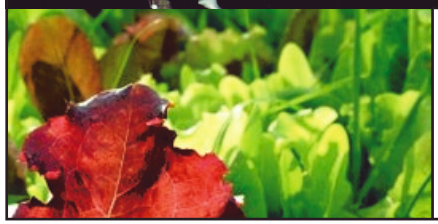


Large scale urban agriculture for developing and developed progress

Tom Bosschaert

1. Introduction

Food and water are universally the two only resources mankind needs to provide for basic survival. We all have to eat, that is certainly clear. Our ways of producing the majority of our food has in many ways changed only little over time, while virtually everything else, the way we live, work and interact, has changed dramatically. We have a choice in how we produce food, and as the world is changing before our very eyes, it might be worthwhile investigating alternatives to our traditional way of food production. One reason for doing so is that the traditional way of producing food has resulted in a specialization of crop areas, so that entire regions only grow one or two types of food. This results in major transport operations to distribute the crops evenly. In addition to this our agricultural land is quickly running out, and the world's population ever increasing with a large part already having difficulty securing food. This paper explores the possibility of large scale organized agriculture in an urban setting, to increase the world's supply of agricultural capacity, reduce food related transportation, assist in waste and water filtration requirements of cities, and the benefits they can deliver to developed and developing countries.

2. Need for expansion and integration of agricultural land

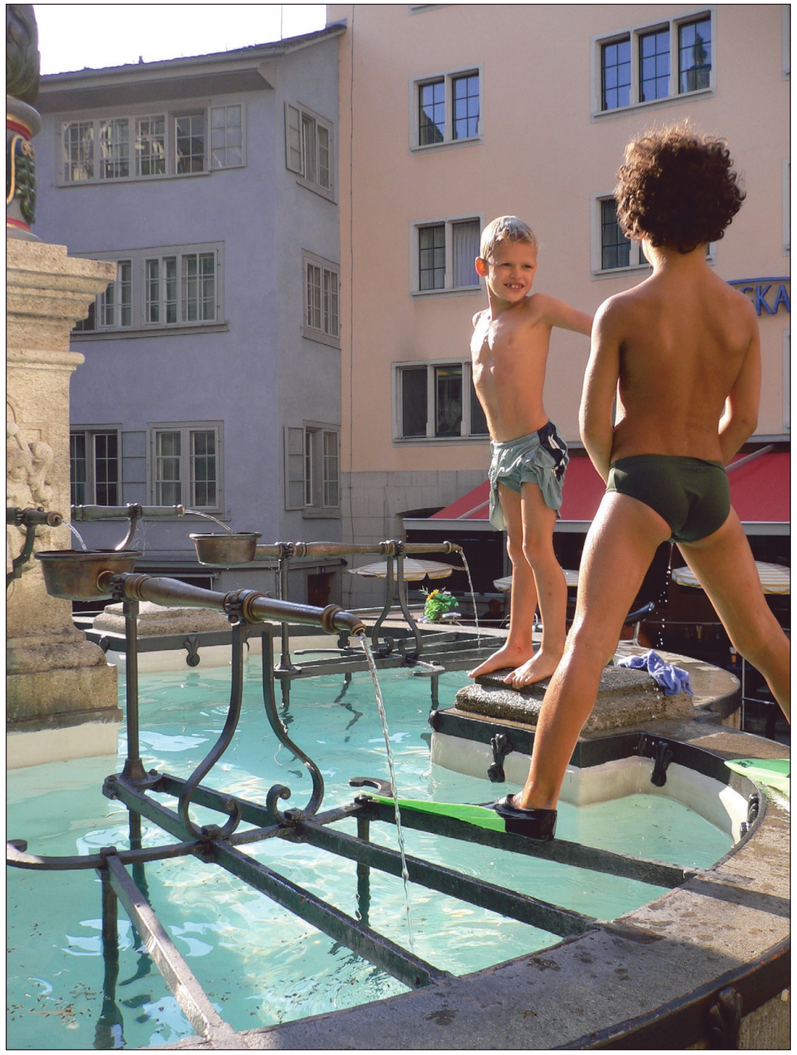
The formula to calculate the surface of a sphere was devised by Archimedes of Syracuse around 150 BC, along with a few other useful things that allowed us to crawl out of a feudal existence and enter the age of what believe to be developed culture. Since then we can safely say that our planet seems to have a fixed surface area, of which about 70% consists of water and of the 30% that remains only 35% is by any stretch of the imagination arable land, and of this only roughly half is used as agricultural land. By 'any stretch of the imagination' I mean that it is highly unlikely for anyone to throw up a strawberry patch in the gobi desert or farmer John to start a successful endive operation on the shores of greenland. Due to erosion and desertification large areas of arable land have become degraded, up to 75% in central America[1]. While the total area of agricultural land keeps growing (4.5 billion in 1955 to 4.93 billion in 1996[2]), it does not keep pace with the growing population or its increasing food consumption per capita (24% more than in 1964[3]). Already large numbers of people are succumbing to starvation or on the brink of it, and threats to the food supply such as the use of food crops for fuel such as Ethanol seem to suggest these circumstances are expected to worsen rather than alleviate in the near future. In short, decent agri-

