Food & Business Global Challenges Programme
2014 – 2nd call for proposals
Application form for Fast Track Research

Please consult Section 6.1 of the call for proposals for instructions on the application form

Registration

Aquaponics Ethiopia: Developing a business model for sustainable implementation of small scale aquaponics systems improving food and nutrition security of rural and peri-urban households in Ethiopia.

1. Title

Aquaponics Ethiopia: Developing a business model for sustainable implementation of small scale aquaponics systems improving food and nutrition security of rural and peri-urban households in Ethiopia.

2. Project

a) Focus/foci:

x	A. Inclusive business models for food security
	B. Regional trade for food security

b) Duration (max. 60 months)

27	Months

c) Main field of research (compulsory)
Please fill out one or more research fields and code from the NWO research field list.
Code & Field of research: Development studies
If applicable: other fields of research, in order of relevance
Code & Field of research: Life sciences; Micro-economics;

3. Composition of the consortium

Main applicant (coordinator)		Co-applicant	
Family name:	**Slingerland**	**Family name:**	**Getahun**
First name(s):	Maja	First name(s):	Abebe
Title(s):	Dr Ir	Title(s):	Dr
Male/Female (M/F):	F	Male/Female (M/F):	M
Expertise(s):	Farming systems & business models	Expertise(s):	Aquaponics, aquaculture
E-mail:	Maja.slingerland@wur.nl	E-mail:	abebe12002@yahoo.com
Organisation's name:	**Wageningen University**	**Organisation's name:**	**University of Addis Abeba**
Type of organisation*:	Research organisation	Type of organisation*:	Research organisation
Address:	Droevendaalse steeg 1; 6708 PB Wageningen, Netherlands	Address:	P.O. Box 32594, Addis Ababa, Ethiopia
Tel.:	+31 317-483512	Tel.:	+251-011-1239471

Co-applicant		Co-applicant	
Family name:	**Toorman**	**Family name:**	**Tadesse**
First name(s):	Rutger	First name(s):	Kibru
Title(s):	BSc	Title(s):	
Male/Female (M/F):	M	Male/Female (M/F):	M
Expertise(s):	Aquaponics engineering & business models	Expertise(s):	Director NGO
E-mail:	rutger_toorman@yahoo.com	E-mail:	tbakib@gmail.com
Organisation's name:	**TGS business development**	**Organisation's name:**	**Great Commission Ministry (GCM)**
Type of organisation*:	Private non-profit	Type of organisation*:	Private non-profit
Address:	PO Box 154, 6870 AD Renkum, Netherlands	Address:	P.O.Box, 41303 Addis Ababa , Ethiopia
Tel.:	+31 317 311 212	Tel.:	+251 116 514503

* Research organisation or other organisation (public, private non-profit or private for-profit)

4. Consortium and track record

a) Consortium: roles and added value — Word count: 400

The University of Addis Abeba (AAU) and TGS both have research/training/demonstration aquaponics facilities where more fundamental research questions can be addressed. Supported by FAO funding a prototype aquaponics system has been developed by AAU in Ethiopia and is ready to be implemented in farm households in Ziway and Shewarobit region. One role of AAU is implementation of aquaponics systems in selected households meaning installation, training, support in input provision and marketing and providing technical assistance during the production cycli. TGS has secured funding to support GCM, a NGO, in building an aquaponics training and demonstration centre in Hawassa. TGS and AAU will provide training of the staff of this centre (training the trainers) and provide backstopping on the establishment of aquaponics systems in households, selected by GCM. Supervised by Wageningen University (WU), GCM will conduct monitoring and evaluation activities on the aquaponics systems and their effect on household nutrition security. WU has expertise in modelling of nutrient cycling in integrated production systems. AAU supervises a PhD that works on developing alternative fish feed. At TGS facility in the Netherlands WU is conducting preliminary research on nutrient cycling for one fish-vegetable system and this will be extended to the Ethiopian systems. WU will take the lead in the design research for monitoring and evaluation of the aquaponics system and its impact on food and nutrition security of farm households, together with the project partners. WU and TGS both have theoretical and practical experience with different business models (cooperatives, outgrowers model, franchise system, etc) for different innovations proposed to farmers in different contexts. To develop a sustainable business model for aquaponics for Ethiopian farmers, the technical expertise of AAU and TGS, the knowledge of and interaction with farm households by GCM, the expertise on business models by WU and TGS and the possibilities of the demonstration centers run by AAU and GCM will be matched with the possibilities of local market players for input provision, credit facilities and marketing identified during the project duration and supported by the results of the research conducted during the project duration. WU and AAU will jointly design the research, supervise students and research assistants, and write scientific articles. TGS will guarantee knowledge sharing between the project participants and aquaponics projects in other countries. WU will be responsible for management and reporting of project progress and finances towards WOTRO. AAU will be responsible for the field work.

