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# Sustainable Urban Life Beyond Peak Oil

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## Abstract

Cities are highly dependent on fossil energy. Mechanization of agriculture has resulted in a situation where food is produced and transported to urban areas by using significant quantities of fossil fuels. While there is little dispute that oil will ultimately peak, recent estimates indicate that fossil energy use in food production also contributes some 25% of global $CO_2$ emissions. With less available fossil energy, and to reduce climate change, providing future urban populations with food hence imply a major challenge. This paper therefore explores urban agriculture as a strategy for reducing climate change derived from food production, and for sustaining urban life in times of increasing energy and resource scarcity. Experiences in Cuba and Brazil are briefly discussed, to explore some common opportunities and constraints of urban agriculture as a strategy for sustainable development. The paper also presents a recently initiated research project on urban agriculture in Brazil. The project will run until the end of 2010 and includes case studies and participatory fieldwork on urban agriculture in Rio de Janeiro. By applying a trans-disciplinary approach, the study explores opportunities and constraints for increasing urban self-sufficiency, sustainability and food security, while decreasing energy consumption at aggregate levels of society. In the study, the methodologies Emergy Synthesis and Participatory Learning and Action are used in parallel. Few previous studies have in this way applied physical and social science methodologies simultaneously to urban agriculture. At this point, the current status of the research is presented, after which its implications are related to global issues of energy use, climate change and sustainable development.

*Keywords: Urban agriculture, peak oil, climate change, sustainable development, Brazil.*

## 1 Introduction

Meeting the challenge of climate change is difficult, among other things due to society's dependence on fossil energy (Heinberg 2006, 2007). Increasing mechanization in agriculture means that food demand is met by using significant quantities of fossil fuels. As a result, a considerable part of global $CO_2$ emissions is derived from food production. In Sweden, the food system alone contributes to some 28% of the country's total greenhouse gas emissions (Sonesson et al 2005). In addition, there is little dispute that oil production will ultimately peak (Robelius 2007). It may therefore be expected that to counteract climate change and sustain urban life beyond peak oil, humankind will face major challenges in providing growing urban populations with food. This paper explores how this challenge may be met, by examining urban agriculture as a strategy for reducing climate change derived from food production, and for sustaining urban life in times of increasing energy and resource scarcity.

*1.1 Aims and objectives*

The main objective of this paper is to discuss the potential of urban agriculture for reducing climate change derived from food production, and for sustaining urban life beyond peak oil. Past experiences from Cuba are examined, and the current state of urban agriculture in Brazil is briefly accounted for, to highlight some common opportunities and constraints. The paper also presents a research project recently initiated in Brazil, which aims to generate new and interdisciplinary knowledge on urban agriculture as a strategy for sustainable development.

## 2 Theoretical framework

There is growing skepticism towards the feasibility of infinite expansion of global industrialization, food production and consumption sustained by essentially finite sources of energy. As pointed out by Hornborg (2001) fossil fuels have hitherto been an effective illusory emancipation from natural resource dependence. In addition, efficiency gains are often reinvested in new consumption, which implies improved energy efficiency potentially fails to decrease rates of consumption and $CO_2$ emissions at global aggregate levels. Prioritizing short term technological fixes in conventional agriculture may therefore be counterproductive, in that it shifts focus from the more burning question; i.e. whether contemporary urban society may be sustained with less fossil fuels. This calls for exploration of alternative strategies that not only prepare humankind for the resource scarcity ahead, but do so while considering global cumulative effects. For this purpose, theoretical perspectives and analytical tools are needed that acknowledge resource limits, can handle local and global interactions simultaneously and holistically address sustainability and equity aspects of development (c.f. Alarcon et al 2008). This challenge has been embraced by advocates of alternative strategies to sustainable development, mainly within a range of systems perspectives (c.f. Gotts 2007)

*2.1 System theories and sustainable development*

The systems view departs from the notion that essential properties and overall functions of interlinked socio-ecological systems are only visible when observing the whole. As pointed out by Bergquist (2008), systems can therefore not be fully understood through isolated and sectorized analysis. Based on this conviction, systems theories are always contextual and synthetic, as opposed to conventional disciplinary analysis, which only generates partial knowledge, whereas intrinsic properties of systems and relations to multiple scales are overlooked.

