Integrated Agri-Aquaculture with brackish waters in Egypt

Mission Report (March 9 – March 17, 2014)

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Key words: agriculture, aquaculture, brackish groundwater, arid regions, Egypt, recirculating aquaculture systems RAS, irrigation, fertigation, private sector, SMEs

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Abstract

This report contains a summary of a feasibility study on Integrated Agri-Aquaculture (IAA) with brackish water in Egypt that was done in May 2013, plus the findings of a mission that discussed IAA with private enterprises, research institutes and government institutes in March 2014. There is considerable interest in the concept and several pioneering companies have already started with fish farming in recirculation systems (RAS) and with IAA in various ways. It is recommended to bring the various Egyptian and Dutch companies and research institutes that are active on the subject of IAA with brackish water together in an informal network to exchange knowledge, experiences and to initiate new pilot projects. There is a need for a clear definition in the Egyptian law and regulations of the salinity levels between which water is classified as brackish.

List of abbreviations

ACO	Aquaculture Consultant Office
WMP	Water Mondiaal Panel for Water Management
CDI	Centre for Development Innovation – Wageningen UR
CGIAR	Consultative Group of International Agricultural Research Centres
CLAR	Central Laboratory for Aquaculture Research
DLG	Dienst Landelijk Gebied (Government Service for Land and Water Management)
DRC	Desert Research Centre
EAGA	Egyptian Agribusiness Association
EBRD	European Bank for Reconstruction and Development
EEAA	Egyptian Environmental Affairs Agency
EFC	Egyptian Fish Council
EFPEA	Egyptian Fish Producers and Exporters Association
EIA	Environmental Impact Assessment
EU	European Union
FAO	Food and Agriculture Organisation of the United Nations
FCR	Food Conversion Ratio
FDOV	Fonds Duurzaam Ondernemerschap en Voedselvoorziening (Fund Sustainable Entrepreneurship and Food Security)
FDW	Fonds Duurzaam Water (Sustainable Water Fund)
FFS	Farmer Field Schools
GAFRD	General Authority for Fish Resources Development
GOVS	General Organisation for Veterinary Services
HEIA	Horticulture Export and Import Association
HP	Horse Power
HQ	Head Quarter
IAA	Integrated Agri- Aquaculture
ICAPP	International Company for Agricultural Production and Processing
IEIDEAS	Improving Employment and Income through the Development of Egypt's Aquaculture Sector
IIIMP	Integrated Irrigation Improvement and Management Project
IFC	International Finance Corporation
IFI	International Financial Institutions
IQF	Individually Quick-Frozen
KDEC	Knowledge Development and Exchange Community
LE	Egyptian Pound
MALR	Ministry of Agriculture and Land Reclamation

MCPD	More Crop Per Drop
MWRI	Ministry of Water Resources and Irrigation
N	Nitrogen
NGO	Non-Governmental Organisation
NMT	Natural Male Tilapia
NWP	Netherlands Water Partnership
P	Phosphorus
PPT	Parts Per Thousand
PPM	Parts Per Million
PRI	Plant Research International - Wageningen UR
RAS	Recirculating Aquaculture System
RfLR	Rula for Land Reclamation
SME	Small and Medium Enterprises
STOP	Salt Tolerant Potatoes
TOR	Terms Of Reference
UAC	Union of Aquatic Cooperatives
UPEHC	Union of Producers and Exporters of Horticultural Products
USD	US Dollar
VAT	Value Added Taxes
WF	WorldFish
WM	Water Mondiaal
WUR	Wageningen University and Research centre

Summary

Executive summary IAA mission March 2014

The objective of the mission was to update knowledge of the developments in the field of Integrated Agri-Aquaculture (IAA) systems using brackish groundwater in Egypt. As such the present mission can be considered as a follow-up of the previous activities in May 2013 in which we concluded that developing IAA should start in a pilot area first before developing the national level potential.

