Exploratory Workshop Scheme

Scientific Review Group for Life, Earth and Environmental Sciences

ESF Exploratory Workshop on

EU Future Aquaponics

EW13-057 (LEE)

London (United Kingdom) 1 -2 September, 2014

Convened by:

Dr Benz Kotzen

Department of Architecture and Landscape, University of Greenwich, London, UK.

SCIENTIFIC REPORT

Co-sponsored by

UNIVERSITY of GREENWICH

1. Executive summary

The ESF Exploratory Workshop on EU Future Aquaponics was held at the Greenwich Maritime Campus in Greenwich, on Monday the 2nd and Tuesday the 3rd of September 2014. Participants arrived on Sunday the 31st of August and were met by the convener Dr Benz Kotzen and his colleague Dr Sarah Milliken at the Ibis Hotel, which is located 5 minutes walk away from the conference venue. (The University of Greenwich [the venue – Queen Anne 075] is located within the Greenwich World Heritage Site, provided a strong historical and academic backdrop for the conference.) On Sunday evening participants were guided to a local restaurant (Jamie's Italian) where dinner had been pre-booked. Late arriving participants were directed to the restaurant by the hotel staff. The restaurant provided a perfect opportunity for participants, including the ESF rapporteur, Dr Isabel Ambar (University of Lisbon) to be introduced and to get to know one another. There were 18 participants from 13 countries (Belgium, France, Hungary, Finland, Germany, Iceland, Israel, Norway, Slovenia, Spain, Switzerland, Turkey and the U.K.) Others present included the rapporteur and an administrative assistant. 8 out of the overall 19 participants were female.

On Monday the 1st of September, participants met after breakfast at the hotel lobby and were led to the meeting room by Dr Kotzen and Dr Milliken on the University campus. The University of Greenwich provided the meeting room, with audio-visual facilities. Additionally the University contributed through the assistance of Dr Milliken and providing printing and other sundry elements at no charge. This financial obligation was considered to be €1817.

Day 1 commenced with welcoming introductory talks by the convener, Dr Benz Kotzen and the ESF rapporteur Dr Isabel Ambar and a short introduction by each applicant about themselves, their institutions and their research projects and interests.

The two-day event was divided into six sessions, either side of tea/coffee and lunch breaks. Each session had a particular scientific focus and a core set of issues set out as bullet points for scientific discussion. Chairpersons were organised beforehand for each session based on their established skill sets and experience in various aspects of aquaponics. An additional reason for selecting session Chairs was to better democratise the sessions and allow discussion to flow more readily. This approach was readily accepted by participants and the Chairpersons and proved very successful.
The sessions were as follows:

- Session 1: Overview, policy review, knowledge hub;
- Session 2: Economic, Environmental, Social and Sustainability;
- Session 3: EU Aquaponics Training and Knowledge Dissemination;
- Session 4/1: Science and Systems Development;
- Session 4/2: Continuation of Science and Systems Development; and
- Session 5: Plenary - Outcomes of the Workshop and Next Moves.

The session topics and bullet points topics were chosen as key areas for discussion and helped to focus the dialogue over the two day event. The discussions were thus wide-ranging and extensive, covering the topic areas and more. Each session was headlined by a PowerPoint presentation by the Session Chair on a topic area related to the session. These opening talks provided a necessary focus and entry into the session. The broad spectrum of knowledge and experience in various aspects of aquaponics and the associated fields displayed by the participants provided for extensive dialogue but also an opportunity for learning about new ideas, new methods and the 'state of the art' for example in hydroponics and the current status quo in the European knowledge base.

All the participants entered into the spirit of the workshop by contributing their knowledge and ideas over the two days. Many participants as well as the Rapporteur noted that the workshop was free, democratic and the all the main topic areas were well covered through robust and lively discussion.