In systems theory, the world is therefore conceptualized as one global socio-ecological system, within which is nested a complex web of subsystems that together display emergent properties, self-organize in hierarchical structures that dissipate energy, create entropy, pulse and collapse, leading to nonlinearity and multiple steady states (c.f. Odum and Odum 2001; Hornborg and Crumley 2007). By this conceptualization, it is apparent that humans and nature are intricately linked to each other and that problems related to sustainable development may only be understood through interdisciplinary approaches (c.f. Hornborg and Crumley 2007; Odum and Odum 2001).

It is a general misconception among many scientists and policy makers that society can grow into a sustainable steady state (Ulgiati and Brown 1998). As an opposite, systems theories generally accept that a period of descent in terms of energy consumption is to expect (cf. Odum 1996, 2007; Holling 2004). Therefore, it is increasingly probable that future policies for sustainable development will demand some sort of societal decomposition (Bergquist and Rydberg forthcoming). Several

system perspectives (*c.f.* Gotts 2007) have pointed to the tendency of all systems to follow pulsing patterns. Within general systems theory, this is called the pulsing paradigm. A pulsing system is characterized by alternation between long periods of gradual production and storing of reserves, followed by short but intensive periods of consumption. Whereas the reason why all systems pulse is uncertain, studies of many kinds of systems indicate that pulsing is more productive at aggregate levels and scales of time (Odum and Odum 2001). It may therefore be expected that resource limitations be further accentuated in the future, mainly due to the approaching peak oil and resulting scarcity in food production and global energy storages.

The interconnectedness of nature and human societies, as well as the tendency of all systems to pulse, means that a principle for generating good policy for human activity is to fit the timing of environmental oscillations (c.f. Bergquist 2008, Bergquist and Rydberg forthcoming). That is, to foster consumption in times of high availability of resources, and more importantly, to restrain consumption in times of decreasing availability of resources. Ultimately, and perhaps most importantly, this means that it will be crucial to reorganize society according to oscillations in the resource base. It also means that for some time, humankind must learn how to depend mainly on renewable resources. Therefore, future development strategies need to facilitate better use of local renewable and flow limited resources such as tides, wind, rain and solar energy etc.

Several scholars (e.g. Hornborg 2007, Hopkins 2008, Odum and Odum 2001 and Tainter 1988) claim that such a shift in resource use need not necessarily be catastrophic for society. Instead, the societal change needed may in fact offer an opportunity to dismantle those processes and aspects of contemporary society that are most inefficient and unnecessary, and to favor those that are most useful and appropriate. According to Odum and Odum (2001), there are several opportunities for making the decent to a low energy situation prosperous for society. For example, in rural areas, especially in the North, where farming was abandoned centuries ago, many areas have been left to recuperate and resources have begun to restore as to support rural life again. Thus, a part of the solution may be to shift agricultural and material intensive activities back to these areas. Another solution may be to explore ways for agriculture and food production in other areas, such as in urban and peri-urban environments.

## 3 Urban agriculture

The arguments presented above imply that urbanization strategies are needed that reduce the energy demand of cities, and that enable more efficient use of those resources locally available. In addition to these challenges, urban food security is alone an issue of increasing concern. Hunger and malnutrition in urban areas worldwide are increasing each year. To ensure access to food, and increase self-reliance of cities, urban agriculture thus offers an interesting alternative. However, as stated by Koc et al (1999), for making a long lasting and positive impact, it is important that future initiatives consider a range of aspects, such as economic feasibility, equity, broad participation, and sustainable use of energy and natural resources. In this context, Henn and Henning 2002 have called for more urban agriculture initiatives, motivated by the important role it may play in counteracting a range of environmental and social concerns in urban areas. Also Nugent (1999, cited in Halder et al 2008) pointed to the capacity of urban agriculture to re-orient food systems towards more sustainability and decrease import dependency, as well as urban waste generation.

