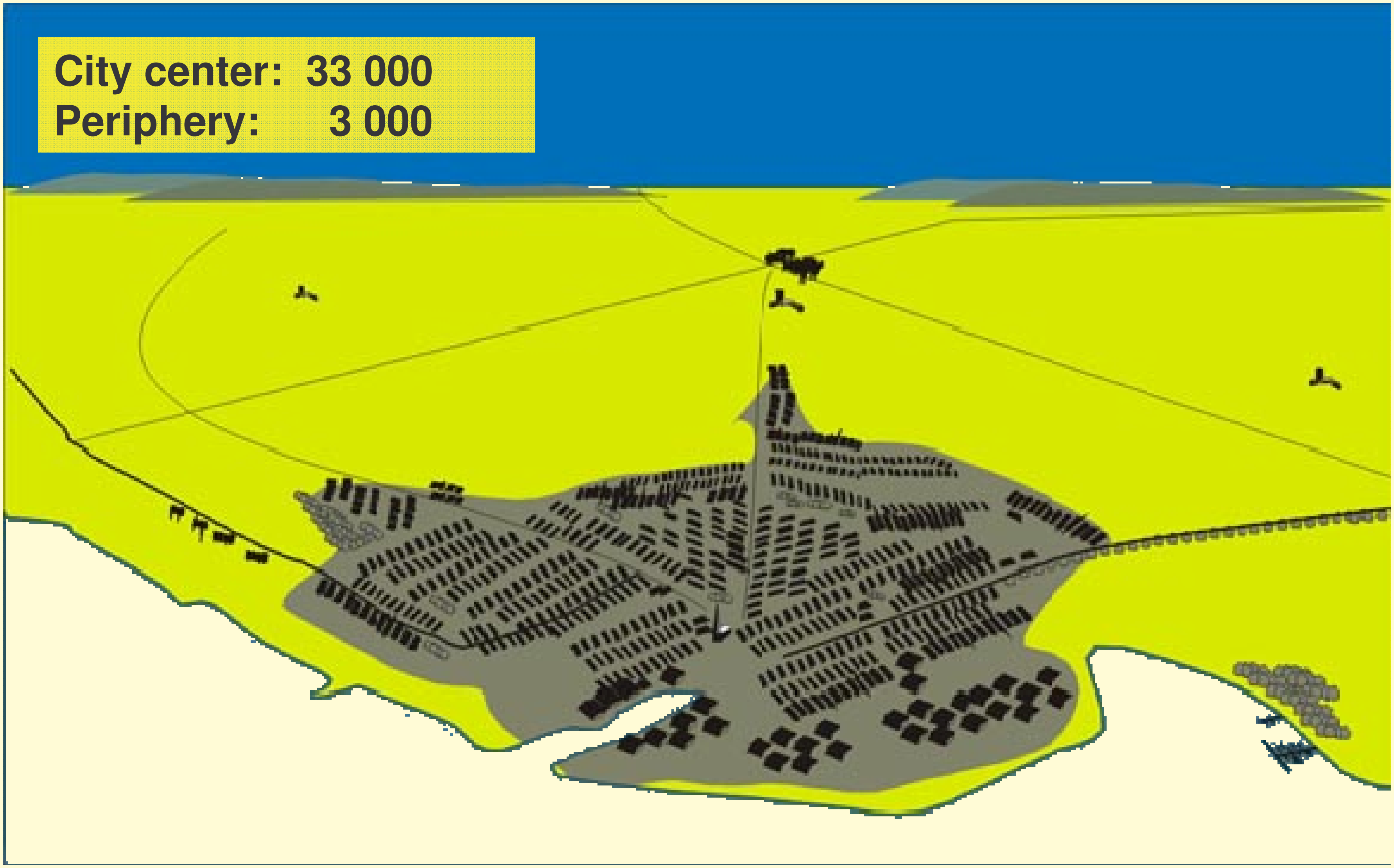
