RECIRC IN ACTION

Green cities and future food supplies:
New opportunities for growth in aquaponics?

At the WAS meetings held in Prague last year, Dr. Paul R. Keldal, director of the Institute of Global Food & Farming (IGFF) based in Hellerup, Denmark, posed some interesting questions concerning how, in the face of increasing urbanization, people will secure food of sufficient quality and quantity, and explained how this has become part of FAO's food and healthy city strategy. Hatchery International *approached Dr. Kledal to share his thoughts on this subject by asking about the potential for setting up aquaponic production systems on rooftops and other small sites in rural or suburban areas to supply local markets with fresh fish and vegetables. According to Keldal, aquaponics offers this potential and is now getting important attention from both private entrepreneurs and public research institutions in Scandinavia.*

Tomatoes in an aquaponics installation at San Sebastian, Spain.

Aquaponics – a fusion of the words 'aquaculture' and 'hydroponics' – is also the fusion of two distinct production systems. Aquaponic systems operate

production profitable, 'Nordic Innovation' has funded a three year project (2012-2015) named Aquaponic Noma (Nordic Marine). The project will support researchers and private entrepreneurs in Denmark, Norway and Iceland to set up aquaponic production systems with the purpose of building up a scientific and commercial aquaponic cluster in Scandinavia. IGFF represents the Danish part of Aquaponic Noma.

THREE PRODUCTION SYSTEMS

Three production systems will be built, one in each of a rural, suburban and urban setting, and each having an annual output of approximately 4-6 tons of fish and 12-18 tons of various types of vegetables depending on market demand.

Iceland will take advantage of its geothermal resources for heating a greenhouse producing tilapia, whereas Norway will produce a cold water fish like trout, and focus on the economic trade-offs from saving energy compared to a slower plant growth under cooler greenhouse temperature.

In Denmark IGFF will explore the opportunities for integrating aquaponic food production with 'green' city planning policies that are already promoting green roofs, CO^2 neutral cities, and climate resilience. The Danish objective is to advance the economic viability of integrating aquaponics into urban farming, and also link the concept of 'multifunctional agriculture' to supply urban eco-services.

A 400m2 aquaponic greenhouse will be constructed on the roof of a library in Copenhagen, and combined with public space for gardening, leisure and learning. The

Juvenile tilapia are not currently available in Denmark and will have to be imported.

Heating elements inside a fish tank, more effective than simply using the air in the greenhouse.

numbers of each species.

Rainwater will be collected and used in the system, thus eliminating the need (and cost) of treating storm water in the municipal sewage system.

City compost will be applied as a growing media for the hydroponic section. 'Dynamic climate control' will

installation at San Sebastian, Spain.

subject by asking about the potential for setting up aquaponic production systems on rooftops and other small sites in rural or suburban areas to supply local markets with fresh fish and vegetables. According to Keldal, aquaponics offers this potential and is now getting important attention from both private entrepreneurs and public research institutions in Scandinavia.

Aquaponics – a fusion of the words 'aquaculture' and 'hydroponics' – is also the fusion of two distinct production systems. Aquaponic systems operate by growing fish in tanks from which the waste is collected and passed to a biofilter where the larger solid particles are removed and organic matter is transformed to inorganic nutrients used to feed the plants.

This cleans the water, which can then recycle back to the fish tanks, making aquaponics one of the most water-efficient production systems for both fish and plants. Normally the entire aquaponic production system is located in a greenhouse. However, in warmer climates, the fish can be reared in open ponds and the plants grown in a greenhouse, connected via the water recirculation system. Depending on the local climate, supply of fish and fish food, accesses to markets, and other cost constraints, aquaponics offers many opportunities for producing food efficiently and environmentally safely.

To explore the different economic and biological constraints more scientifically, and also to make aquaponic

on the economic trade-offs from saving energy compared to a slower plant growth under cooler greenhouse temperature.

In Denmark IGFF will explore the opportunities for integrating aquaponic food production with 'green' city planning policies that are already promoting green roofs, CO^2-neutral cities, and climate resilience. The Danish objective is to advance the economic viability of integrating aquaponics into urban farming, and also link the concept of 'multifunctional agriculture' to supply urban eco-services.

A 400m2 aquaponic greenhouse will be constructed on the roof of a library in Copenhagen, and combined with public space for gardening, leisure and learning. The rooftop is seen as a conflict-free zone in that it makes no demand for street-level urban space, while providing the required sunlight. A normal roof would need additional investment for reinforcing to support the weight of fish tanks and water, as well as taking into account access for resource inputs, sales and security. In this regard, the municipality that owns the library will cover these extra costs, and IGFF will be responsible for the cost of building and running the system.

TILAPIA FIRST

Initially, tilapia will be used, but other fish species will be slowly integrated into the system, either as mono-or polyculture. For the latter, crayfish will be placed in cages in the bottom of the fish tanks to examine the potential for increasing total tank biomass despite growing smaller

Heating elements inside a fish tank, more effective than simply using the air in the greenhouse.

numbers of each species.

Rainwater will be collected and used in the system, thus eliminating the need (and cost) of treating storm water in the municipal sewage system.

City compost will be applied as a growing media for the hydroponic section. 'Dynamic climate control' will be applied utilizing the fish tanks as temperature buffer during night with expected 20% savings on heating cost, but have an all year round stable production. Markets for the produce will be public institutions like schools and kinder gardens, as well as private outlets. This will be an example of a modern industry closing the urban resource cycle.