(Max. 400 words, please add word count)

Consortium: recent publications
(Max. 5 per consortium member)

Only scientific staff within the consortium provided publications as both in TGS and GCM writing scientific publications is not within their tasks. We included a report of AAU to FAO to show that the work on aquaponics is very recent (2013) and has not yet been in a stage of scientific publication.

Getahun, A. 2013. A final report on "Support to sustainable aquaculture development through the smart use of water: promotion and technology transfer of small-scale aquaponic in Ethiopia" submitted to FAO Smart Fish Project, FAO

Vijverberg, J. Dejen, E., **Getahun, A**. and Nagelkerke, L. A. J. (2013). Zooplankton, fish communities and the role of planktivory in nine Ethiopian lakes. *Hydrobiologia*; Volume 722: Number 1: 45-60.

Anteneh, W., **Getahun, A.** and Dejen E.. (2013). Spawning migrations of Lake Tana *Labeobarbus* spp. (Teleostei: Cyprinidae) in the Ribb River, Ethiopia. *African Journal of Aquatic Sciences*; 1-8

Getahun, A. and Dejen, E**.** (2012). Fishes of Lake Tana: A Guide Book. Addis Ababa University Press, Addis Ababa, Ethiopia

Anteneh, W., **Getahun, A**., Dejen, E., Sibbing, F.A.,. Nagelkerke, L. A. J, De Graaf, M., Wudneh, W. Vijverberg J., and Palstra, A. P. (2012). Spawning migrations of the endemic *Labeobarbus* (Cyprinidae, Teleostei) species of Lake Tana, Ethiopia: status and threats. *Journal of Fish Biology* (2012) **81**, 750–765.

Gibtan, A**. Getahun, A.** and Mengistou, S**.** (2008). Effect of stocking density on the growth performance and yield of Nile tilapia (*Oreochromis niloticus* L., 1758) in a cage culture system in Lake Kuriftu, Ethiopia. *Aquaculture research* (2008): 1-11

João Guilherme Dal Belo Leite, Jos Bijman, Martin K. van Ittersum, **Maja Slingerland** (2014). Producer organisations, family farms and market connection: lessons for the emerging biodiesel supply chain in Brazil, *Outlook on Agriculture, Vol 43, No 2, pp 101–108 doi:10.5367/oa.2014.0159*

Schut, M., Cunha Soares, N., van de Ven, G.W.J., **Slingerland, M.A.** (2014).Multi-actor governance of sustainable biofuels in developing countries: The case of Mozambique*. Energy Policy* 65, 631-643

C.P. Pabón-Pereira, J.W. de Vries, **M.A. Slingerland**, G. Zeeman, and J.B. van Lier.(2014).Impact of crop-manure ratios and digestion time on the fertilizing characteristics of liquid and solid digestate during co-digestion. *Environmental Technology*. **DOI:**10.1080/09593330.2014.908242