Previous work

The current activities implemented during the March 2014 mission are based on the results of the previous activities. These results included:

- The technical pre-feasibility of an IAA system consisting of medium technology Recirculating Aquaculture System (RAS) with red tilapia combined with a crop rotation of potatoes and Quinoa seemed feasible with an investment break-even time of 5 – 6 years.
- Research and Development was needed for amongst others:
  - Pilot testing of technical details by Egyptian entrepreneurs;
  - Establishing a learning platform to exchange knowledge;
  - Performing a market analysis of new crops and new fish types to be considered.
- A road map that considered an approval of the plan of activities in the June 2013 Panel Meeting and an elaborated business plan to be submitted to the November 2013 Panel meeting.
- A consultation of the Dutch Small and Medium Enterprises (SMEs) interested in the future development of IAA in Egypt in November 2013 in Wageningen, the Netherlands.

Observations

During our 5-days visit to private companies and research institutes in Egypt we made a number of observations including the following:

- Large investment plans to integrate aquaculture in agriculture in desert areas using brackish groundwater are under development. These large companies (we identified several and visited two of them) are working with large investment funds and have an interest in developing and refining the technologies.
- Several pilots on IAA are currently operational and running. Several more are under construction. These are all done by the private sector that wants to make a living out of this business and wants to learn how to optimise the systems.
- In the northern Nile Delta with the traditional fish farming (extensive pond system) no attempts for developing IAA is known to the mission members.
- WorldFish and the Desert Research Centre (DRC) seem to be knowledgeable partners for the further development of IAA.
- The brackish water definition needs to be confirmed by the Egyptian Government to enable entrepreneurs to invest in IAA.

Knowledge gaps

During our field visits we saw the struggle of the different entrepreneurs with mastering their IAA systems. The knowledge gaps that they are facing are not all rocket science problems but also simple and practical problems and challenges to adapt the systems (RAS systems and irrigation systems with brackish water) to the local physical and socio-economic conditions. The knowledge gap agenda is best provided by the sector itself to avoid lengthy research projects leading to solutions that may or may not be economically feasible. Filling in knowledge gaps is best implemented in close cooperation between Government, private sector and research organisations.

Actions
We have identified three actions to bring IAA to the national scale: 1) establishment of a short term IAA knowledge development and exchange platform; 2) involvement of Dutch and Egyptian SMEs; and 3) activities to enable export of cultured fish.

1 IAA Knowledge Development Exchange Platform
In order to quick-start learning from the different IAA pilots that are already operational and new pilots that may start in the near future and to avoid duplication of mistakes, knowledge exchange between pilots is needed. For such experimenting by the Egyptian private sector with participation of the Dutch private sector and facilitated by the Egyptian and Dutch research organisations about 240 k€ (VAT excluded) would be needed for a period of two years. After two years the project Knowledge Development and Exchange Community (KDEC) would be merged with the pilot project opportunity mentioned below.

KDEC is a very powerful project instrument similar to the mechanism that made the Dutch greenhouse sector competitive and changed it from an energy user to a potential energy producer. The majority of the project costs would be provided by the participating private sector companies (IAA front runners). Only a small proportion of the costs (small subsidies for the experiments and financing of the knowledge exchange) would be financed by Water Mondiaal.