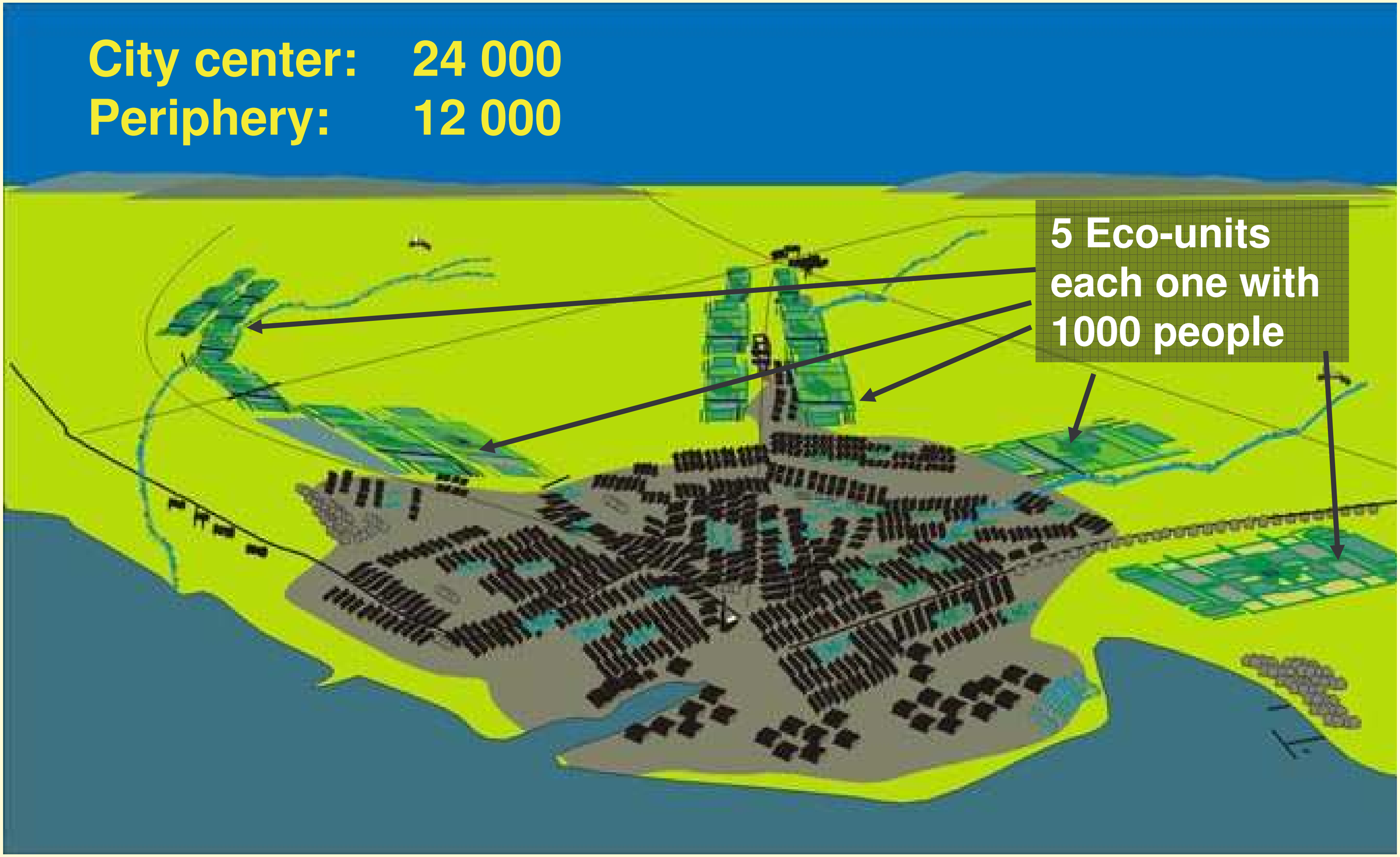