1 http://archive.wri.org/item_detail.cfm?id=76&section=newsroom&page=newsrelease_text&z=?, 12/15/2007
2 Ibid
3 Ibid

cultural land is in short demand while an unstoppable population growth of the world stresses the current supply beyond its capacity. Current estimates for the world population reveal a growth of 40% in just 40 yours time, dragging the numbers in an ever increasing downward spiral that is hard to fathom.

It is important to realize that the remaining portion of arable land that is suitable for effective agriculture does not consist of large expanses of green rolling hills behind someone’s tool shed. It mostly consists of pockets of land enclosed within steep mountain regions, fragmented in urban and industrial areas and remote natural lands best left undisturbed for obvious preservation reasons. We only have very little space to grow, and in time food and the water it requires for its growth will stress not just the capacity of the poorest of the developing countries and its population, but shift major economic processes affecting all of society.

There are various enterprises being developed to assist in this issue. They can be divided into the creation of more agricultural land, via new irrigation methods and new food crops that grow in harsher conditions, and the increase of the output of existing agricultural lands by new food crops (through genetic engineering), alternate irrigation methods and higher capacity fertilizers. In addition to more effective food crops,



irrigation and efficient use of agricultural land, recently a new possibility has been explored. Rather than growing our food in remote areas of the land and spending large amounts of resources in transportation to distribute these, the growing of food within cities itself may provide an additional source of agricultural capital, with the added advantage that the consumer and the producer are now geographically linked, which brings us to the next advantage of urban agriculture; a sociological one.

Let’s look at another development of modern civilization the likes of which we can see sprouting all over the developing world. Food is grown in some remote area, where it is harvested and transported to an equally remote processing plant. From there it is further processed and packaged in perhaps a third plant and is then transported to large retail outlets where most people purchase it and and take it home. Growing up in this type of society does not allow generations to come to connect with the natural world and its source of nutrition, the cycle of life and energy sources and what the efforts to keep us alive comprise of. It has been recognized on various levels and in various disciplines that this remove from an understanding of the natural world and our food cycle is detrimental to the development of humanity through the lack of a basic understanding and respect for its fundamentals. Urban agriculture could play a large role in reintroducing the knowledge and understanding of these fundamentals into

the life of the urban dweller, of whom there are ever more compared to rural dwellers each day.

Community Gardens, Bath England," Kevin Muente, oil on canvas, 2004

3. The scales and possibilities of urban farming

We can imagine urban farming in a variety of scales, starting with a few consumable plants in the window sill to large scale vertical farming industries. We can roughly divide these activities in three scales. The small scale concerns itself solely with the production of food for one person or family, an allotment garden or small vegetable patch on the roof of a building. The medium scale caters for some or all of the needs of a small to medium sized group of people, where the production facilities belong to or are a part of the organization that benefits from it. Large scale urban farming enterprises typify themselves by the production of food starting from several thousand to whole city districts, where the producers are not necessarily part of these areas. An example would be a forty floor high tower with agricultural activities, eg a vertical farm.