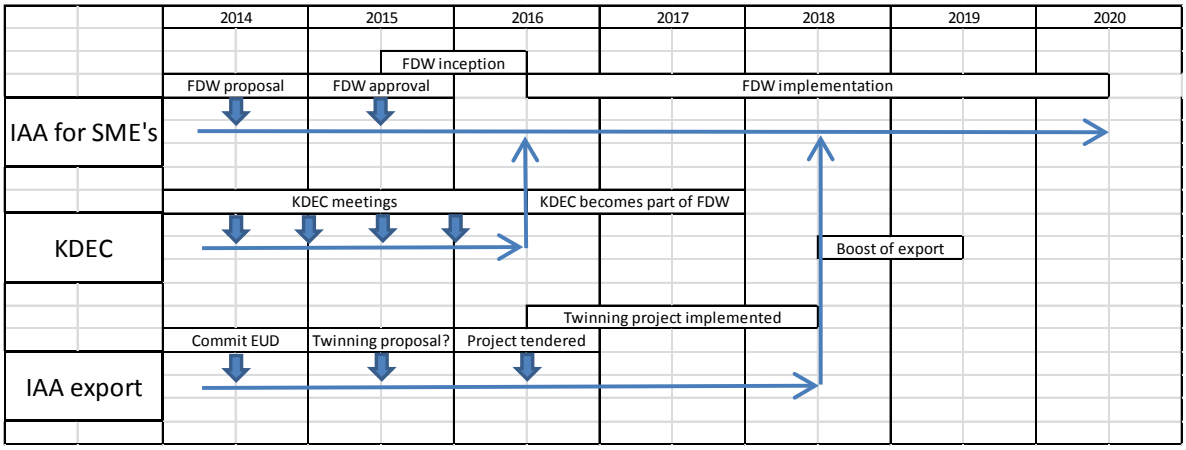
2 Involvement of SMEs
Both extensive RAS systems as well as precision irrigated agriculture, which are both included in IAA, are labour and capital intensive and less suitable for large scale mechanization. The Netherlands has a good track record in the knowledge intensive RAS systems as well as in precision irrigation. This brings the Small en Medium Enterprises to the forefront for the further development and rolling out of IAA.

This year (2014) there are two open calls for proposals for projects on Sustainable Water Use (FDW) and Sustainable Entrepreneurship and Food Security (FDOV). For both calls a subsidy of maximum of 4 million Euro (or 60% of the total eligible cost) is available for projects that may have a maximum duration of seven years. Consortia requesting subsidy must consist of at least one private sector party, one government party and one Non-Governmental Organisation (NGO) and at least one party should be from the receiving country (Egypt) and one party from the Netherlands. An important condition of the subsidy request is that the small and medium enterprises (such as the fish farmers in the Northern Nile Delta) are included in the project.

We suggest bringing partners together from three types of private sector organisations for such a project:
1. Large investors and agricultural companies who can benefit from the introduction of IAA on their establishments and /or who can benefit by small and medium enterprises for contract farming of crops and fish.
2. The current front runners in developing the IAA technology under Egyptian conditions. These are the innovators that deserve some support from the Government for the fast development and exchange of knowledge on IAA.
3. Small and medium enterprises that can learn from the experience of the front runners and benefit from the investment capacity of the large investors and private companies.

3 Enabling export.
Although the domestic market for farmed tilapia is large, the profit margins for the producer of farmed tilapia are often low due to the seasonality of the culture cycle. Most fish is offered for sale between October – December to avoid mortality due to cold weather. The large seasonal supply causes low profit margins. The margins are also shrinking due to rising feed prices. When adjusted for inflation the real price for tilapia in Egypt has declined with 37.7% in the period 2000 – 2010. This offers a serious challenge for the financial performance of the sector (Macfadyen et al, 2011). Entrepreneurs would have more marketing opportunities, more flexibility and less risk if the export opportunities for farmed fish from Egypt would be wider, including the EU. The European Union has an extensive

twinning program running through which Government Authorities and institutes in the EU countries can exchange and train their Government counterparts in the European Neighbouring Countries.



1 Introduction

1.1 Background

Fish farming has shown tremendous growth during the last decade in Egypt and has turned the country into a world-player in this field. Fresh water use for fish production is not allowed in Egypt (except government-owned hatcheries) and farmers use drainage water, ground water and marine water for this. Increasingly also brackish water is used for agriculture and for fish production.

Large pockets of (brackish) groundwater are available in the Oases in the Western Desert between the Nile and Libya. Oases are vulnerable and precious ecosystems and also represent an important cultural heritage, which has a large potential value in tourism. Uncontrolled farming and fish growing without restrictions on the drainage water discharge is therefore not desirable.

During the last decades, the Netherlands is also increasingly confronted with the salinity theme. Large parts of the country are below sea level and are very vulnerable for sea level rise as a result of climate change. Climate change adaptation of agriculture and other land use functions has progressed considerably in the Netherlands. The paradigm shift that is taking place deals with the change from 'protecting against climate change' towards 'adapting to the inevitable results of climate change'. Through government stimulation programs the sector is challenged to find solutions for adaptation. Through programs like 'Living with Salt' of the Top-sector 'Water' innovations are created to deal with the future saline conditions in the Netherlands caused by the expected sea level rise.