The key conclusions of the ESF Exploratory Workshop on *'EU Future Aquaponics'* are to:

- Promote the need for continued collaboration amongst EU researchers and practitioners and continue the progress made through COST Action FA1305 *'The EU Aquaponics Hub – Realising Sustainable Integrated Fish and Vegetable Production for the EU'*;
- Inform the public on what is Aquaponics and its benefits including environmental benefits;
- Define aquaponics and it's principles;
- Draft an 'Aquaponics Code of Practice';
- Make the case for aquaponics simple for investors;
- Focus on 'Certification' and standardisation and organic accreditation as these are big issue;
- Better understand the benefits and lifecycle costs of raft, media, nft and ebb and flow systems;
- Inform policy makers (food, farming, aquaculture, environment) about aquaponics;
- Concentrate on adding aquaponics at all levels in Schools and focus on aquaponics as a tool for learning in schools;
- Investigate publicity and marketing and potential in tourism rekated aquaponics;
- Research new fish and vegetable products;
- Gain a better understanding of Industrial scale aquaponics and whether this is viable either with regular or 'decoupled' systems;
- Focus on Industrial scale aquaponics, urban agriculture aquaponics and developing world aquaponics;
- Work together to develop aquaponics courses and content with an EU 'outcome based curriculum';
- Develop collaborations for research including Horizon 2020;
- Continue the workshop findings and the development of a 'Code of Practice' through COST Action FA1305.
- Seek collaborations across the globe.
- Ascertain who was doing, what and where in aquaponics.

The meeting was considered successful and a fruitful experience, by participants and the convenor in the exchange of knowledge and building a foundation for furthering collaboration, research, education, systems development etc., and most importantly providing a core group of people across the EU who will develop aquaponics as an important source of sustainable food which will benefit the environment and socio-economic conditions in the EU and extending across the world and particularly in developing countries. The ESF Exploratory Workshop on EU Future Aquaponics provided an important impetus to the newly formed COST Action FA1305 *'The EU Aquaponics Hub – Realising Sustainable Integrated Fish and Vegetable Production for the EU'* which will take the ideas and issues forward over the 4 year period of it's remit.

Aquaponists in the EU and around the world believe that aquaponics has a key role to play in sustainable food production in the EU and around the world and that the EU needs to, and has to provide opportunities for EU aquaponics to develop and for the EU to become a leader in aquaponics science and education. Thus, on behalf of the participants of the workshop we thank the European Science Foundation for this opportunity, which brought a

group of scientist, researchers and practitioners together to brainstorm and formulate the key issues and opportunities facing EU aquaponics development in the near future.

2. Scientific content of the event

The Exploratory Workshop was divided in 5 sessions, over two days. Each session ranged between 1.5 and 4 hours depending on the scope and extent of the issues that were being discussed.

Session 1: Overview, policy review, knowledge hub: Chair and Speaker: Ragnheidur Thorarinsdottir (Iceland) – *'Market Entry for Aquaponic Food Products'*
This session was chaired by Dr. Ragnheidur Thorarinsdottir from Iceland and commenced with her talk *'Market Entry for Aquaponic Foodproducts'*. The talk and following discussion noted the new interest in aquaponics in Iceland and in Scandinavia and noted that aquaponics was charcaterised by small units, but there were no large industrial scale facilities. The main challenges that are envisaged were merging the two parts of aquaculture and hydroponics, (this was a key outcome/observation of the workshop), visual quality of aquaponics and that aquaponics was not 'sexy' (the debate concluded that this depended on how you sell it) and marketing. The key to industrial scale aquaponics was seen to be technology as is the case for industrial scale hydroponics. Investment is a key deficiency and a key target for industrial scale aquaponics and the benefits need to be shown and proven. Aquaponics needs much better publicity and marketing and has potential in tourism and in the delivery of health/healthy products. The term 'Ecoponics' was mooted as the systems provided significant environmental benefits. Discussions also centred on vermiculture, water quality and fish welfare.

Research was discussed as an important issue. Aquaponics is seen to be in its 2nd phase (2nd Generation aquaponics). There is a significant move now towards 'decoupled aquaponics' in large-scale systems where there is no return of water from the hydroponic system to the aquaculture system. The issue of certification and whether the produce can be considered 'organic' was a key focus. Organic certification and the 'rules' across the EU and around the world was discussed as well as whether aquaponics needed to be organic or at least try to be organic and whether aquaponics could claim 'moral principles' and whether this would be just another 'sustainable label'. Other aspects that arose regarding this topic included the need to provide a premium and high quality products, meeting clear environmental standards, farming 'non-native species' such as *Tilapia* in Norway and Spain, using less energy and less water and generally minimising inputs and minimising negative outputs. The consumer needed to be provided appropriate information to make informed decisions. A discussion followed on food security, E.coli, salmonella, passing on pathogens and particularly the risks involved compared to traditional farming systems.

