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Report on Economies of Space

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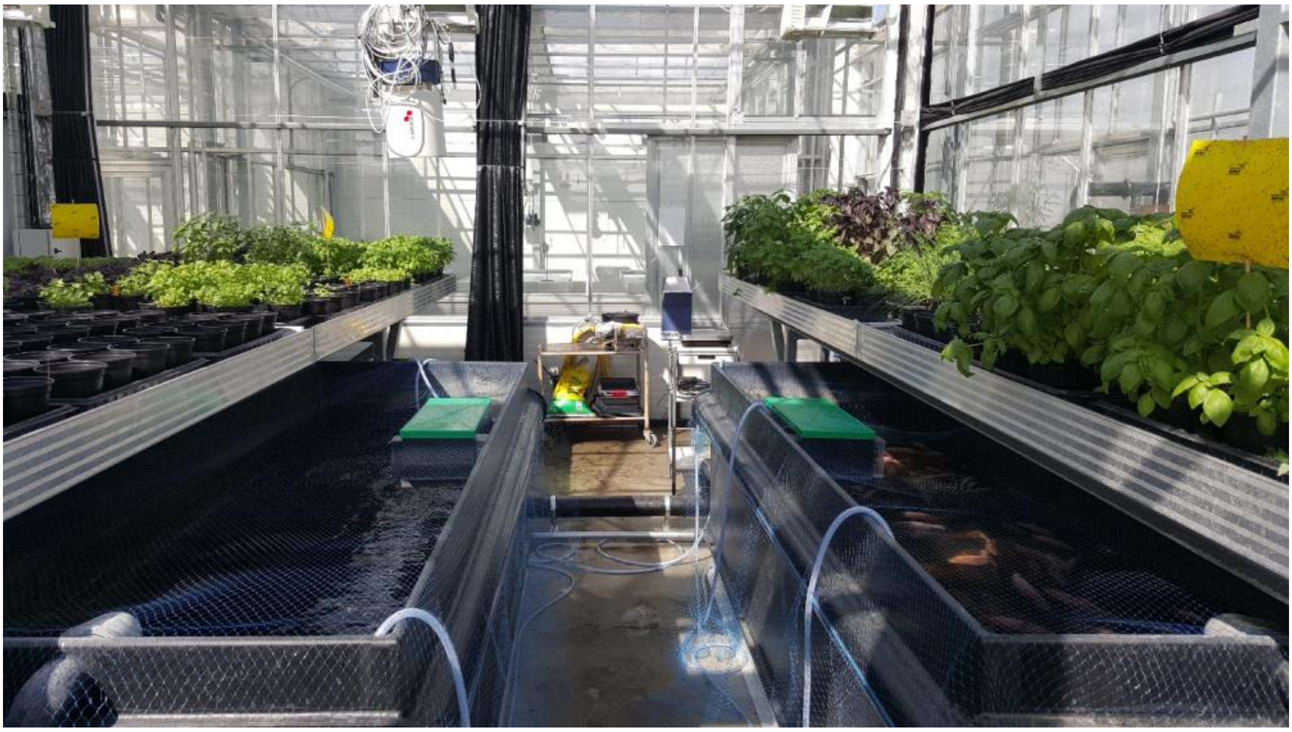


IGFF Aquaponic testplant: plant tables above the fish tanks saving space hence lowering investment cost and in the same time providing shade for the fish (2015)

1. Spatial economics as a symbiotic effect in aquaponics

Aquaponics opens up for taking advantage of various symbiotic effects when joining fish and plants together into a closed production system. The most important goes in regards to fish manure that becomes a fertilizer resource in the horticultural section, which in return cleans the water so the water can be recycled back to the fish reducing water consumption tremendously as well as pollution from the aquaculture section. Likewise, warm water fish kept in a heated greenhouse could in a similar way take advantage of the cost for heating, and hence contribute to the total revenue of the aquaponics production.

However, total earnings in aquaponics consists not only of various variable cost savings. Earnings are simultaneously burdened by high fixed cost derived from investments in two production systems.

IGFF has therefore analyzed the *spatial economics* as a potential symbiotic effect for cost savings in aquaponics, when combining the two production systems.

Both production systems require space in the form of fish tanks, bio-filters, sump tanks as well a large area for the horticulture produce itself. In cold climate zones, this would even mean large investments for a greenhouse to cover the space utilized. Could there be ways in the design of an aquaponics system, where the two systems could a) utilize the same space and hence reduce the fixed cost on the greenhouse investment, and b) in the same time support positive biological factors increasing productivity?