### *3.1 Potential benefits of urban agriculture*

Several researchers and other professionals (e.g. Cruz and Medina 2001, Halder et al 2008) have pointed to an array of potential benefits derived from the implementation of urban agriculture. Out of these, perhaps the most important are:

- creation of cooler microclimates within cities
- better soil management for increased fertility and rain water permeability
- reduced urban waste generation through recycling organic (as fertilizers) and non-organic materials
- reduced need for imports and transportation of food products
- more efficient use of local water sources (e.g. rain and natural springs)
- increased biodiversity
- more balanced oxygen-$CO^2$ levels (on a very limited scale)
- transformation of urban dumping and polluted still water sites
- elimination of habitats for rodents and mosquitoes etc, and hence reduced human diseases
- therapeutic and aesthetic effects of increased contact with nature
- raised environmental awareness and interest among urban dwellers

*3.2 Urban agriculture and the urban-rural nexus*

In mainstream notions of the modern city, urban agriculture is however seldom conceived of as an alternative. It is often forgotten, or worse, denied by urban planners, policy makers as well as researchers (Madaleno 2001). Halder et al (2008) explain this as the result of most people seeing cities as separated from nature. However, this does not mean that cities are independent from nature. On the contrary, and as pointed out by Nugent (1999), urban areas typically import labor and natural resources, and export goods, services and waste. Thus, no city that exists today could do so without the agricultural support from rural areas, and hence indirectly, the support from nature. Rather may the urban illusory emancipation from nature be seen as the result of modern society's division of labor, where nature and agriculture are perceived as activities that belong in the countryside. However, when analyzing some 5000 years of urban history, the separation of urban life from agricultural activities is in fact a relatively recent phenomenon (Halder et al 2008).

*3.1 The Cuban experience*

Cuba is the one place on Earth that has already faced and responded to an oil peak, although for political and economic reasons resulting in an artificial peak oil situation. Due to the collapse of the Soviet Union in 1989 and sanctions by the U.S., Cuba's access to fossil fuel reserves was cut off more or less overnight. Cuba then became the first nation to face extreme resource scarcity, a situation similar to what may be expected globally beyond peak oil.

In Cuba, sustaining the urban populations with food suddenly became a major problem. An important reason why the transition into a post fossil society was so difficult was the highly mechanized agriculture system. Similarly to most

contemporary food production worldwide, Cuban agriculture was highly dependent on fossil fuels, such as diesel for tractors and tools, petroleum based fertilizers and transportation etc. In the wake of severe energy shortages and the resulting food crisis, urban agriculture emerged (Gonzales Novo and Murphy 2000). In 1993, the majority of state farms were dissolved to form small cooperatives owned and run by workers. The aim was to facilitate access to arable land, increase self-sufficiency, food security and autonomy among workers. Urban gardening, localized production and consumption, crop diversification and local cooperation are all examples of emerging strategies, which make Cuba an inspiring candidate for guiding the remaining world in preparation for the descent ahead.

### *3.2 Experiences in Brazil*

Beginning in the latter half of the 20th century, Brazil has experienced an intensive urbanization process. Among the many people migrating to the cities from the country's peripheries, many were agriculturalists (Halder et al 2008). Thanks to their previous agricultural knowledge, and due to lacking work opportunities in the cities, many started farming in small urban plots. Today, each year an increasing number of urban dwellers in Brazil receive part of their food from such urban gardens. Subsistence is more commonly its aim than commercialization. Hitherto, economic benefits have thus been relatively low and mostly in indirect form, i.e. trough decreasing the farming families' needs for purchased and imported food (Halder et al 2008). Also from a food security perspective, the contribution from urban agriculture is quite low, and far from its full potential.

Halder et al (2008) argue that the marginal character of urban agriculture in Brazil is the result of most city planners seeing agriculture as a sign of a negative or backwards development. As an activity seldom perceived by most people, it is even less seldom acknowledged by the government. Nevertheless, in times of crisis such as today when food and energy prices are escalating, urban agriculture is emerging as an innovative phenomenon contributing several positive effects and social change in Brazilian cities (Halder et al 2008). However, research on the current status and potential of urban agriculture in Brazil remains scarce (Arruda 2006).