Other aspects that were discussed in this session and continued within later sessions included: recycling and zero waste (zeroponics), every school needs an aquaponics systems, requirements for training and better training, the great need to make aquaponics economically viable at all levels and the need to use high-tech at the large scale.

Session 2: Economic, Environmental, Social and Sustainability Chair and Speaker: Tom Beyers (Belgium) – *'The 7 Year Itch - Findings (cost-benefit analysis and practical issues) on industrial-scale systems'*

- Indicators for environmental, social and economic sustainability of aquaponic systems;
- Life-cycle cost analyses;

- From subsistence to industrial scales: analysis of social / financial benefits, cost-benefit analyses, valuation of ecosystem services, analysis of market chains etc.
- Develop best practice for:
- Automation for industry and manpower;
- Up-scaling and economisation;
- Marketing and strategies to manage price competition.

This session was chaired by Dr. Tom Beyers, with a talk about his experience with large scale hydroponic and research aquaponic production in Belgium titled *'The 7 Year Itch - Findings (cost-benefit analysis and practical issues) on industrial-scale systems'*. Belgium and the Netherlands are at the leading edge of green house horticulture. The talk centred on aspects of the sophisticated production in Belgium and the need to help farmers with low cost systems. Energy supply is a significant cost and the way to efficiency in glasshouse production is through CHP plants where energy can be sold to national grid and the CO_2 is used in the greenhouse, as is the excess heat. Two of the Belgian reseachers suggest that decoupled systems are the only way forward for industrial scale aquaponics as connected systems are less productive. This was seen as controversial as many participants are still of the opinion that aquaponics is at a premature development stage and that much work has yet to be done to effectively understand commercial viability. Aquaponics in urban agriculture scenarios and 'developing world aquaponics' were key areas to be researched and the commercial aspects were but part of an overall package of benefits. Jade Perch (*Scortum barcoo)* is being tested as a new fish product. It is omnivorous like *Tilapia* species and it tolerates high nitrate levels and is high in Omega 3. However this fish is sensitive to the approach of people and it gets stressed. Balancing water quality and requirements is a big issue in aquaponics and this was discussed. Potassium bicarbonate ($KHCO_3$) is used to raise the pH and plants use the potassium (K) for healthy growth. Another way is through the use of dolomite or the use of seashells as seen through Israeli experience. The methane produced through denitrification of effluent could be used for power or other purposes. The issue of manpower arose. In Belgium 6 people would be adequate per ha in greenhouses. The optimum for production for both fish and plants appears to be 70kg/m^2 with production levels of 636 tons of tomatoes and 18 tons of jade perch per hectare.

Session 3: EU Aquaponics Training and Knowledge Dissemination
Chair and Speaker: Hijran Yavuzcan Yildiz (Turkey) – *''Developing a blueprint for educational systems'*

- EU aquaponics facilities and training of next generation researchers;
- Developing blueprint for educational systems, specifically designed to demonstrate concepts and pitfalls in aquaponics with exhibitions and aquaponics 'kit';
- Developing practical training material for farmers and entrepreneurs;
- Creating social awareness of sustainable food production systems;
- Coordinating research cooperation through meetings, scientific exchanges, joint research proposals, joint publications, and conferences;
- Review paper possibilities and assemblage in a book.
- Common practice (or current best practice) white paper.