Many fish species do not require maximum light as plants do to perform optimally, but actually prefer to live in shade. The most obvious common area to utilize then would be the area above the fish tanks.

However, when trying to combine two food production systems, where one is physically covering the other you run into some practical barriers. One is the prevalent industrial design making it difficult to combine production systems that are highly specialized and made for optimizing the system by its own. Secondly, living food systems needs to be monitored daily, and access has to be easy. So when you start covering, you also need to be able to uncover the facilities in a fast and easy way as well.

2. Mobile plant tables for testing

In Denmark, more than half of the horticulture production takes place on mobile plant tables where the plants grow in pots. The other large part of the horticulture production takes place with NFT (Nutrient Film Technique) pipes. The mobility of the plant tables is made to have them cover as much of the greenhouse area as possible. When the laborer needs to have access for monitoring the plants, the tables are then pushed to one of the sides creating flexible aisle to walk at.

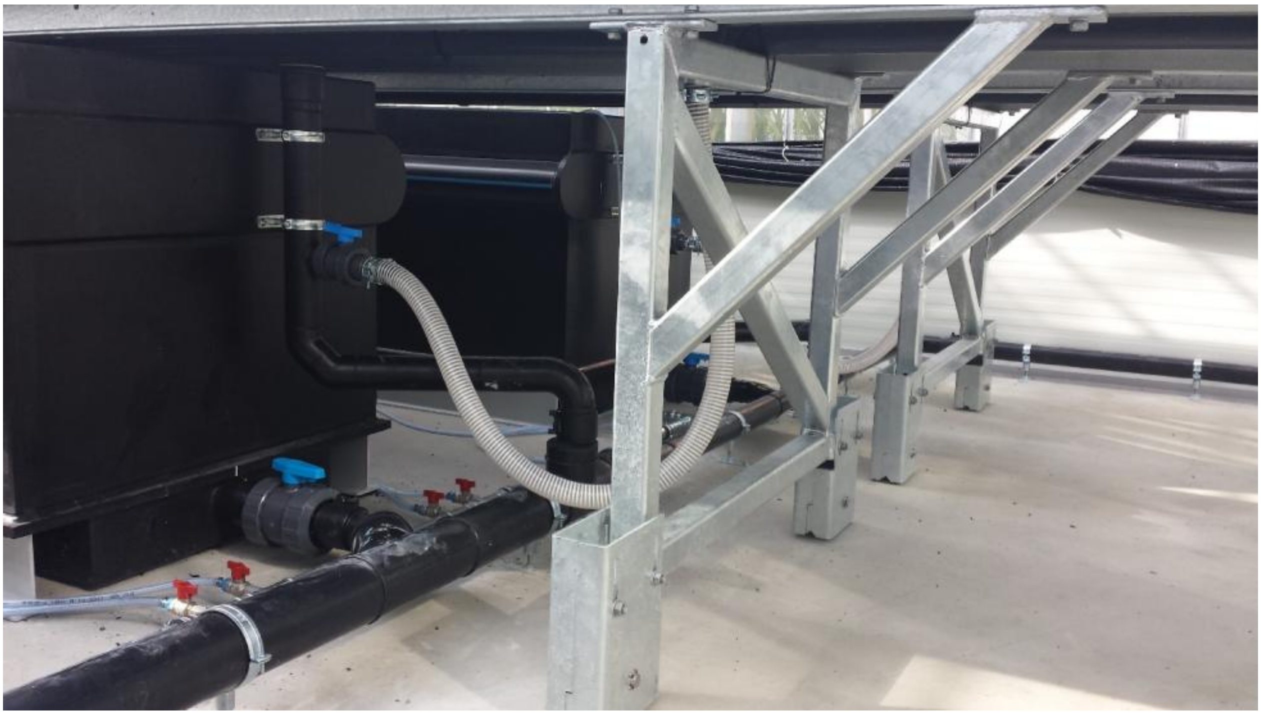
The IGFF test plant was installed with three traditional mobile plant tables of 9.5 m^2 each (1.4 m in width multiplied with 6.8 m in length) providing a total plant area of 28.5 m^2. The tables were then placed above three fish tanks of 3 m^2 each.

In total, the test plant with sump tanks, bio-filters and walking area covered approximately $70m^2$ greenhouse. The ratio of the common fish/plant area out of the total greenhouse area was 13% (9 m^2/ 70 m^2 x 100).