Figure 2. Exploring the potential of areas of Eco Unit.

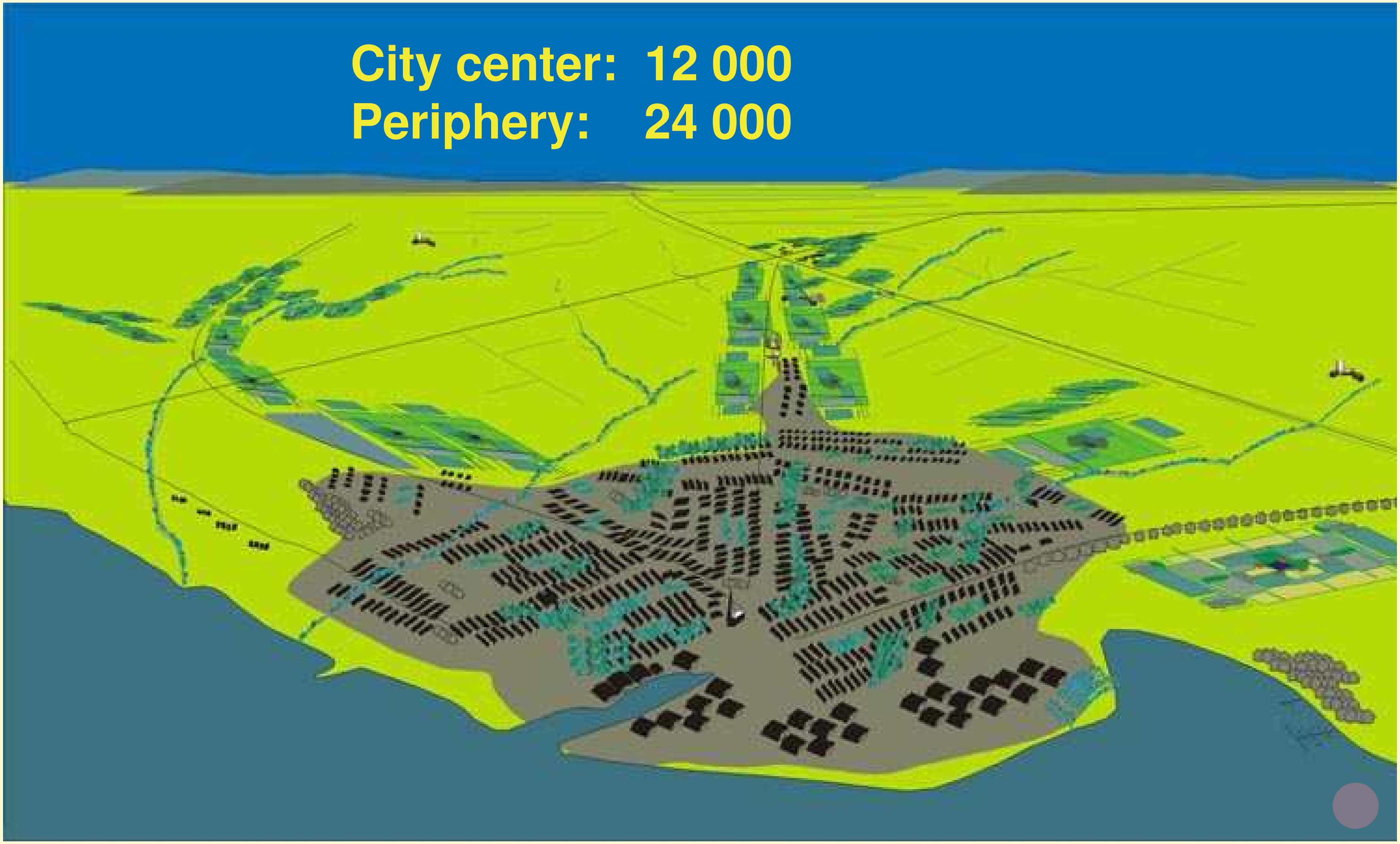
Ruralization scenery – initial point



Ruralization – after 2 years



Ruralization – after 25 years

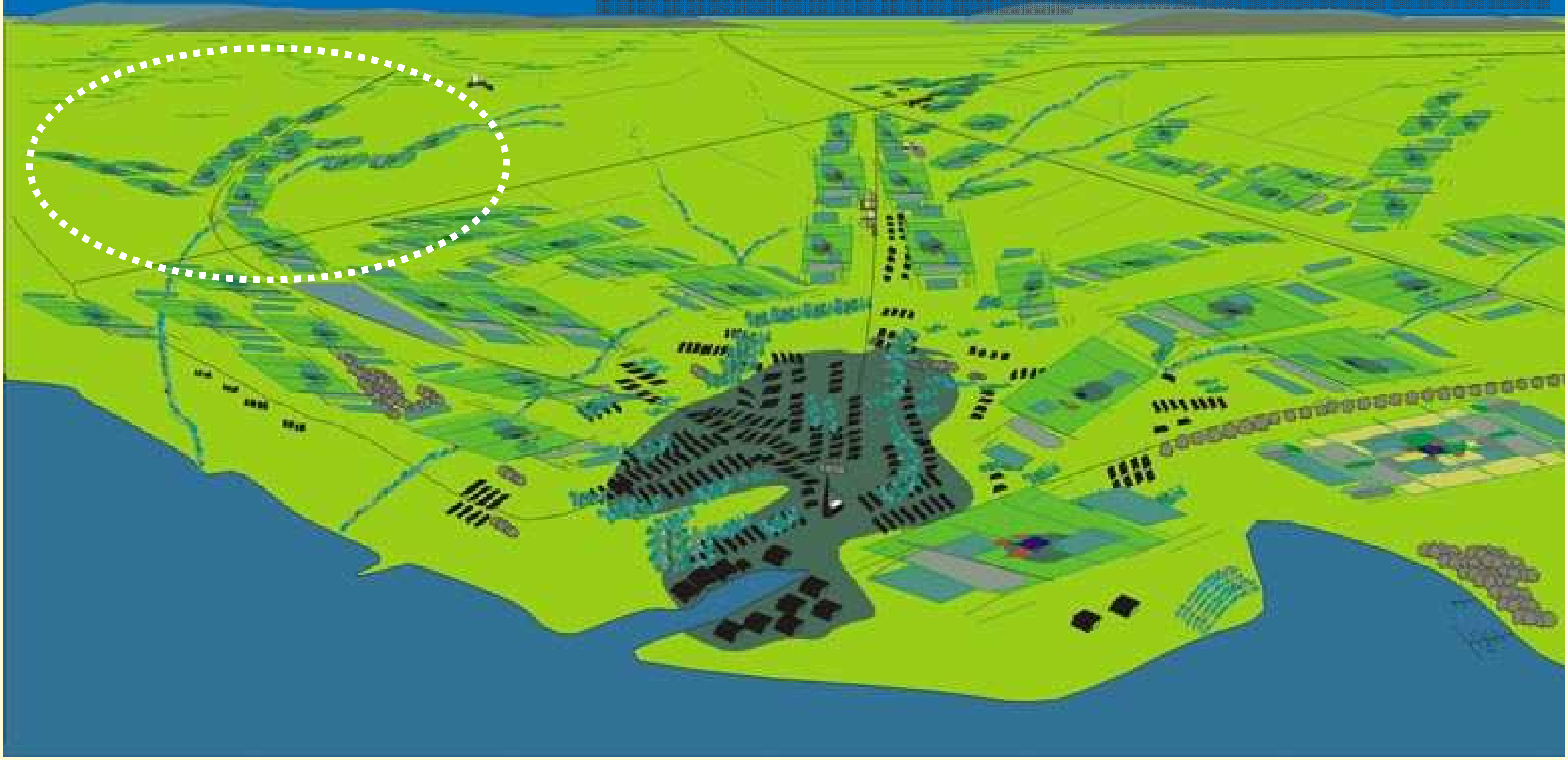


Ruralization after 50 years fits Agenda 21 goals

City center: 3 000
Periphery: 36 000

- High diversity
- Perennial plants
- Cooperation
- Nutrients circulation

- Local consumption
- Improved water flow
- Slow changes
- Cohesiveness



ETHANOL PRODUCTION ALTERNATIVES IN BRAZIL

Brazil had, for many years, a deficit in petroleum and today it has a temporary surplus. According to forecasts, the global reserves will be exhausted in three decades and price will keep growing up.

The biomass fuels can constitute an alternative for "greenhouse effect" [Cerqueira Leite, 1988, 2006] and new economic model [Vasconcelos and Vidal, 2002]. It is necessary to elaborate in each country a energy self-sufficiency plan.

However, to be viable for the long run, the planning should consider the ecological and social aspects of energy supply [Wiesner, 1984; Minc, 1987; Ortega, 1987; Bacic, *et al*. 1988].