The session was chaired by Prof. Hijran Yildiz with an initial talk *'Developing a blueprint for educational systems'*. The talk and the session discussed the potentials for aquaponics as an educational tool in schools and aquaponics education. Aquaponics is seen as being fashionable and there are over 1 million sites on the web and lots of on-line courses and short courses are offered. This is confusing to the public as there are many opportunists who have very little experience in aquaponics jumping on the fashion bandwagon 'trying to make

a fast buck'. It was suggested that the blueprint for aquaponics education should be based on a 'life long learning' model. The issue of valuing food and the environment were important foci for aquaponics education. A key starting issue is that the man in the street, and generally people outside agriculture have little knowledge of aquaponics. Discussions covered the potential for learning using aquaponics in primary and secondary schools with a focus on core subjects such as maths, science, chemistry, botany but also on the environment and particularly care for the land / land management and land resources. The point was raised that in secondary schools pupils have a tendency to reject agricultural activities, as perhaps not being 'cool', whereas in primary schools there is a much stronger enthusiasm by pupils for growing vegetables and plants.

It was agreed that the issue of education was extremely important for the development of aquaponics and as a learning tool for children at all levels. Regarding higher education, discussions focused on where does aquaponics sit within the educational framework. Does it sit within agriculture, or aquaculture and should studies commence at undergraduate and/or postgraduate levels. It is intended that a new aquaponics course will be opened at Ankara University in Turkey and Prof Yildiz will ask participants for their input on the scope and content of the course. It was suggested that rather than setting up a complete programme that it would be best to introduce credits little by little into the system. 'Aquavet' was mentioned as a model. It is a 5-week course offered by Cornell University's College of Veterinary Medicine to provide practical training in aquarium and captive aquatic animal medicine. There is also a vocational programme in San Sebastian Spain (BREEN) that provides special programmes for unemployed people. The courses are 150 hours duration.

The discussions turned to the importance of who was doing what in aquaponics, how many researchers there are and how many people were undertaking PhD studies. There needs to be a 'map of training' to understand where people can obtain various skills sets at which institutes.

Session 4/1: Science and Systems Development
Chair and Speaker: Adrian Barnes (Israel) – '*Aquaponics - Technology, Timing, Trade'*

- Review systems / technologies of recirculating aquaculture and hydroponics;
- Development of technologies / strategies for water recycling;
- Review systems for northern/southern European scenarios;
- Define best practice to carry forward;
- Review best vegetable / fish products for EU.
- Develop scenarios for 1) industrial scale, 2) urban agriculture and 3) developing countries.

Adrian Barnes kicked off day 2 with a discussion on whether aquaponics could contribute to sustainable food production and what is required to implement aquaponics successfully. The discussion focused on Research and Development and case studies in Israel. A key question was 'Why Aquaponics?' and the issue of creating sustainable and successful systems. The need for aquaponics is illustrated by the peak in marine fishing and the growth in aquaculture on land. The merits of aquaponics as part of sustainable production was discussed in terms of water and energy conservation, potential use of non agricultural lands and as efficient protein production. The issue of ethical food production and educational value was raised. The discussion centred around a spreadsheet of a research project in the Negev Desert in Israel, which determined fish and plant production levels relative to cost. This was related to costs and production levels at two aquaponics facilities in the USA. The discussion also noted the need for Standard Operating Procedures (SOPs) and the important requirement to

match both fish and plant species with the climate and which species is best within the socio-economic framework. Additional points relate to what fish fry and / or seedlings are available as well as the availability of suitable feed. Further issues that contribute to sustainable and economic viability include the type of system (raft versus ebb and flow gravel based systems), materials and infrastructure costs and energy costs relating to aeration, pumping and climate control. The issue of biosecurity and pests both in the water and in the air was discussed. Aquaponic systems require robust 'Integrated Pest Control' (IPC) solutions and these will affect whether the produce can be considered organic or otherwise. Aquaponics could also use re-use water from neighbouring producers as they do in Holland and Belgium. There is also the potential to expand marine and saline water aquaponics. Aquaponists should also consider the case for producing less, but maintaining a high quality. The discussion on whether aquaponics could be labelled organic continued from the first day as well as a discussion on the benefits or otherwise of raft, media, nft and ebb and flow systems. What was required is a comprehensive list of benefits and drawbacks and lifecycle analysis of each type including the cost of materials, the waste produced as well as the overall cost of infrastructure and production costs. Can aquaponics for example compete with the 25-28 kg of produce per metre squared produced by hydroponics. The discussion continued in areas concerning scale of systems, coupled and decoupled systems, the advantages of aquaponics with 'free' nutrients from the fish. The discussion ended with the question of where we are going with aquaponics and the need to develop a knowledge base and identify the gaps in knowledge to be researched.