André Monteiro Novo; **Maja Slingerland**; Kees Jansen; Argyris P Kanellopoulos; Ken E Giller (2013). Feasibility and competitiveness of intensive smallholder dairy farming in Brazil in comparison with soya and sugarcane: Case study of the Balde Cheio Programme, *Agricultural Systems, Volume 121*, *pp 63-72*

Zvinavashe, E.; Elbersen, H.W.; **Slingerland, M.A.,** Kolijn, S.; Sanders, J.P.M. (2011) Cassava for food and energy: exploring potential benefits of processing of cassava into cassava flour and bioenergy at farmstead and community levels in rural Mozambique. *Biofuels Bioproducts and Biorefining 5 (2). - p. 151 - 614.*

b) CVs of consortium members
(max 1 page per CV, include in Annex)

Research proposal

5. **Summary of the project proposal** Word count: 149
(Max. 150 words, please add word count)

Food & Business Global Challenges Programme, 2014 – 2nd call for proposals
Application form for Fast Track Research

To increase nutrition security of rural households in Ethiopia the project aims to increase the production of fish and vegetables while saving scarce natural resources, through the transfer of prototype aquaponics systems to 27 rural households in Ethiopia. A generic model for nutrient and water balances will be developed to support design and management of different fish-vegetable species combinations in different circumstances. Business models will be developed to allow establishment and running of aquaponics systems without need of external funding. Next to the existing research centre in Addis Abeba university the project will establish a training centre for the GCM (a NGO) in Hawassa and provide training of trainers. The centres will support further spread of the systems. Data will be collected in all rural aquaponics facilities and the research centres and results will be shared between AAU, TGS and GCM to increase performance of the rural aquaponic systems.

Description of the project Word count: 1997

(Max. 2,000 words, please add word count)

a) Background and rationale)

Food security is defined, according to the World Food Summit of 1996, as existing "when all people at all times have physical and economic access to sufficient, safe, nutritious food to maintain a healthy and active life". In Ethiopia the world Bank (prevalence of undernourishment index 2008-2012) estimates that in 2012, 40 percent of its population is undernourished. Erratic rainfall and frequent droughts limit food production. Hence dependency on rainfall for food production is risky and available water needs to be efficiently used. More than half of Ethiopian population is below the poverty line (IFAD, Rural poverty in Ethiopia, 2007) limiting their access to food. A lack of nutritious foods is responsible for protein, mineral and vitamin malnutrition. Stunting is indicative of chronic, long-term malnutrition and in Ethiopia this affects 44 percent of children under age five (UNICEF, 2012). Nearly fifty percent of the under-five mortality rate in Ethiopia is related to malnutrition. The World Health Organisation reported that in 2005, 20% of babies had low birth weight, 53.5% of children under five and 30.6% of pregnant women were anaemic, 34.6% of children were considered underweight and 50.7% of children suffered from growth retardation as a result of inadequate diets. Malnutrition at young age can have permanent effects such as impaired cognitive abilities limiting their capacities to learn. The available staple foods, mainly grains, provide energy but have low nutritional quality. An adequate diet therefore needs also to contain protein sources and vegetables. Production of nutritious foods at household level is often lacking, and the lack of income limits households accessing nutritious foods from the market. The "Cost of Hunger in Africa" study (WFP, 2012) states that Ethiopia loses around 16.5 percent of its GDP each year to the long-term effects of child malnutrition. Improved nutrition will mean greater progress in development for Ethiopia, in addition to greater economic returns and a more productive and healthier population.