Small scale urban farming is not uncommon in large parts of the world. Typical of the small scale is that the food is produced by the same people that consume it. In many communities people enjoy growing certain herbs or spices in their own domain to guarantee freshness or a flavor they cannot obtain otherwise. Sometimes a hobby in food gardening can extend itself to the cultivation of a allotment garden, not uncommon in the United Kingdom, Germany and Sweden. These provide important com-

munity functions as well as educational and leisure services to a wide range of age groups. However, their food production is limited and inefficient due to a high degree of fragmentation and it can not be expected for a small roof gardens to be a major contribution to actual agricultural land. Its benefits should mainly be sought in its sociological and ecological benefits, such as water collection, waste recycling and educational purposes.

Medium scale urban farming is usually an enterprise organized by a single entity in which members of the community it feeds are employed, either paid or voluntarily, to provide food for this community. They often focus on a certain environmental approach to food production that normal channels do not provide or only at a high premium such as organic and special crops. Usually the grounds are in the vicinity of the organization benefiting from them. An excellent example of medium scale urban farming are the Yale University food gardens, providing some or all of the food for a number of residential colleges. The gardens are run an maintained by the university, with students from the community assisting in its operations. Medium scale urban farming is a great way to use smaller fragmented areas of urban fabric as food production lands as well as providing a visually, culturally and socially stimulating space, while aiding biodiversity, urban heat island effects and providing for functionally active open

Chinese Urban Garden

spaces. It is interesting to note that traditional Chinese gardens, admired around the world for their quality and sophistication, were food gardens for the most part. Also Cuba has employed medium scale urban farming to overcome the hardships it faced after the soviet block fell and the economic boycott of the United States put the economy under pressure and increased the prices of oil significantly. Cuba reverted to the use of oxen and manpower for its agricultural needs in favor of tractors and machinery, and converted open areas in and around cities to small farming enterprises where members of the community work to grow the food. This has put Cuba at an advantage in relation to the rest of the world, because of its increasing independence from oil. With the rising oil prices, Cuba will be hardly affected and has meanwhile ensured a more sustainable method of operating.