Session 4/2: Continuation of Science and Systems Development
Chair: Adrian Barnes (Israel), Speaker: Benz Kotzen (United Kingdom) – *'Aquaponics and Architecture'*

- Review systems / technologies of recirculating aquaculture and hydroponics;
- Development of technologies / strategies for water recycling;
- Review systems for northern/southern European scenarios;
- Define best practice to carry forward;
- Review best vegetable / fish products for EU.
- Develop scenarios for 1) industrial scale, 2) urban agriculture and 3) developing countries.

The penultimate session was chaired by Adrian Barnes with a discussion and presentation led by Benz Kotzen (convener) on aspects of architecture and aquaponics. The theme behind the presentation and discussion was a fashionable trend at that it was considered 'COOL'. Aquaponics was beginning to be seen as part of the 'Green Cities Agenda' with green roofs and living walls and as an important part of urban agriculture especially on rooftops. Large-scale multi-disciplinary design companies are investigating aquaponics as is evidenced in their evocative and trendy graphic images. Apart from numerous types of singular purpose aquaponic structures that can be located in backyards, on rooftops and in containers there are now designs which integrate aquaponics into large scale headquarters buildings as well as adapting existing structures to become 'state of the art' production facilities located immediately adjacent to the market. Biophilia is the next key phase in architecture where architecture integrates nature into the very fabric of architecture. However this trend will be surpassed by including food production within and integrated with buildings. The extensive inclusion of nature in buildings is not 'pie in the sky' but has already been achieved in the 'Bosco Verticale' in Milan. The following discussion focused on the provision of local food, lowering carbon footprints and integrating aquaponics with vertical structures. There is a great need to educate and train people in biophilic and food producing buildings and aquaponic engineered buildings. Other positive aspects of including aquaponics in

architecture include therapeutic gardening and using ornamental fish for aesthetics. The discussion continued on what fish to use and densities as well as the availability of fish species including tilapia, pike perch and sturgeon. There is also the potential to initiate new plant species with Asian vegetables, and strand vegetables such as samphire and sea kale. The discussion continued on the important area of 'off flavour' of some fish including tilapia which is caused by geosmin.

Session 5: Plenary - Outcomes of the Workshop and Next Moves
Chair: Benz Kotzen (United Kingdom)

Prior to the end of the workshop, the participants divided into equal groups to discuss and to arrive at an outline of a 'Code of Practice'. Each group were invited to answer key questions including a definition for aquaponics. The draft Code of Practice, which provides a focus for the future, is as follows:

Code of practice

Quality management

Aquaponics is defined as the activity and management of an integrated system of plants and aquatic organisms, while attempting to minimise non-renewable resource use.

Food safety

The food or ornamental products, both plant and animal are required to comply with the state of the art and relevant EU food safety standards and best practises.

Animal welfare

The treatment of the animals and production procedures are required to comply with the state of the art and relevant EU animal welfare standards and best practises.

Standards and quality of the produce

A product specification will be developed for each aquaponic product. This will be signed off by the chain of stakeholders and the relevant authority, which defines the acceptable limits of product quality.

Quality control procedures will be implemented to ensure specification standards are maintained accordingly. This applies to processing procedures, shelf life, maximum bacterial levels, environmental impact issues and organoleptic standards amongst others.

Certification

Until a specific certification scheme exists for aquaponics, it is good practise to utilise certification schemes for plant and fish products that meet existing acceptable EU standards. In addition, the parties that undersign this code of practise, will be preparing a certification scheme and suggesting membership to all interested aquaponic producers and stakeholders.

Regulation

The code of practise proposes involvement of aquaponic stakeholders in a self-regulated and documented certification scheme that will cover the standards to ensure absence of food safety issues and related impact on sustainable market development.

Systems

Aquaponics: (suggestion, change Wikipedia definition with:) a synergy of recirculation aquaculture systems and hydroponics to optimize the sustainable use of water, nutrients and energy
Inputs: (fingerlings, feed, plant seedlings, water, heat/energy): sources, quarantine restrictions, stable source of fingerlings, materials in system (rock wool, plastics, pvc piping, biofilter material…) and consumables (pot for plants, packaging fish).