## 4 SusUrbia – a research project

This section presents a recently initiated research project on urban agriculture in Brazil. The project name is "SusUrbia – Sustainable Urban Life Beyond Peak Oil". The research is currently being carried out as a post doctoral project spanning a total of two years from late 2008 to 2010. It includes case studies and fieldwork in Rio de Janeiro, Brazil and is officially connected to Uppsala Centre for Sustainable Development (CSD Uppsala) in Sweden and the Center for Environmental Policy at the University of Florida in USA.

In particular, the project aims to 1) analyze urban agriculture systems emphasizing external versus internal input dependence, self-sufficiency and substitution of fossil fuels by local renewable resources, 2) determine how much urban space per capita is needed for self-sufficient and sustainable urban food production, 3) analyze social dynamics and change derived from community participation in urban agriculture, 4) to find solutions for meeting the nutritional needs of growing urban populations in times of decreasing fossil energy reserves, 5) explore possibilities for sustainable urban life that decreases energy consumption at aggregate levels of society, and 6) contribute to improvement of transdisciplinary tools for analysis of coupled social-ecological systems in food production and consumption.

The approach is hence transdisciplinary, which means that it aims to analyze urban

agriculture from different disciplinary, yet complementary angles. Furthermore, it aims to define the problem and base the analysis on local people perceptions. Apart from the theoretical basis in systems theory, a range of methods, tools and techniques are applied. Out of these, the two methodologies Emergy Synthesis (ES) and Participatory Learning and Action (PLA) are the most important.

*4.1 Emergy Synthesis*

ES is an environmental accounting methodology aiming to illustrate nature's contribution to human economic sub-systems. By using ES, inputs from the human realm (i.e. social-economic system) and those coming "free" from nature are considered on equal terms. Contrary to similar approaches such as energy and exergy analyses, ES is based on a donor perspective (Federici et al 2003), i.e. environmental contribution to a system's dynamics is accounted for regardless of the value perceived by users, e.g. in terms of money, exergy etc. It is expressed in emergy, a "currency" that determines value of non-monetary and monetary resources, services and products together (Herendeen 2004).

Emergy (energy memory) is a theoretical concept and methodology that accounts for environmental and human support to economic processes on equal terms, and offers a means to illuminate social and economic [un]fairness, sustainability of production and consumption, e.g. by focusing on the degree to which production systems are dependent on local versus external, renewable and non-renewable, resources. As such, emergy offers guidance in re-designing food production systems to benefit humans as well as nature. For a thorough introduction to environmental accounting using emergy, see for example Odum (1996, 2007).

*4.2 Participatory Learning and Action*

PLA is an intervention method explicitly developed to facilitate learning based on participation. It stems from the notion that the most efficient learning takes place when people work on real-time problems. PLA is also a counter reaction to the view of local traditional knowledge as obsolete. According to Checkland and Holwell (1998) the most crucial characteristics of action based learning and research are: a) a collaborative process between researchers and people in the situation, b) a process of social inquiry, c) a focus on social practice, and (d) a deliberate process of reflective learning. Another important aspect of PLA embraced in this project is that it aims at bringing about real-life change during and through the research process, while learning, applying and generating theory through action.

A number of practical techniques originate from PLA, all striving towards changing roles, behaviors and relationships, where the outsider (i.e. researcher) does not dominate and lecture, but facilitates information exchange with and between local people, based on their perceptions and needs (Chambers 1997). PLA is thus more of a toolbox than an explicit method. Examples of some PLA exercises used in this study are semi-structured interviews, Venn-diagrams, seasonal calendars, problem analysis and focus groups. Pretty et al (1995) provide a thorough introduction to PLA and related tools.

*4.3. Case studies*

Currently, pilot studies are being carried out in Rio de Janeiro, Brazil, with the purpose of learning more about agriculture in the region, and to identify an appropriate location for a deepened case study. The ambition is then to initiate the fieldwork in close collaboration with the selected urban community, and to engage participants in experimental research and development of pre-existing urban

agriculture practices. The explicit purpose of such an experimental research design is to not only extract knowledge, but also to give something back to the local community, e.g. by making use of research findings for improvement based on the participants needs and knowledge, yet in a joint and deliberate process of reflective learning, while applying and developing scientific theory in the field.