One of the ways to contribute to solving the problem of malnutrition is the production of protein, mineral and vitamin rich foods in rural and peri-urban areas. As resources such as water and fertile soils are scarce in Ethiopia, there is a preference for production systems that are efficient in using these resources and do not depend on erratic rainfall. An option might be to grow crops in a water solution (hydroponics) not needing (fertile) soil and efficiently using water and nutrients to high yields (Grewal et al, 2011). However water and nutrient inputs are still required. Another solution might be aquaculture, producing fish. However the system can negatively impact the environment through the discharge of output effluent into the surrounding areas (Martins et al, 2010). The effluents can contain suspended solids, treatment chemicals and excess nutrients from fish waste and leftover fish feed, leading to problems of salinity, eutrophication and chemical pollution (Cheng, 2011). Systems have been developed where the waste water undergoes treatment to enable recirculation of the water to the fish. This can reduce the water exchange rate from $50m^3$ to $0.1m^3$ per kg of fish, but requires substantial investments in technology and capital. The sludge containing nutrients often remains underutilized and may cause environmental problems when discharged (Martins et al., 201). An aquaponics system is a system in which hydroponics is incorporated into a recirculation aquaculture system as part of the treatment of waste water priori to recirculation (Rackoy et al, 2006; AquaponicsUK, 2013). The fish water is biologically filtered through bacteria and the nutrients are extracted and used by the vegetables after which the water can flow back to the fish. The system is composed of fish tanks, solids filter, vegetable grow beds, pumps and the biological components are fish, bacteria (for biological nitrification of ammonia through nitrite to nitrate) and plants.

The university of Addis Abeba has developed a prototype aquaponics system (Getahun, 2013 report for the FAO). GTS in the Netherlands (Van Vliet, 2013) has equally experimented with aquaponic systems and has engaged with GCM Ethiopia to start implementation of such systems in Ethiopia. This system can be implemented at household level. Effectiveness of this technology is context specific which might lead to farmers preference for a variety of fish-vegetable combinations and levels of production, depending on input supply, market demand and dietary preferences. Given this variety of combinations adjacent research is needed to balance the system in terms of fish-plant ratios, quality and quantity of fish feed, water pH and temperature and water volume and recirculation rate. Furthermore research is needed on its economic feasibility. To prepare the future, the research aims at developing a business model that allows for its sustainable introduction, accounting for access to adequate technical assistance, affordable capital, quality inputs and markets.

b) Objectives

The objective of the project is to provide households with an affordable and profitable aquaponics system to generate protein and micronutrient rich food and income to improve their food security situation while being efficient with scarce resources such as water and nutrients. A second objective is to prepare the sustainability of existing and dissemination of new aquaponics systems through the development of a business model that can support establishment, technical assistance, input supply and marketing of products of such a well-performing aquaponics system.

c) Research and innovation questions and methods

When transferring aquaponics to the household level, different contexts may lead to a variety of appropriate fish-vegetable combinations and levels of production. Given this variety adjacent research is needed to balance the system in terms of fish-plant ratios, quality and quantity of fish feed, water pH and temperature and water volume and recirculation rate. Nutrient levels in the water will depend on the level of excretion of the fish and the absorption by plants, which may differ between fish and plant species and will also be related to the fish feeding rate and the total amount of water in the system (Seawright et al, 1998; Rakocy et al, 2006). The ratio between fish and plants is closely related to the nutrient balance in the system. The nutrient availability is affected by pH and temperature of the water. Most plants need a pH of the water between 5 and 7 but fish need pH between 5 to 10. The pH of the entire system needs to reach a compromise between the optima for fish, bacteria and plants (Bernstein, 2011). For most plants optimum water temperature is around 23 ^{0}C but several species may also grow at other temperatures (Rakocy et al, 2006). For Tilapia optimum temperature is between 28 and 30 ^{0}C whereas for carp temperature may be lower (Kotzen and Apelbaum, 2010; Bernstein, 2011). Under suboptimal water temperatures feeding of fish should decrease (Kotzen and Apelbaum, 2010). Plants and fish require different oxygen levels in the water and different species show different tolerance to suboptimal oxygen levels. Oxygen demand of fish goes up with higher feed consumption. The technical research will focus on these parameters and on achieving a nutrient balance in the system at appropriate pH, temperature and oxygen levels.