In the 70's, whem Pró-alcohol was implanted in Brazil the big plants option (120 000 liters/day or more) was choose even other possibilities exist [Bueno, 1980]; as result there were rural exodus, native forests and diversified farm land occupied by sugar cane plantations.

The preference for great scale resulted in land ownership concentration, pollution, decrease of soil fertility and biodiversity, loss of interaction within livestock and agriculture [Paschoal, 1983; San Martin, 1985].

The choice also affected the atmosphere due to CO_2 emissions by direct and indirect use of fossil fuels).

Scales and social-political models.

Modality of organization for ethanol production	Farming area (ha). Tons of cane per day (TCD)	Liters of ethanol/day MegaWatts of electricity / year
Actual model with high concentration of land ownership and distribution of negative externalities	40 000 ha 5000 TCD	5 000 000 l / day ~730 000 MW / year
New proposal with partial environmental adjustment	4 000 ha 500 TCD	500 000 l / day 73 000 MW / year
New medium size rural establishments	400 ha 50 TCD	50 000 l / day -
New intermediate size rural establishments	40 ha. 5 TCD	5 000 l / day -
New small rural establishments	4 ha. 0.5 TCD	500 l / day -

The study of the production of alcohol in small scale was topic of scientific interest for several researchers of many research institutions and also of private enterprises.