This experience of Egypt with producing brackish water fish species and the Netherlands with developing agricultural adaptation measures makes the combination of fish farming with agriculture using brackish water in an Integrated Aqua – Agricultural (IAA) approach a high potential for future economic cooperation activity between both countries. This integrated approach allows the reuse of water and nutrients to save on pumping costs and fertiliser input and to protect the environment (groundwater) against pollution. the Netherlands are quite advanced in knowledge and technology whereas Egypt has a strong private sector and a large potential of brackish, unpolluted groundwater.

The subject IAA has been on the agenda of the Water Mondiaal Panel since 2012 when the Panel members selected the subject 'Use of Brackish groundwater in agriculture and aquaculture: innovative trend at the national scale' for further elaboration. During 2013 a pre-feasibility study was implemented and the results were presented to the Panel meeting on June 14th. The Panel judged the results of the feasibility study as promising in terms of opportunities for private sector involvement for both Egyptian and Dutch entrepreneurs.

1.2 Terms of reference

1.2.1 Objectives

The direct objective of the Consultant Mission is to follow up the pre-feasibility study of 2013 and consultation of Dutch private companies. Specific objectives are:

- To identify and specify the knowledge gaps, bottlenecks and chances for the development of an IAA.
- To implement the stakeholder analysis.
- To develop and maintain the networks.
- To identify interested Private Sector parties.
- To update and upgrade the roadmap defined in 2013.
- To present the results to the Panel Meeting targeted in March 2014.

1.2.2 Expected results

The expected results of the Consultant Mission is a technical report with a clear indication of: 1) the knowledge gaps, threats and chances, 2) a stakeholder analysis, 3) a number of private sector parties interested in participation in further research and development and 4) an updated roadmap for the future IAA activities with 5) an indication of costs and financial sources to cover these costs. Further, a presentation to the Panel meeting targeted in March 2014 is also expected.

This result can be considered as an intermediate step in the development of a full proposal which will be ready in June.

1.2.3 Activities

The following activities need to be implemented as a follow up of the pre-feasibility study of May 2013:

1. Identify the knowledge gaps, bottlenecks and chances and formulate actions to remedy these, including but not limited to:
   - Agronomy in relation to precision irrigation techniques and salinity management (leaching to the top soil as a sustainability measure).
   - How to deal with nutrient management under a constant effluent-water supply and variable plant demand (optimising the use of the fish drainage nutrients).
   - How to limit the leaching of saline polluted water to the precious but brackish groundwater resource to a minimum.
   - Improve the financial and economic analysis performed by collecting and introducing better basic data.
   - How to develop a competitive business model targeting e.g. export.
   - How to improve the certification system of quality control to enable production of export quality and associated high prices.
   - How to develop a RAS fish culture system that is adapted to local conditions and the existing Egyptian fish culture system; How to manage temperature control in such systems to optimize production.
   - Which salt tolerant cash crops are attractive to entrepreneurs, how are their (national and international) market perspectives and do they already have existing chains?
   - How can plant growth and fish production optimally be matched throughout the year in terms of demand and supply for water and nutrients?

2. Develop, maintain and connect networks on Dutch and Egyptian side (the saline agriculture and aquaculture platform).

3. Identify Private sector parties willing to participate:
   - Egyptian parties with land, water, capital and entrepreneurial capacities.
   - Producers and retail organisations and NGOs.
   - Dutch parties interested to act as suppliers of technology and knowledge as well as importers and trade partners for the produced fish and agricultural products.

4. Identify IFIs (like the EBRD, IFC etc.) to enable the financing of private sector initiatives.

5. Perform a stakeholder analysis with specific attention to the Governmental regulatory role.

6. Identify the follow-up:
   - Update the road map based on the findings during the mission and propose follow-up actions.
   - Identify financing sources for the proposed follow-up road map.