Vertical Farm Design by chris Jacobs

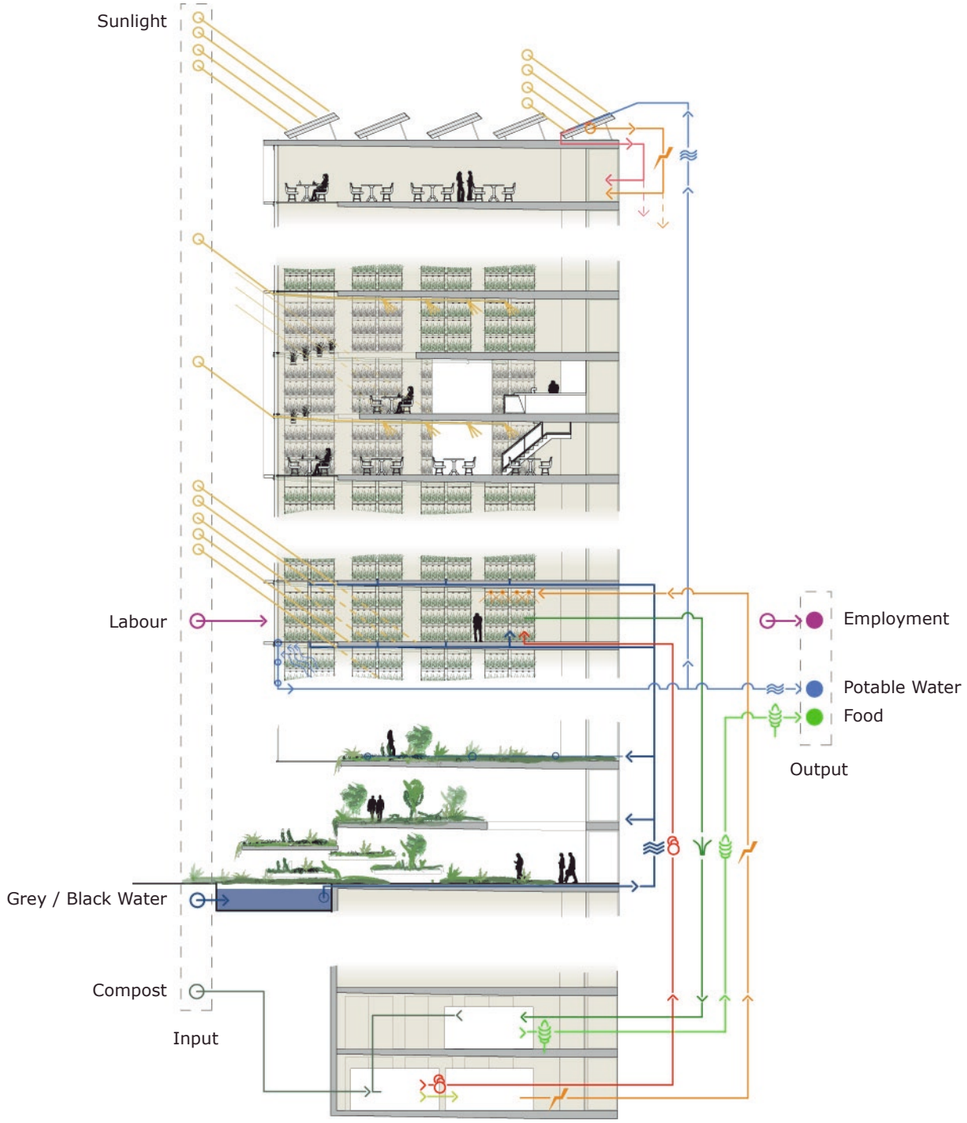
4. Large scale urban farming profile

Urban farming on a large scale is a different animal than medium and small scale altogether. Relying on a large volume of production it is hard to imagine this being organized by anything other than a single professional entity that employes people on a full time basis to operate its facilities. To achieve a large volume of production in urban areas, and observing the economic forces at play in such an environment, agriculture will need to be stacked to make use of the costly land as efficiently as possible. Depending on the price of land this could be just several stories or as many as those of the tallest skyscraper. This alters the way agriculture is performed in many ways quite radically, and the interaction with such a farm in a city context is also an entirely different experience than traditional farming allows.

Current research profiles a possible enterprise to feed up to 50.000 people based on a caloric intake of 2,200 people, a staple built up from the Center for Nutrition Policy and Promotion’s dietary requirements and 19 floors on a 250.000 square foot area, or 43 floors on a 90.000 square foot area. This would include the growing of Tilapia in tanks (the most nutritious fish), and breeding chickens for mainly egg production. Of course the farms could be larger (which might be impractical in an urban setting),

and there is no reason to assume a smaller farm won’t operate less efficiently, given a certain minimum size, which is currently not yet known.
Urban farming requires a different approach to farming, since one has less access to daylight, artificial light has to be provided. Since working with soil is impractical different techniques can improve the growing conditions and by regulating the environment high efficiencies can be reached.

Large scale urban farming is currently being researched by, among others, Columbia university. The Netherlands and China have expressed interests and are negotiating experimental projects to be devised.



5. Current technology and state of development

Current research is exploring two paths along which to develop methods of vertically stacked farming. One is Hydroponics, using artificial non-consumable substrates on which the plants are anchored through which water flows with added nutrients. Without the involvement of soil, the process becomes cleaner, and the plants grow more efficiently. When a full day and night cycle is employed for growth using artificial light, an efficiency of up to five times compared to traditional agricultural practices might be achieved. Using Aeroponics, in which the roots of plants are suspended in dark boxes in which a vaporized nutrient solution is channeled, the growth efficiency can be even higher. Using hydroponics however, the plants evaporate much of the excess moisture, which can then be collected easily on condenser surfaces (such as windows), and is then ready for usage. The vertical farm then does not only provide food for a large community, it filters the water from grey or even black state to that fit for human consumption. In addition to this the farm can use compost waste from the community as nutrients and energy conversion. Using the inedible parts of the grown plants as well as the compost influx energy can be generated using methane conversion to power the lights, assisted by Photovoltaics on the roof. There are various other ways of energy generation technologies that can be applied, as well as several light trans-