Many small autonomous distilleries were installed in several places of the State of São Paulo [Folha de São Paulo, 1985].

Special prominence deserve some more integrated projects or ideas, as that of Jundiaí [Solnik, 1984] and São Carlos [Corsini, 1981].

At that time, appeared a new concept of alcohol production as an integrated system with production of food, forage for bovine cattle, biogas, biofertilizers, with utilization of residues as vinasse and spare pulp in other industrial activities that could increase profitability [La Rovere and Tolmasquim, 1984].

After the oil embargo crisis the oil price felt down and micro-distilleries were disassembled, because they could not compete with a fuel of high quality with a extremely low price. The oil price is artificially maintained at very low levels to subsidize the global industry.

But as petroleum shows to be a finite resource that causes a great impact on nature, society and atmosphere, research on integrated mini-systems is now retaken in many countries.

In the first decade of this new century the situation lived during the 70´s is being repeated, however affecting still larger rural areas. The new pro-Alcool could be 10 times bigger!

The critical reflections of scientists and social movements on the unfair economic model an also the implications of chemical agriculture on climatic of changes are not considered until now.

Estimatives of environmental benefits and costs.

Measured of Effect	Ecological model US$/ha/year	Chemical model US$/ha/year
Maintenance of rural jobs, one in 10 ha (one wage) against one in 300 ha (two minimum wages) [14].	180,00	12,00
Social problems in cities periphery: infra-structure and services, drugs traffic, criminality, etc. [00].	0	-30,00
Soil formation [17].	0	-13,60
Accumulation of sand in rivers [20].	0	-83,00
Maintenance of the covering and biodiversity [17].	0	-4,00
Generation of climatic of changes: carbon dioxide, nitrous of oxide methane [03][17].	-10	-60,00
Percolation of water in forests, water filtration in swamps, river water quality preservation [01].	180,00	22,50
Water pollution problems [17].	0	-39,70
Rural life quality and landscape esthetics preservation [20].	3,7	0
Ecosystem destruction (forest, savannah): soil and biodiversity replacement costs [14].	0	-98,38
Health problems provoked by pesticides [17].	0	-0,20
Total	353,70	-303,38
Difference	657,00	

Value estimative of social, military and ideological forces.

Measured of Effect	Ecological model US$/ha/year	Chemical model US$/ha/year
Preservation of the national sovereignty	?	0
Destruction of national social structure [15]	0	300,00
Total difference	957,00	

Until now, the inclusion of these additional benefits and costs has not been made, probably by lack of knowledge of the real values of externalities.

It is a hidden subsidy to the great land owners (the so called “scale economy”).

If those values were counted in the alcohol enterprises, it would be possible to discover that economic profit disappears and notice that integrated ecological agriculture systems with small distilleries can be economically viable in facilities of small (100, 1000 liters/day) and medium size (5000-20000 l/d), that we will refer as "micro" and "mini-distillery", respectively.

A network of small integrated ecological distilleries can generate a profitable self-sufficiency energy program, if there were training of labor, self-sufficiency of foods and support for ecological agriculture, forestry, livestock husbandry, and decrease of use of toxic chemicals.

In this case, technology can be applied with technical viability, social commitment, economical profitability and ecological sustentation [Sachs, 1988].

Case study

The farm “Fazenda Jardim” in Minas Gerais, has a micro-distillery developed by his proprietor (Marcello Mello) working since 2002. It has 300 ha; however the alcohol micro-distillery system occupies only 20 ha. From those 20 ha, sugarcane occupies only 3 ha, a native forest area 10 ha, a diversified plantation (banana, eucalypt and orchard) occupy 1 ha and grazing land for cattle 6 ha.

Diversified occupation of contributes for a good value of sustainability, for the preservation of quality of atmosphere and existence of water springs.

Figure 2 show details of the alcohol micro-distillery.