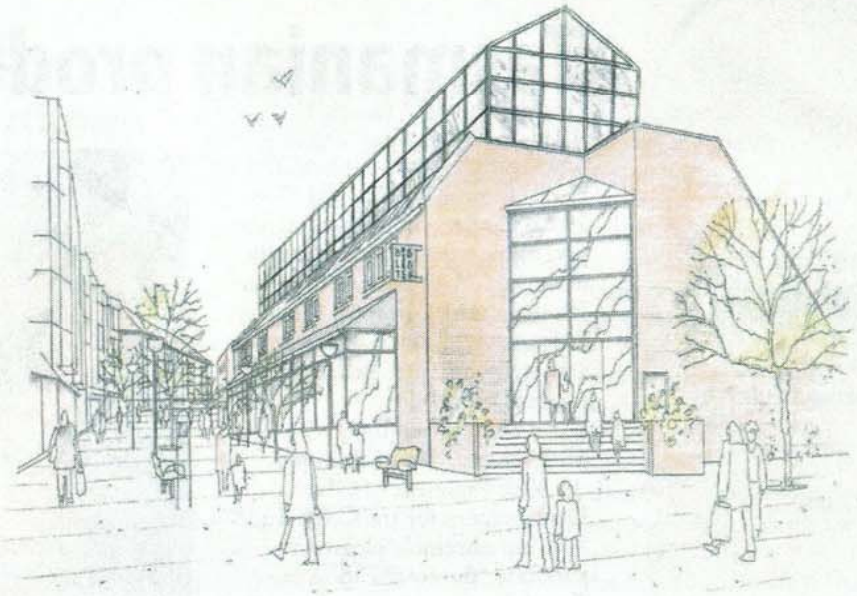
ECONOMIC RESEARCH

Economic research will explore the differences in potential trade-offs on energy costs of production in urban and rural settings. Likewise, the symbiotic effects on energy costs of combining two production systems will be the core focus. This will include:

- 'Economies of space'; by using the growing beds to shade the fish tanks and saving costs on cooling the water,

RECIRC IN ACTION

- Savings on CO^2 normally applied in greenhouses to the plants, but now produced by the fish and used by the plants,
- Applying *dynamic climate control* that exploits the variation in temperature in the greenhouse during day and night by allowing the fish tanks to operate as a heating buffer. Six months of energy savings are expected by reducing the demand for overnight heating.



Artists rendition of an aquaponic greenhouse on the library roof.

BLUEPRINT FOR CERTIFICATION

The Danish team has also accepted the task of making a blueprint for organic certification of aquaponics products, since no such rules exist today. Current EU organic certification rules do not allow for including aquaponics since recirculating systems and hydroponic systems without soil are specifically forbidden. According to Dr. Kledal, who is responsible for the Danish aquaponic plant proposal described here, 'organic' rules were originally set up in reaction to the intensification taking place within the conventional aquaculture- and horticulture sectors. They were not intended to discriminate against aquaponics *per se*, so he is very positive about changing the rules so that aquaponics can be a technology of choice for future 'organic' fish and vegetable producers.

COST STILL HIGH

Costs are still very high for entrepreneurs planning to start an aquaponic production system, plus the lack of good science-based knowledge on investment-and labor costs, as well as the insecurities and risks of producing food using three very different biological systems are heavy constraints for the expansion of this technology. In all three case studies by Aquaponic Noma the focus will be on how to manage and combine fish biology with bacterial – and plant biology. They will consider the different growth rates before harvest,

since no such rules exist today. Current EU organic certification rules do not allow for including aquaponics since recirculating systems and hydroponic systems without soil are specifically forbidden. According to Dr. Kledal, who is responsible for the Danish aquaponic plant proposal described here, 'organic' rules were originally set up in reaction to the intensification taking place within the conventional aquaculture- and horticulture sectors. They were not intended to discriminate against aquaponics *per se*, so he is very positive about changing the rules so that aquaponics can be a technology of choice for future 'organic' fish and vegetable producers.

COST STILL HIGH

Costs are still very high for entrepreneurs planning to start an aquaponic production system, plus the lack of good science-based knowledge on investment-and labor costs, as well as the insecurities and risks of producing food using three very different biological systems are heavy constraints for the expansion of this technology. In all three case studies by Aquaponic Noma the focus will be on how to manage and combine fish biology with bacterial – and plant biology. They will consider the different growth rates before harvest, the feed required for optimal fish growth, the related nutrient disposal for meeting plant requirements, and controlling diseases. Also included will be the problem of managing a demand-driven production system with volatile market prices, while operating a biological system that requires some measure of stability.

MORE RESEARCH AND KNOWLEDGE

They will also explore which plants or fish species that an entrepreneur could harvest quickly, and replace with another in response to changes in prices or demand, without risking the stability of the whole system? The will determine how long it will take to build up a stable bio-mass, and how one plans an on-going supply so a steady demand-driven harvest can take place and sustainable income secured? These are the sorts of questions that will be asked.

"To be a flexible aquaponic *bio-farmer* will require a broad based knowledge of management and thresholds within both economics and biology," says Dr. Kledal. "Of course the larger a production system is the more one can hire specialized labor with the specialized fish- and horticulture skills, but at this point it will require a much better understanding of the combined risks, and some agreements on demand that will secure a buffer of stability in markets and price."

EXPANSION PLANS

IGFF plans to expand its urban farming and green eco-service system to other cities, first and foremost to North Africa and the Middle East where land and water are scarce and under increased pressure owing to heavy population growth.

"These will be the centers of world population, production, consumption, leisure and sources of pollution," said Dr. Kledal. "Food will therefore be a central part of how to reorganize our cities so they become both more sustainable and secure, and increase our well-being."

Dr. Paul F. Kledal is director of the Institute of Global Food & Farming (IGFF) located in Hellerup, Denmark. He provided Hatchery International *with additional information, and furnished the illustrations. For more information contact Dr. Kledal at: paul@igff.dk*

– DJS for Hatchery International