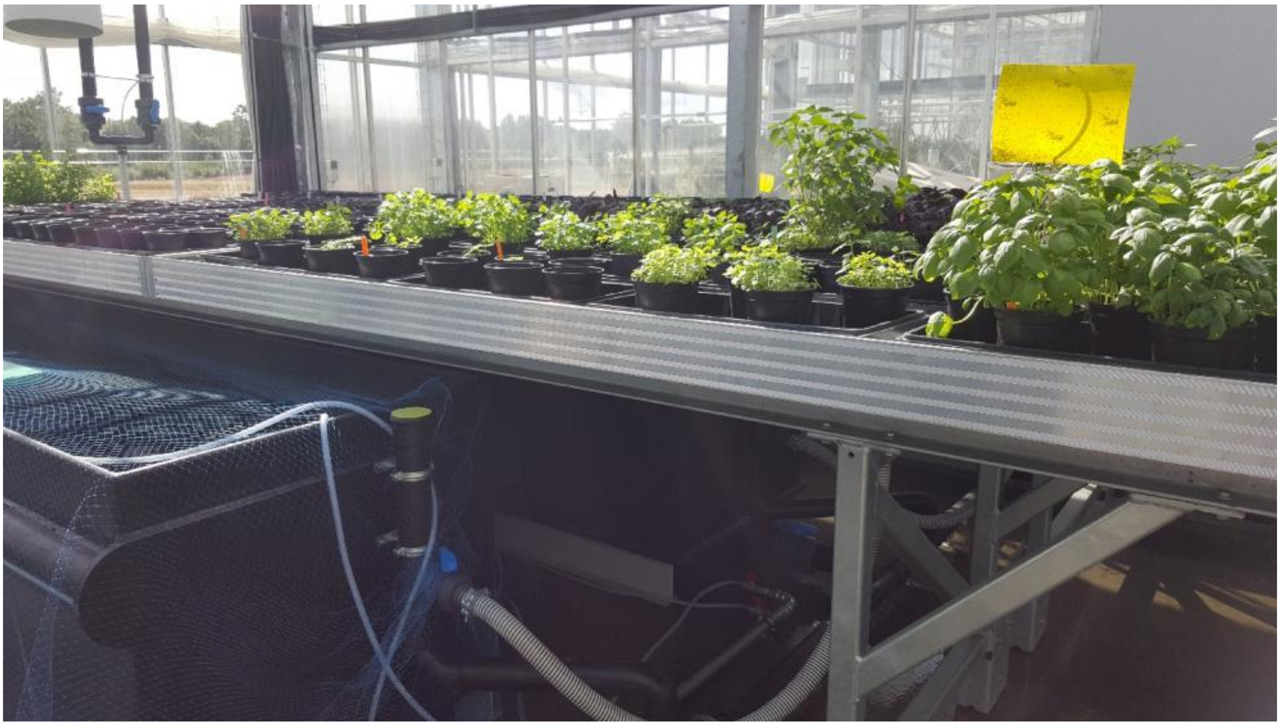
Normally the legging for plant tables does not make it possible to place them above fish tanks. Similar problem occurs with industrial systems using NFT piping.

A new legging design therefore had to be made, which could both carry the tables full loaded with plants and water on top, as well as securing that the tables had an easy mobility any time the fish had to be monitored.

In picture 1 and 2 the new design for mobile legging is shown carrying the plant tables. Likewise, a soft water pipe is seen attached from the plant table to the pipes returning excess water to the sump tank. In this way, the mobility of the plant tables are kept, when monitoring the fish are needed.



Picture 1. IGFF Legging of mobile plant tables, and supplied with flexible soft piping that leads the water from the plant tables back to the sump tank during ‘flood and ebb’ on the tables for feeding the plants.



Picture 2. IGFF mobile plant tables with horticulture produce placed above the fish tanks.