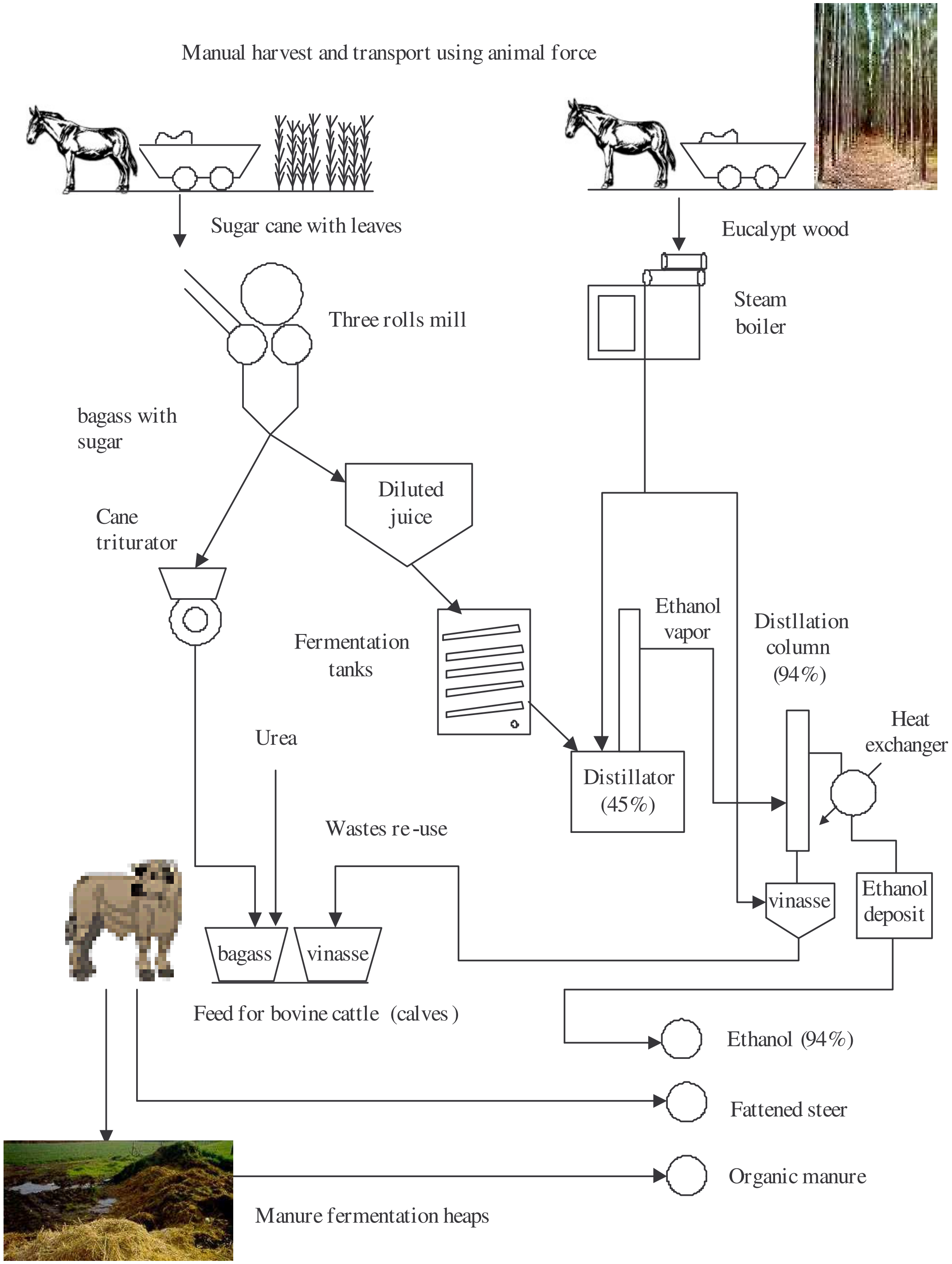


Figure 3. Flowchart of an alcohol micro-distillery.

Fig. 3a. Farm landscape.

Fig. 3b. Micro-distillery and facilities.

Fig. 3c. Extraction equipment.