## 5 Implications for sustainable development

If the challenges of climate change, peak oil and the resulting post fossil fuel society are taken seriously, there will be a pressing need for alternative strategies to sustain urban life in the future. However, it also means that for studying and understanding this challenge, and finding solutions to it, many dimensions of sustainability have to be dealt with. This is why the research project presented here applies a transdisciplinary approach, emphasizing and synthesizing ecological, economic and socio-cultural aspects. In this way, urban agriculture is used for probing also wider issues such as global energy use and availability, climate change, agriculture, food security and urban social dynamics.

The research project thus has the potential to generate important theoretical and empirical findings at a local level, but also for policy formulation globally. As pointed out by Arruda (2006), research on urban agriculture in Brazil is scarce. Also on a global level, more knowledge is needed, especially originating from trans-disciplinary analyses. For example, there is insufficient knowledge in terms of how urban agriculture affects community structures, i.e. how it affects social dynamics and relations among people. When urban neighborhoods in Cuba engaged in urban agriculture, this altered previous social relations, e.g. resulting in significant implications for gender issues. Many women have become empowered through their important role in urban food production for domestic use, mainly since all members of the urban communities (including men, women, children and marginalized community members) take part in the work. This indicates that urban agriculture is an important contributor to strengthening the position of women in their local communities, but also for including other marginalized groups, e.g. poor, unemployed, elderly people etc.

Also the potential of urban agriculture to decrease the energy and resource demand of cities, and hence increasing energy and food security is a seldom explored field of research, as well as to determine the potential of urban agriculture to reduce fossil energy consumption at global aggregate levels. Hitherto, little research has been carried out that holistically emphasize these aspects of urban development. This project aims to contribute toward filling this gap.

## 6. References

Alarcón, C., Bergquist, D., Bjureby, E., Friman, E., Gallardo, G., Hajdu, F., Jacobson, K., Johansson, S., Lagerberg Fogelberg, C., Rydberg, T. 2008). Understanding Global Patterns of Production and Consumption: Prospects of an Interdisciplinary Approach. In: B. Frostell, Å. Danielsson, L. Hagberg, B.-O. Linnér, E. Lisberg Jensen, (Eds.), *Science for Sustainable Development - The Social Challenge with emphasis on conditions for change*, Proceedings from the 2nd VHU Conference Linköping 6-7 September 2007, Uppsala: VHU, pp. 15-21

Arruda, J. 2006. Agricultura urbana e peri-urbana em Campinas/SP: análise do Programa de Hortas Comunitárias como subsídio para políticas públicas. Universidade estadual de Campinas (Unicamp), Brasil. Dissertação de Mestre, 162 pp.

Bergquist, Daniel. A. 2008. Colonised Coasts. Aquaculture and emergy flows in the world system: Cases from Sri Lanka and the Philippines. Doctoral thesis, *Geografiska Regionstudier* 77, Department of Social and Economic Geography, Uppsala University, Sweden.

Bergquist, D. A. and Rydberg, T. (forthcoming). Towards a Transdisciplinary Understanding of Emergy Accumulation. *Emergy Synthesis* 5, *Theory and Applications of the Emergy Methodology.* Proceedings of the 5th Biennial Emergy Research Conference, University of Florida, Gainesville, USA.

Chambers, R. 1997. Whose reality counts? Putting the first last. ITDG Publishing, London.

Checkland, P. and Holwell, S. 1998. Action research: Its nature and validity. *Systemic Practice and Action Research*:11: 9-17.

Cruz, M. C., Medina, R. S. (Eds.), 2001. *Agricultura y ciudad: una clave para la sustentabilidad*. Fundación Núñez Jiménez de la naturaleza y el hombre. La Havanna, Cuba.

Federici, M., Ulgiati, S., Verdesca, D. and Basosi, R. 2003. Efficiency and sustainability indicators for passenger and commodities transportation systems. The case of Siena, Italy. *Ecological Indicators* 3:155-169.