This research is designed to accompany this transfer of aquaponics to household level.
To reach the projects objectives (see section 6b) we identified the following three **research questions:**

1. How to optimize technical and socio-economic performance of the aquaponics systems with different fish-vegetable combinations in household conditions?

2. Does the aquaponics system contribute to providing food and nutrition security at household level?
3. Which business model is feasible to sustainably introduce aquaponics systems in rural Ethiopian households?

Addis Abeba University (AAU) has one aquaponics research/demonstration units itself and there is also a demonstration unit in Ziway and in Shewa Robit. The project will consists of establishing aquaponics units with 9 farm households around each of these demonstration units. In Hawassa TGS will first assist in the establishment of a central demonstration/training facility. AAU will support training of the trainers. Afterwards GCM and TGS will also establish nine aquaponic units with farm households. TGS has also a research facility in the Netherlands and WU will collect data in that unit to support the development of a nutrient balance model. Similar research will be conducted in AAU centers on different fish-vegetable combinations. Establishment consist of building the unit, providing small fish and vegetable seeds, providing fish feed for the first cycle and training of farmers how to run the system. After the first production cycle farmers need to buy inputs themselves from their revenues. Farmers will also be trained in financial management to being able to oversee the relation between investment and benefits and to deal with different time spans of fish and vegetable production. The project will technically support and monitor farmers for 2-3 fish production cycles of 6 months each. Within one fish cycle 4-5 vegetable growth cycles take place, depending on the vegetable species. Support also includes assisting in searching for reliable input provision to replace provision by the project and attractive marketing channels. After selection of the farmers a baseline study will be done with selected farmers and non-selected ones with similar profiles. The baseline study will be designed by WU and AAU but for execution of the baseline the project will use master students or technical staff of AAU. AAU will provide one PhD student and staff at different levels will be hired part time by the project to organize and guarantee data collection during the project duration.

We will use a mixture of **research methods**:

For **the first research question** a very important component is continuous and systematically monitoring of inputs and outputs in nutrients, water, energy, labour, cash and fish and vegetable biomass to assess the performance of the systems that are established. Each unit will be provided with a logbook that facilitates data collection and field assistants will regularly check those logbooks with the farmers. Furthermore water pH, temperature and nutrient content will be regularly measured and management will be adapted where needed. In parallel measurements in the experimental units in AAU and TGS and will be used to develop a model representing the nutrient cycling in aquaponics systems. The combination will allow for optimization of the systems regarding economic and biophysical efficiency. An Ethiopian PhD student is doing research on replacing fish feed by nuge cake and will be incorporated in the project as he will also include research on nutrient balances and economics. He will also research biological control of fungi. By gathering data from aquaponics systems in different households we will generate insight in the sensitivity of the system to farm households differences in management which in turn might depend on households resource endowments.
For the **second research question** a baseline survey will be done with aquaponics and non aquaponics households just before installation of aquaponics units, assessing current food and nutrition and income positions of households. The survey will be repeated at the end of the project. This allows to compare before and after the project and between aquaponics and non aquaponics households. To being able to attribute changes to project interventions more detailed data will be collected during the project duration through monitoring of the distribution of aquaponic products between home consumption and sales and the proportion of the income generated by aquaponics spend on purchasing food items.
For the **third research question** marketing information will be gathered and potential business partners will be interviewed. Based on the results of research question 1 and the differences between the GMC led and the AUU led system and the three field contexts different business models can be explored. We will use transaction costs theory, cost benefit analysis and other economic tools to assess different business models. Examples to be discussed include collective input provision and /or collective marketing by aquaponic farmers which might decrease transaction costs but this requires strong harmonization of the production cycli. Furthermore different funding models need to be explored especially covering installation costs and funding per cycle and payback mechanisms. The potential role of the demonstration and training units (AAU and GCM) in the business models needs to be identified.