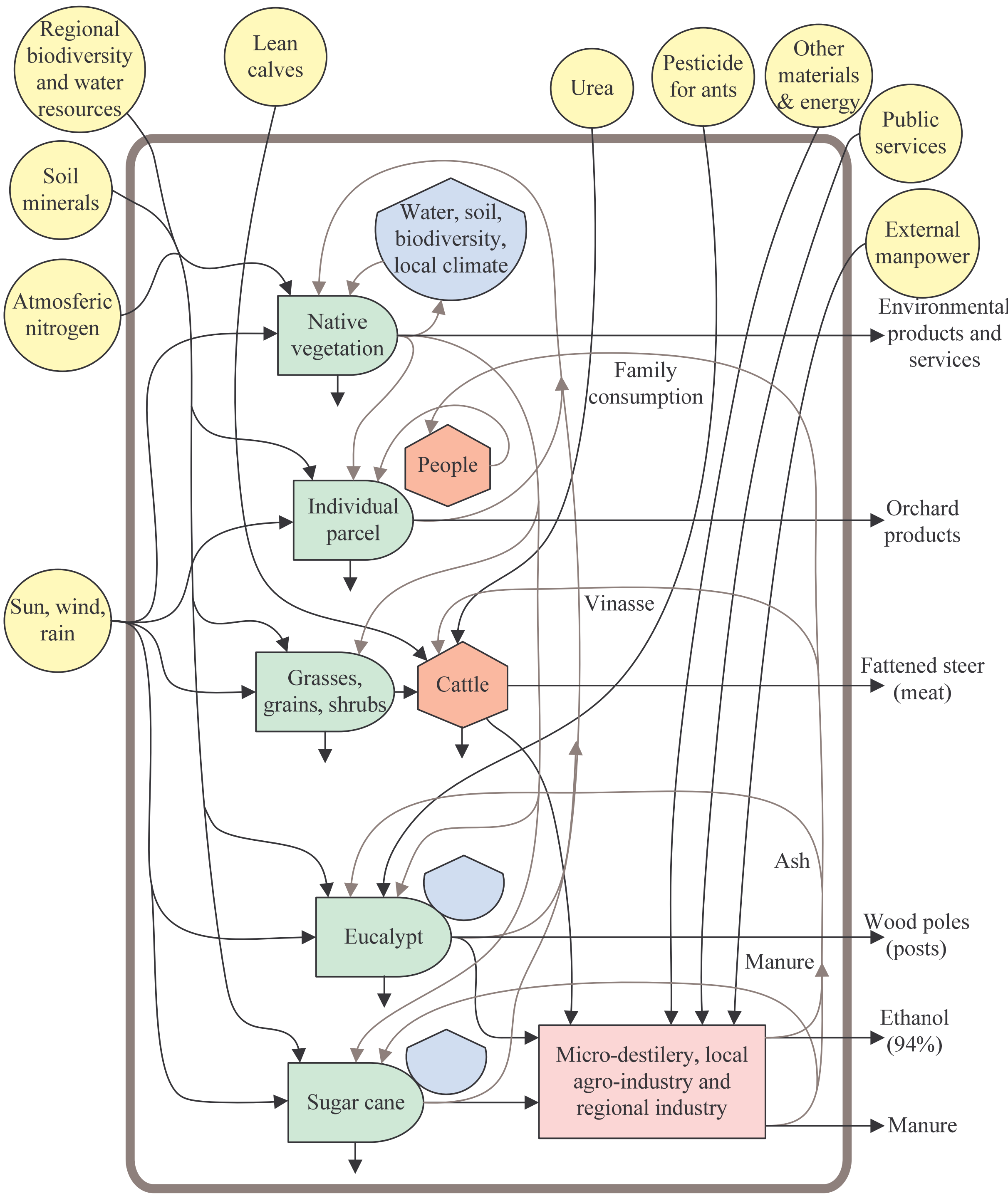
Fig. 3d. Three rolls mill.

Figure 3e. Dilution tank.