mission techniques such as light tubes and tunnels to channel light further into the building than direct sunlight allows. Currently the most promising technique for using methane as an energy source is cogeneration. By burning the methane electricity is generated as well as heat. The heat is then used for various tasks within the building itself and can provide neighboring buildings with heating and hot water as well. Even though burning would occur, this would be a carbon neutral solution since the carbon was sequestered by the growing plants in the first place in order for it to end up in the methane. Taking all this together and performing a rough but conservative energy balance analysis it has been concluded that it is very likely that a farm can be built that uses little to no energy from exterior sources.

Most if not al of these technologies are realities and are in effect in various configurations around the world. However, they have not yet been combined, and the challenge of building a vertical farm lies in connecting and operating these separate technologies as one efficient system.

6. Economic viability

Sometimes someone else's words say it so much better. Under the direction of Dr. Dickson Desponnier of Columbia University a financial analysis was performed to investigate the viability of a vertical farming enterprise. The report concludes as follows:

1. *The urban hydroponics model of Vertical Farming is both presently realizable and profitable. The investment return is comparable to stock market averages.*
2. *Properly implemented renewable energy sources can significantly reduce utilities expenditures, justifying their initial capital cost.*
3. *Corporate and institutional investors are willing to finance Vertical Farming as a result of the operations significant secondary benefits.*
4. *Vertical Farming presents a unique investment opportunity as it aims to revolutionize our understanding of food production and urban development.*[4]

The report is positive about the financial viability of a VF project, but understands and recognizes that a project with normal return on investment characteristics but with a high risk factor will not be easy, and that emphasis should be placed on the secondary benefits of vertical farms such as water filtration functions, reduction of food transportation costs, increase in food quality and laying the foundations for a sustainable urban development.

4 http://www.verticalfarm.com/plans-2k6_eco.htm, 15/10/2007

Funding for the first, experimental, vertical farm should be sought in the area of Philanthropic organizations as well as Venture Capital firms, according to the report. However, I believe that with government support in countries with active participating governments such as in Scandinavia, Germany or the Benelux, it should be possible to create an experimental project to serve as a foundation for further investment on a larger level. With countries such as the Netherlands taking pride in environmental technological achievement (e.g. Delta Works), it would suit their international agendas by being the first to develop the technology and expertise to build and run these operations.

Once the experimental nature of vertical farms has been explored and the knowledge has been gathered to implement these effectively, they could be used to effect an even more substantial gain by providing developing countries with the ability to build and maintain these operations. Already highly profitable Spirulina Algae plants have been built in Africa to aid small towns in both generating nutrition and economical resources. The Central Food Technology Institute has been active since 1960[5] to implement algae growing plants in India quite successfully, and the African Green Future initiative in cooperation with IIMSAM (Intergovernmental Institution for the use of Micro-algae Spirulina against Malnutrition) uses algae plants built by hand out of mud

5 http://www.cftri.com/aboutus/index.html, 12/15/2007

and some bricks to treat large quantities of raw sewage and turn it into animal feed, fertilizers and bio fuel[6]. It should be noted that algae plants are of a technological very different nature from vertical farms, and the latter requires a much higher standard of maintenance, operation and investment. Also, spirulina plants are highly profitable and require only very little investment. Their development profile is quite substantially different from a vertical farm. That said, their usefulness is only limited, and one can only do so much with algae. While it can be used for human consumption (it is also one of the few non-animal sources of vitamin B12)[7], it really is not diverse enough to become a staple of nutrition for a nation.