6. Capacity development and knowledge sharing activities

Word count: 320

(Max. 400 words, please add word count)

a) Capacity development
The project will enhance the research capacity of Ethiopian scientific staff in modelling nutrient cycles, socio-economics, business models, monitoring and evaluation. The GCM staff will be trained by AAU and TGS in aquaponics technology and by WU in data collection methods for monitoring and evaluation. Results will be discussed to improve their performance. The project has a strong training component for farm households consisting of a formal two weeks training by AAU, TGS or GCM at the establishment phase of the aquaponics systems but equally during monitoring and evaluation as the beneficiaries assist in collecting data during the production cycles (18 months) and results will be discussed to increase their management capacities. BSc and MSc students will be participating in the project and thereby be trained in research questions, methods, data collection, analysis and discussion.

b) Knowledge sharing with the F&B Knowledge Platform and its local networks (including communication strategies)
TGS has a network of aquaponics initiatives in other countries such as the Netherlands, Egypt and Indonesia and will assure sharing of experiences during the project duration. The project will initiate a small internet platform where project results will be posted and also a question and answer section will be available. AAU has contacts from their prior FAO funded Smart Fish project and will assure that these contacts will be connected to the platform. Promotion/information activities will include well planned meetings and field visits for Ethiopian entrepreneurs, government staff, Dutch embassy staff, NGOs, university staff, without leading to much disturbance to aquaponics farmers. Such activities will also be organised amongst aquaponics beneficiaries to foster joint learning. Scientific findings will be presented in seminars in AAU and WU and published in scientific journals. Practical issues regarding establishment of aquaponics systems will be reported on in leaflets, field manuals, or simple calculation sheets. These will be shared between projects. GCM will especially focus on preparing these to support their field staff and farmers. TGS will annually share the project findings and products with the F&B Knowledge Platform.

7. Theory of Change & Research Impact Pathway with indicators

Word count: 298

(Max. 300 words for the Theory of Change, please add word count & max. 1 page for the Research Impact Pathway)

The long term aim of decreasing malnutrition through increased production of and access to nutritious food in rural areas of developing countries depends on a number of intermediate steps. First of all technically feasible, economically profitable and environmentally sustainable production systems need to be developed. This project choses for aquaponics systems combining fish and vegetable production, efficiently using scarce natural resources such as water and nutrients. A multifaceted approach focussing on high production, optimizing recycling of nutrients and economic profitability allows to develop an optimized system. Aquaponics allow households to produce nutritious foods for home consumption and for sale increasing their access to nutritious foods in the markets. By making a generic model of such systems they can be adapted to different local circumstances including different fish –vegetable combinations and different production levels depending on available inputs and market demand and prices. Secondly these systems need to be sustainably connected to market parties assuring regular supply of inputs and sales of produce against competitive prices. By establishing two training centres, training of its staff and by training of trainers, dissemination of the systems to farmers is supported, making use of the generic model. Business models are developed allowing for establishment and running of aquaponics systems without project funding. Publication in practical manuals and making the calculation model publically available allows easy access to and use of project results by parties in developing countries that consider implementing aquaponics systems. Publication of scientific papers enhances knowledge of the systems and allows others to scientifically build on research finding. Implementation of aquaponics systems is possible in all developing countries in forms adapted to local circumstances. This project provides the scientific underpinning for such implementation and thereby enhances production and access of nutritious foods decreasing malnutrition in rural areas of developing countries.