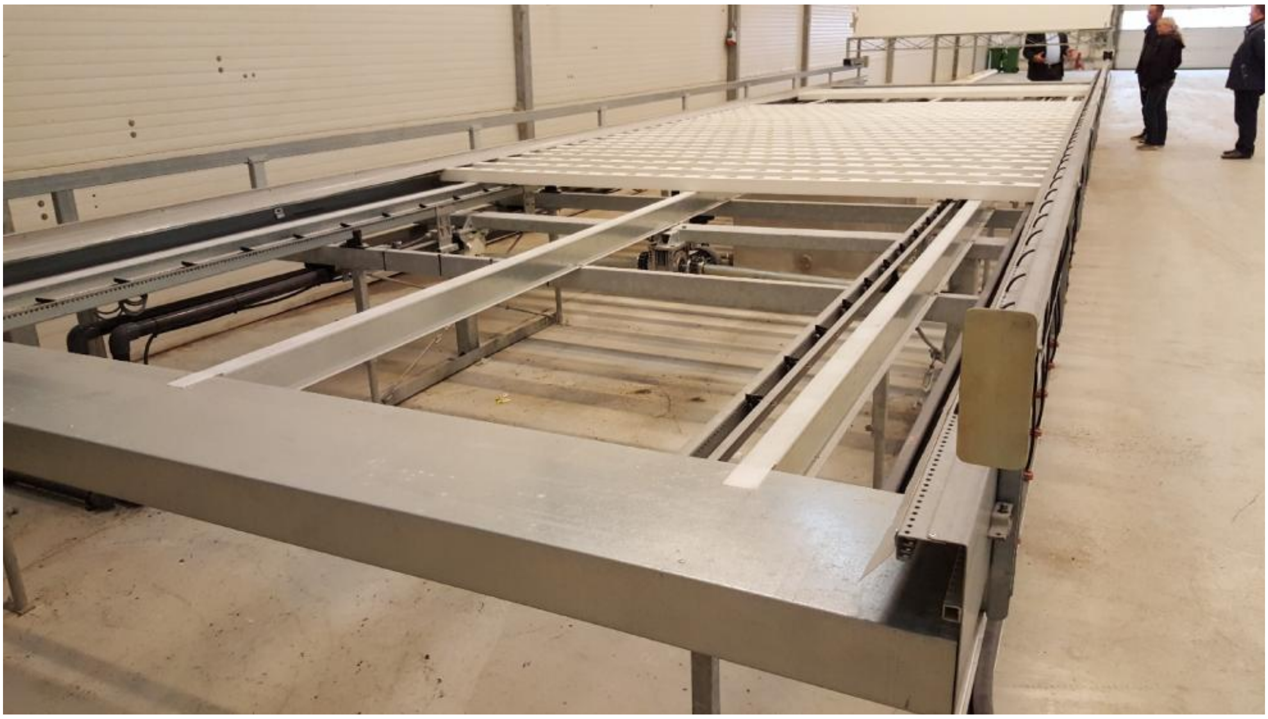
In practical terms, the system of mobile plant tables placed above the fish tanks worked well compared to the productivity of fish and plant output. However, the ratio between the common fish:plant area and the total greenhouse area should be raised to increase profitability in aquaponics.

Based on the experiences made during trials in the IGFF test plant, and preparing for the commercial production of 25 tons of Pike Pearch and 300.000 organic herbs per year (see IGFF report delivery 3.8) a new redesign for increasing '*economies of space*' was made.

Instead of using mobile plant tables in the new commercial production, the technique of NFT pipes was chosen. Likewise, the whole production flow in the horticulture- as well as the fish production had to be thought through, in comparison with the set-up of the test plant. In the horticulture production this went in regards to the whole flow from seed germination to propagation, transplanting and later sales. On the fish side, further space was needed for a) the input of small fingerlings placed in separate quarantine tanks all connected in a closed loop with its own bio-filters and sump tanks to avoid any contamination of the whole fish production, b) an area for pre-grow out fish tanks followed by grow-out and purge tanks.

All in all more space was needed, so the challenge of increasing '*economies of space'* further became even greater.

To secure the highest productivity on the horticultural side the 'Moving gutter system' with NFT piping was chosen.



Picture 3. The moving gutter system using NFT piping illustrating how an industrial design does not make it feasible to have fish tanks underneath, or if redesigned, would not make a daily monitoring optimal at all.

As illustrated in picture 3 the moving gutter system based on NFT piping, cannot be placed above fish tanks, and in the same time secure an optimal production with easy labor access and possibility of monitoring the fish. Instead, it was chosen to place the propagation area on grid shelves two meters above all the grow-out tanks. Access to the grid shelves are provided with a latter and a platform, making monitoring easy as well as the possibility for carrying away the trays with seedlings for transplanting. Despite of the extra area needed in the new aquaponics production, when the whole production flow was incorporated in both the horticulture and fish production, the common utilization area between fish and plant in relation to the whole greenhouse area increased to 25%.

3. Results

In the IGFF test plant the common fish:plant ratio area out of the total greenhouse area was 13%. Based on those experiences, together with the preparations for a commercial production, a redesign of technology choice and production organization was made. A moving gutter system for the plants were chosen using NFT piping. Above all the grow-out fish tanks propagation trays and seedlings were placed. This almost doubled the common fish:plant area ratio in relation to the total greenhouse area needed, so it covered 25%. In other words: by incorporating the symbiotic effects of aquaponics into a space optimizing production design the contribution on the fixed costs for housing in a cold climate was a reduction of 25% on the total greenhouse investment.

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