Input/output: water quality: suspended solids, pH, oxygen, nitrogen, conductivity, trace elements, sodium and chloride. Differentiate between incoming and outgoing water to the fish and to the plants.

Outputs: (market fish, sludge, market plants, nutrient rich water, maybe heat/energy/CO2): stable market demand, waste materials, recyclable consumables (rock wool, plastics…), and consumables (pot for plants, packaging fish), other waste. Sludge use: for fertilizer, biogas production, biofloc, denitrification, source other elements that can be extracted (e.g., phosphorous)

Technology and best practice: C*ould include* Pest management: plants, fish, and humans as vectors of disease. Note: crop protection products need to be registered for each method of cultivation (we do not want to be a separate system, since companies will need re-register products)

Sustainability

Leaves more natural non-renewable resources available for future generations
Inputs (hardware, substrate, fish, feed, plants, water, oxygen, ozone, energy: heat, visible light, UV lights, pumps, additional plant nutrients)
Outputs (fish, plants, sludge, organic waste (reusable)
EIA:
- Positive: aquaponics is less polluting to air, water, and soil; produces less waste, smaller carbon footprint, smaller water footprint, enables sites for food production otherwise
- Negative: light pollution

Sustainability impact assessment: reuses waste as resource + EIA
Greenhouse gas emissions: smaller carbon footprint
Resource conservation: (water use): smaller water footprint, reuses waste as resource
Invasive species: safe, closed system, promotes native plant and fish species

Aquaponics Definition:
Aquaponics is :
1. A system of aquaculture in which the waste produced by farmed fish or other aquatic creatures supplies the nutrients for plants grown hydroponically, which in turn purify the water (Oxford dictionary);
2. The integration of aquaculture and hydroponics;
3. The integration of aquaculture and hydroponics optimizing use of resources and securing animal welfare.

Commercial aspects

Nutritional value – See also Food safety
Ensure food safety and defined quality through controlled management.
- Monitor water quality parameters (DO, pH, EC, macro- and micronutrients) according to monitoring plan
- Microbiological tests of products

- Estimating shelf life
- Measuring ingredients and estimating quality of products
-

Economic viability
Analysis of unit cost of production
- FCR
- Energy cost
- Water use
- Mass balance
- Labour
- Investment cost / IRR
- Waste management / aim for zero waste

Market analysis
- Consumer demand
- Current market supply
- Flexibility of production system and marketing

Business ethics
- Sharing knowledge and supporting uptake
- Integrity
- Transparency
- Social responsibility
- Regulatory compliance

Acceptable marketing procedures
- Transparency
- Meeting supply contracts
- Branding

Education

Scientific definition: Aquaponics is an integrated multi-trophic system that combines elements of recirculating aquaculture and hydroponics resulting in a symbiosis between fish, microorganisms and plants, encouraging sustainable use of water and nutrients, by minimizing the input of nutrients and the output of waste
Practical definition: Aquaponics is the production of fish and vegetables in one recirculating water system.
Marketing definition: Innovative and sustainable local and fresh production of fish and plant with water efficient; fertilizer saving.
- Aquaponics as an educational tool/tourism
- Aquaponics requires a scientific transversal approach (plant and fish biology, chemistry, microbiology, water and food science, engineer in automation, mathematics, design,…)
- Aquaponics sensitizes and addresses environmental issues engineering
- It is multi-problem solving, multidisciplinary skill building.
- It teaches ethics (animal care, food safety,…) and responsibility
- It educates people through practice to ecosystem functioning, resource use, reuse and waste management (water, organic matter,…).
- It connects people to nature and its function of food production.