6 http://www.africangreenfuture.com/ 12/15/2007
7 Initial Opportunities Research document for Shire of Merredin, Tom Bosschaert, 2001, http://www.except.nl/Archi/meredin/index.htm

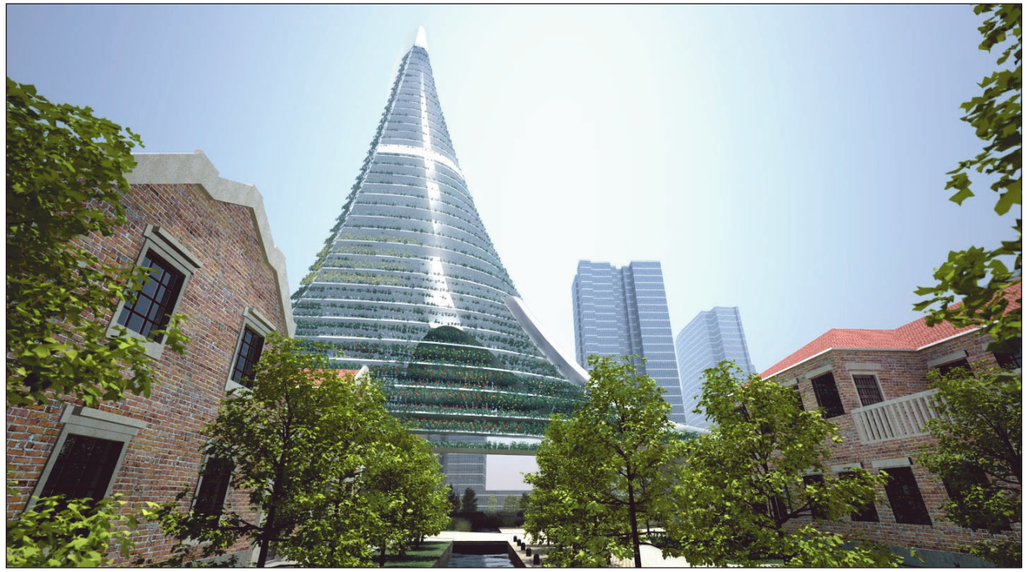
7. Social and Political consequences

Imagining a future where urban vertical farming becomes a staple of the food production industry, the consequences on a social and political level would be hard to predict. Major shifts in food distribution networks would ensue and therefore changes in political trade balances between nations and regions. Urban farms would compete and most likely gain the upper hand in the production of the majority of food in urban regions, leaving agricultural land to be used for more specialized uses, or to be returned to a natural state. Of course the production of food crops on land will quite likely remain financially beneficial as its primary investments are low, but as oil and energy prices rise, the transportation of these crops will gain an increasing share in the cost of traditionally cultivated food.

On a sociological level people in dense urban environments would be partially reconnected with the cycle of resources that exists in the natural world. Waste would be locally treated and used to grow nutrients that are then consumed locally. The requirements of the vertical farms in terms of labor and maintenance would mingle a modern agrarian work force with that of more typical urban dwellers, which might prove for an interesting cultural interchange. It might serve to reestablish a certain respect and understanding for natural processes in the educational system as farms and schools

can be co-located, and other functions be integrated as well. It would not be a large stretch of the imagination to envision the merger of public places and food production, after all Chinese gardens could do it, so why not in a modern urban setting?

For developing worlds the farms could be a center for development, and substituting some high technology solutions with labor intensive solutions provide for employment for a substantial part of the population. For developing areas it would mean a more reliable source of food, a more solid infrastructural foundation to build a society upon and a basis for a more solid economy. In addition it would likely reduce the amount of food related traffic within the city, although that is difficult to quantify. The quality of food could be regulated better and the water filtration properties of a vertical farm are paramount to healthy future development, this being a major issue in many developing areas. It could assist in providing employment for women in countries where women have lower (agricultural) social status and provide for a framework of reintegration of these classes and an emancipation of this status. But not just for developing countries vertical farms could be a solution to multiple problems. Countries like Iceland, Chili and Japan, which have very little agricultural land available, could start reducing their dependence on imported goods, making them vulnerable to economic sanctions.



8. Conclusion

In such an early stage it is difficult to predict what the effects of large scale urban farming would be. In could range from a nice and functional addition to the agricultural services that could provide some places with a percentage of their food contribution in highly developed countries, to being a revolutionary development in food production that shifts the balance from rural to urban and empowers developing countries in economical, political and social ways as not seen before.

Until then it is necessary to continue to push for experimentation and exploration of this realm. Without preliminary studies and the lessons learned from them it will be impossible to progress to a more detailed stage concerning the impacts of these kind of developments.