Gonzalez Novo, M., and Murphy, C. 2000. Urban Agriculture in the City of Havana: A Popular Response to a Crisis. In: Growing Cities, growing food: Urban Agriculture on the Policy Agenda, pp. 329-347. RUAF foundation.

Gotts, N. 2007. Resilience, panarchy, and world-systems analysis. *Ecology and Society* 12:1:24. [online]: http://www.ecologyandsociety.org/vol12/iss1/art24/.

Halder, S.J., Mattos de Mendonça, M. and Monteiro, D. 2008. *Agricultura urbana: natural aqui do Rio de Janeiro*. Assessoria e Serviços a Projetos em Agricultura Alternativa, AS-PTA. Rio de Janeiro, Brasil.

Henn, P., and Henning, J. 2002. Urban Agriculture and Sustainable Urban Systems: A Benefits Assessment of the Garden Movement in Havana, Cuba. *International Journal of Environmental and Sustainable Development*:1:3:202-09.

Heinberg, R. 2006. The Oil Depletion Protocol – A plan to Avert Oil Wars, Terrorism and Economic Collapse. New Society Publishers, Canada.

Heinberg, R. 2007. Peak Everything – Waking Up to the Century of Declines. New Society Publishers, Canada.

Herendeen, R. 2004. Energy analysis and EMERGY analysis - a comparison. *Ecological Modelling* 178:227-237.

Holling, C. S. 2004. From complex regions to complex worlds. *Ecology and Society* 9:1:11. [online] URL: http://www.ecologyandsociety.org/vol9/iss1/art11/.
Hopkins, B., 2008. The Transition Handbook: from oil dependency to local resilience. Green Books, Totnes.

Hornborg, A. 2001. *The Power of the Machine. Global Inequalities of Economy, Technology and Environment.* Altamira Press, U.S.

Hornborg, A. 2007. Learning from the Tiv: Why a Sustainable Economy Would have to be "Multicentric". Culture & Agriculture, 29;2:63-69. American Anthropological Association.

Hornborg, A. and Crumley, C., (Eds.), 2007. The World System and the Earth System. Global Socioenvironmental Change and Sustainability Since the Neolithic. Left Coast Press, Walnut Creek, California.

Koc, M., MacRae, R., Mougeot, L. A. and Welsh, J., (Eds.), *For hunger proof cities: sustainable urban food systems.* Toronto: IDRC, p. 95-99.

Madaleno, I., M. 2001. Urban Agriculture Supportive Policies: two distant cities. *Urban Agriculture Magazine*: 4, Urban Planning, July 2001, RUAF, Leusden The Netherlands.

Nugent, R. A. 1999. Measuring the sustainability of urban agriculture. In Koc, M., MacRae, R., Mougeot, L. A. and Welsh, J., (Eds.), *For hunger proof cities: sustainable urban food systems.* Toronto: IDRC, p. 95-99.

Odum, H. 1996. *Environmental Accounting: EMERGY and Environmental Decision Making.* John Wiley & Sons, New York, pp. 370.

Odum. H. 2007. *Environment, Power, and Society for the Twenty-First Centurey. The Hierarchy of Energy.* Columbia University Press, New York.

Odum, H. and Odum, E. 2001. *A Prosperous Way Down: Principles and Policies*. University Press of Colorado, USA.

Pretty, J., Guijt, I., Thompson, J. and Scoones, I. 1995. Participatory Learning & Action – A Trainer's Guide. Sustainable Agriculture Programme. International Institute for Environment and Development, UK.

Robelius, F. 2007. Giant Oil Fields – The Highway to Oil. Doctoral thesis. Uppsala Dissertations from the Faculty of Science and Technology, Uppsala University, Sweden.

Sonesson, U., Mattsson, B., Nybrant, T. and Ohlsson, T. 2005. Industrial Processing *versus* Home Cooking: An Environmental Comparison between Three Ways to Prepare a Meal. *Ambio*:34 No 4-5:414-421.
Tainter, J. A., 1988. The Collapse of Complex Societies. Cambridge University Press.

Ulgiati, S. and Brown, M. 1998. Monitoring patterns of sustainability in natural and man-made ecosystems. *Ecological Modelling* 108:23-36. Elsevier Science.