Professional training and accreditation (necessary skills and competences):

- Minimal background: knowledge on at least one discipline (aquaculture or hydroponics) or enough proven practice in at least one discipline
- Development of practical training in two disciplines (aquaculture and hydroponics) at technical level
- Development of training in several disciplines (aquaculture, hydroponics, engineering, economics) at management level
- Tools for training : Workshops, internet courses, in situ training

Social aspects

- Autonomy to produce food
- Job creation (at different levels of education)
- Health sector (Therapy)
- Healthy food
- Recreation
- Community facilitator and cohesion
- Physical exercises
- Community wellbeing

3. Assessment of the results, contribution to the future direction of the field, outcome

The purpose of this Exploratory Workshop was to bring together a core group of EU scientists, researchers and practitioners to discuss the future direction of aquaponics in the EU, to establish greater connections amongst the researchers and to define future pathways for research, development of systems and to answer key questions tthat require action now and into the future. Aquaponics is an emerging area, which has great potential to provide sustainable food, on an industrial scale, as part of urban agriculture and in developing countries. The workshop created a forum to discuss these three crucial areas and to draw out the important issues related to aquaponics in general and in these 3 areas. The workshop did exactly that through measured but open and robust discussion. It was envisaged that this exploratory workshop would provide a kick-start, a boost, to the newly formed COST Action FA1305, *'EU Aquaponics Hub: Realising Sustainable Integrated Fish and Vegetable Production for the EU'* and this is exactly what has occurred. The discussions over the two days has created a much needed scientific, collaborative and social bond between the participants, which also extends through them into their institutions and scientific communities. The delivery of a draft 'Code of Practice' is a key outcome although not envisaged at the start of the workshop. Although it is only a draft and preliminary it provides and important step forward for aquaponics in the EU. The creation of a network of scientists, researchers and practitioners is an imperative in developing aquaponics in the EU and participants at the workshop are now involved in COST Action FA1305 which is chaired by the convener of the exploratory workshop, Dr Benz Kotzen. The intention of the Action is not only to create a hub of knowledge, innovation, education and knowledge transfer in the EU but to extend this across Europe's borders, more extensively to developing countries and in collaboration with other leading countries around the world such as the USA, Canada, Australia, Thailand and China. Although not a direct result of the workshop, in mid October 2014, five of the workshop participants presented papers at a special session on Aquaponics at the European Aquaculture Society's *'Aquaculture Europe 2014'* conference in San Sebastian, Spain. This conference brought the participants closer both scientifically and socially, which provides a platform for greater collaboration in the future. For example three of the participants are now involved in a Horizon 2020 Marie Sklodowska-Curie Action Innovative Training Network (ITN) application on aquaponics. One of the outcomes of this

workshop was indeed to look forward to opportunities for collaboration including Horizon 2020.

4. Final programme

Sunday 31 August 2014

Afternoon	Arrival of participants
19:30	Welcome dinner at local restaurant (Jamie's Italian) - Meet in Ibis Greenwich hotel lobby

Monday 01 September 2014

08 :30 – 09 :00 - **Pre-Session:** Welcome by
Benz Kotzen, University of Greenwich, London, United Kingdom and Isabel Ambar, University of Lisbon, Portugal (ESF representative)
Round table Introductions

09:00 - 12:30 **Session 1:** Overview, policy review, knowledge hub:
Chair and Speaker: Ragnheidur Thorarinsdottir (Iceland) – *'Market Entry for Aquaponic Food Products'*

- Policy and legal reviews across EU and the world – aquaculture, hydroponics, aquaponics, water, etc;
- Review / quantify sustainability potential;
- Review and develop common research agendas, in consultation with industry and other stakeholders;

(10:30 – 11:00 Coffee Break)

12:30 – 13:30 Lunch Break

13:30 - 15:30 **Session 2:** Economic, Environmental, Social and Sustainability
Chair and Speaker: Tom Beyers (Belgium) – *'The 7 Year Itch - Findings (cost-benefit analysis and practical issues) on industrial-scale systems'*

- Indicators for environmental, social and economic sustainability of aquaponic systems;
- Life-cycle cost analyses;
- From subsistence to industrial scales: analysis of social / financial benefits, cost-benefit analyses, valuation of ecosystem services, analysis of market chains etc.

Develop best practice for:

- Automation for industry and manpower;
- Up-scaling and economisation;
- Marketing and strategies to manage price competition.