Theory of Change GCP

Problems to be addressed

1. Malnutrition in rural population is high
2. Insufficient production and insufficient sustainable production of food
3. Insufficient production of nutritious food
4. Limited access to nutritious food (protein, minerals, vitamins)

↓

Causes

1. Insufficient productivity of land per area and per unit of time
2. Inefficient and non-sustainable management and use of scarce natural resources such as water and nutrients
3. Insufficient production of nutritious food in rural areas due to focus on staple crops
4. Insufficient income generated in rural areas to access food in the market
5. Lack of infrastructure and business models for the production of nutritious foods in a sustainable and profitable way

↓

Underlying knowledge –related causes

1. Need for knowledge and technologies to develop production systems that produce high yields of nutritious foods per area and per unit of time
2. Need for knowledge and technologies to develop production systems that recycle scarce resources such as water and nutrients to enhance their efficient use and to decrease waste to the environment
3. Need to develop a generic model of water and nutrient cycling in integrated production systems to underpin design of systems with different components
4. Need for knowledge on and insight in the business environment of input providers and prices, output markets and prices, farmers' organization and management capacities and consumer preferences to develop systems that are profitable and sustainable.

→

Research outputs

1. A technically feasible aquaponics system is developed producing high yields of fish and vegetables per unit of area and time.
2. The aquaponics system is efficient in recycling of water and nutrients, limiting waste.
3. A model has been made of the aquaponics system to allow for the design of an efficient and profitable systems with different fish and vegetable combinations
4. The aquaponics system is profitable and connected to input output markets and farmers' organization and management capacities by a business model that guarantees its performance over time
5. Centers of expertise are capable of establishment of technically feasible, economically profitable and environmentally sustainable aquaponics systems based on use of the developed technical and business models.

↑

Research outcomes

1. Increased food production per unit of area and unit of time
2. Improved efficiency and sustainable management and use of natural resources, especially water and nutrients, through recycling
3. Increased nutritional value of food produced in rural areas especially fish and vegetables
4. Increased income from food production in rural areas leading to increased access to nutritious food in the market
5. Business models available for sustainable and profitable production of nutritious foods

↑

Research Impact

1. Malnutrition in rural population has decreased
2. Enhanced production and enhanced sustainability in production of food
3. Enhanced production of nutritious foods
4. Enhanced access to nutritious food (protein, minerals, vitamins)

Complete Research Impact Pathway diagram with indicators at output and outcome level (max. 1 page)*

Research outputs	Indicators	Research outcomes	Indicators	Impact
A technically feasible aquaponics system is developed producing high yields of fish and vegetables per unit time recycling water and nutrients.	Written guidelines and a calculation model are publicly available for establishment of technically feasible and environmentally sustainable aquaponics systems.	Increased sustainable production of nutritious food per unit of area and unit of time.	After 2 years each of the aquaponics systems in 27 households has produced at least once 200 kg of fish per cycle of 6 months and 2000 vegetable plants without use of fertilizer, of which 90% is sold.	Enhanced sustainable production of nutritious food in rural areas leading to increased availability of nutritious food in producing households and in rural markets
The aquaponics system is profitable	See above: guidelines and model include economic profitability	Increased income from food production in rural areas leading to increased access to food in the market.	All 27 aquaponics households make at least 10% profit on investments per production cycle of 6 months.	Enhanced access to nutritious food in rural area through home production and income generation.
Business models available for sustainable and profitable production of nutritious foods production.	Written guidelines available on the connection of aquaponics to the business environment including the role of centers of expertise.	The aquaponics systems are well connected to input output markets and technical support by a business model that guarantees their performance over time	All 27 aquaponic producers are sustainably connected to input and output markets by long term oral or written contracts and have at least twice a year contact with centers of expertise.	Enhanced sustainability in the production of nutritious foods in rural areas through systems that are profitable, well connected to market parties, and supported by centers of expertise.
Institutions are built to support aquaponics systems using the developed models for production and business development.	The centers of expertise(AAU & GCM) have shown to be capable to providing technical and market development support through trainings (2 weeks /household in establishment phase) and individual advice.	Centers of expertise are capable of establishment and support of aquaponics systems based on use of the developed technical and business models.	All 27 aquaponics households have received a two weeks training, and have at least twice a year contact with a center of expertise.	

* The Research Impact Pathway of the project should be aligned with the generic GCP Research Impact Pathway (see annex 6.3 of the call for proposals).