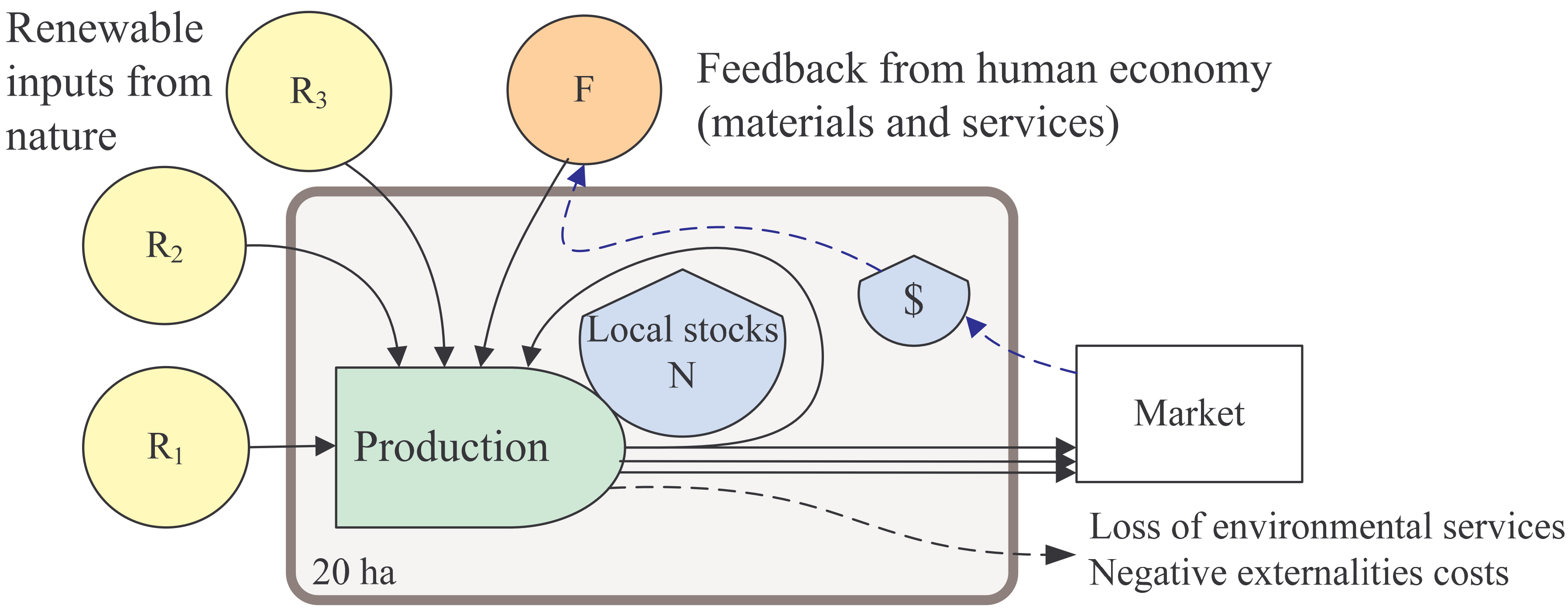
Figure 3f. Batch fermentation tanks.

Figure 3g. Firewood furnace.

Figure 3h. Distillation column.



Emergy analysis of "Fazenda Jardim" eco-unit (20 ha):
It is used the emergy methodology (Odum, 1996).



System's resumed diagram.

Table 5. Aggregated emergy flows.

Flow	Value (E+15 seJ ha^{-1} ano^{-1})
Renewable (R)	6,59
Non renewable (N)	1,12
Nature resources (I)	6,71
Materials (M)	2,32
Services (S)	0,86
Economy resources (F)	3,18
Total emergy (Y)	9,88

Emergy indices obtained.

Emergy indices	Calculation	Value	Units
Transformity	Tr =Y/Ep	260000	seJ/J
Emergy Yield Ratio	EYR = Y/F	3,11	Dimensionless
Emergy Investment Ratio	EIR = F/I	0,47	Dimensionless
Environment Loading Ratio	ELR = (N+F)/R	0,50	Dimensionless
Renewability	%R = 100(R/Y)	66,7	%

Social indicator: at least 2 work places per 10 ha.

Until now this system has been profitable.

In next studies, economic yield will be calculated taking into account externalities and considering global and regional frameworks for eco-unit and big plantation distilleries.

Considerations in relation with Brazilian case

The studied system reveals satisfactory values for all the emergy indices calculated.

Renewability attains 67%, making evident its sustainability.

The value of emergy captured from nature and transferred to productive chain is high (EYR=3.1).

The investment from economy and pressure on environment have low values (EIR=0.47, ELR=0.5).

These calculations can be improved obtaining additional data for other emergy calculations and also economic and social analysis.

Besides that, it is possible to consider a different arrangement for eco-units, as a net of milk producers.

Because they have low income, they cannot afford the whole investment, therefore they could have a simple distillation process (45%) and the ethanol could be transported to a regional micro-distillery that could concentrate to 94% or more.

It would be very interesting in terms of public policy to prepare an emergy analysis of the ethanol macro-distillery proposed as model for a new expansion of Brazilian Ethanol Production Program (35000 ha) and compare the results of the two models, either as stand-alone distilleries as well as national networks.

Acknowledgement

We recognize the merit of Marcello Mello, as developer of a very innovative micro-distillery in Brazil and also their openness for a very valuable interview in order to discuss a tropical ecounit example.