15:30 – 16:00 Coffee Break

16:00 – 17:30 **Session 3:** EU Aquaponics Training and Knowledge Dissemination
Chair and Speaker: Hijran Yavuzcan Yildiz (Turkey) – *"Developing a blueprint for educational systems*

- EU aquaponics facilities and training of next generation researchers;
- Developing blueprint for educational systems, specifically designed to demonstrate concepts and pitfalls in aquaponics with exhibitions and aquaponics 'kit';
- Developing practical training material for farmers and entrepreneurs;
- Creating social awareness of sustainable food production systems;

- Coordinating research cooperation through meetings, scientific exchanges, joint research proposals, joint publications, and conferences;
- Review paper possibilities and assemblage in a book.
- Common practice (or current best practice) white paper.

19:30 Dinner at local restaurant (The Trafalgar) Meet in Ibis Greenwich hotel lobby

Tuesday 02 September 2014

09:00 - 13:00 **Session 4/1:** Science and Systems Development
Chair and Speaker: Adrian Barnes (Israel) – *'Aquaponics - Technology, Timing, Trade'*

- Review systems / technologies of recirculating aquaculture and hydroponics;
- Development of technologies / strategies for water recycling;
- Review systems for northern/southern European scenarios;
- Define best practice to carry forward;
- Review best vegetable / fish products for EU.
- Develop scenarios for 1) industrial scale, 2) urban agriculture and 3) developing countries.

(10:30 – 11:00 Coffee Break)
13:00 – 14:00 Lunch

14:00 - 15:30 **Session 4/2:** Continuation of Science and Systems Development
Chair: Adrian Barnes (Israel)
Speaker: Benz Kotzen (United Kingdom) – *'Aquaponics and Architecture'*

- Review systems / technologies of recirculating aquaculture and hydroponics;
- Development of technologies / strategies for water recycling;
- Review systems for northern/southern European scenarios;
- Define best practice to carry forward;
- Review best vegetable / fish products for EU.
- Develop scenarios for 1) industrial scale, 2) urban agriculture and 3) developing countries.

15:30 – 16:00 Coffee Break

16:00 – 17:30 **Session 5:** Plenary - Outcomes of the Workshop and Next Moves

- Discussions on the workshop;
- Research proposals and consortia;
- Main Outcomes and ways forward;
- Responsibilities for future outputs and activities including newsletter;
- Appointing Steering Group for outputs.

5. Final list of participants

ESF Representative:

Isabel Ambar, University of Lisbon

Participants:

Benz KOTZEN, University of Greenwich, UK
Dieter ANSEEU, Vives, Belgium
Michael Adrian BARNES, Desert Aquaponic Company, Israel
Tom BEYERS, Provinciaal Proefcentrum voor de Groenteteelt Oost-Vlaanderen, Belgium
Andreas GRABER, Zurich University of Applied Sciences, Switzerland
Haïssam JIJAKLI, Gembloux Agro Biot Tech, Belgium
Tamas KOMIVES, Hungarian Academy of Sciences, Plant Protection Institute, Hungary
Bettina KÖNIG, Humboldt University of Berlin, Germany
Mitja KOPINA, Gnezdo d.o.o., Slovenia
Vesna MILICIC, University of Ljubljana, Slovenia
Juhani PIRHONEN, University of Jyväskylä, Finland
Charlie PRICE, Aquaponics UK Ltd., United Kingdom
Lidia ROBAINA, Universidad de Las Palmas de Gran Canaria, Spain
Javier SANCHEZ, University of Murcia, Spain
Siv Lene Gangenes SKAR, Bioforsk East Landvik, Norway
Ragnheidur THORARINSDOTTIR, University of Iceland, Iceland
Morris VILLARROEL, *Universidad Politécnica de Madrid*, Spain
Hijran YAVUZCAN YILDIZ, Ankara University, Turkey

6. Statistical information on participants

GENDER	M: 11	F: 7	
AGE BRACKET	20-30: 2	30-40: 8	40-65: 8

COUNTRY	Belgium: 3
	Finland: 1
	Germany: 1
	Hungary: 1
	Iceland: 1
	Israel: 1
	Norway: 1
	Slovenia: 2
	Spain : 3
	Switzerland : 1
	Turkey : 1
	UK: 1