1.3 Reading guide

The work done previously in the framework of the IAA is summarized in Chapter 2. Chapter 3 elaborates the knowledge gaps identified. An overview of the stakeholder analysis is presented in Chapter 4. In Chapter 5 an overview of the private sector companies interested in further development of IAA is summarized and in Chapter 6 the envisaged road map for future activities is presented.

2 Previous work

A number of IAA activities have already taken place in the past.

The Egyptian – Dutch Advisory Panel Project on Water Management (APP) organised in December 2005 a workshop titled 'The use of brackish groundwater in agriculture and aquaculture: seeking the future'. This workshop was attended by 66 persons and concluded with 14 recommendations of which the following three are very relevant for the present study:

- For development of the efficient use of brackish groundwater, the integrated farming system should be applied: aquaculture, followed by agri/horticulture (and eventually followed by livestock), taking into consideration that the main crop is the agriculture and aquaculture will be associated based on the water volume needed for the agriculture.
- In order to develop brackish groundwater aquaculture by the private sector, it is strongly recommended to establish pilot demonstration farms, since this approach did work very well in the case of freshwater aquaculture. These farms could be used for farming system optimization, applied research, and training and technology transfer. Suitable areas are: Kafr El Sheikh (in the framework of IIIMP): integrated farming system using brackish ground- and surface water and producing fish for domestic consumption and relatively salt-resistant crops (e.g. barley, sugar beet); North Sinai (integrated farming system on groundwater with a salinity of 5,000- 6,000 ppm and good accessibility); Western Desert (Oases), since there shortage of freshwater is imminent.
- It is recommended to organize all pilot activities in cooperation with the private sector (e.g. through professional societies), in order to facilitate the initiation of Public Private Partnerships.

Within the framework of the Water Mondiaal (WM) programme, the 2nd Egypt/Netherlands WM Panel Meeting on Water Management was held in Cairo from 28 to 29 November 2012. The main goal of this meeting was to review and discuss the prepared project papers by the Egyptian and Dutch expert members and to take a decision on concrete projects for further cooperation and a way forward. Under the theme 'More Crop Per Drop/MCPD', the Panel members selected the project 'Use of Brackish groundwater in agriculture and aquaculture: innovative trend at the national scale' for further elaboration.

In this context a pre-feasibility study for initiating a pilot project in the desert (or elsewhere) was commissioned to DLG, Alterra and Imares. The main objectives of this feasibility mission were:

1. Prepare a scoping study (project proposal) on the use of brackish groundwater in agriculture and aquaculture in Egypt. The feasibility of implementation of such an integrated system should be highlighted.
2. Investigate possibilities for strategic Integrated Aqua / Agriculture Systems, and propose relevant project partners from Egypt and the Netherlands, from the Government, research organizations and the private sector.
3. Develop components for a business model / business case, that will result in a structural positive cost/benefit ratio.
4. Propose the required institutional set-up, development of processes and procedures, framework, time schedule, and the required budget for the pilot.

The pre-feasibility study resulted in May 2013 in a concise report, entitled: 'Feasibility of the Use of Brackish Groundwater in Integrated Aqua-Agriculture systems in Egypt' (Moen, Roest and Kamstra, 2013). A number of recommendations and suggestions based on this report were made during the panel meeting:

For the Egyptian side:
- Make the licensing of brackish groundwater use in fragile desert environments conditional on environmentally safe nutrient and drainage water reuse.
- Research on precision irrigation techniques using brackish water for salt tolerant crops in Egypt is needed.
- Research on fish culture with brackish water in Egypt is needed.
- Complete the EU's seafood export file requested by EU.

For the Dutch side:
- Dutch knowledge and experience on IAA should be made available (Water Mondiaal).
- Stimulate Dutch entrepreneurs to participate in IAA development and provide incentives (Dutch Government).
- Assist Egypt to complete the EU's seafood export file requested by EU.

As a combined Egyptian – Dutch effort:
- Credits for facilities for starting entrepreneurs in IAA should / could be provided (Egyptian Government / Dutch Government).
- The establishment of a Centre of Excellence on IAA with brackish water for Egyptian and Dutch entrepreneurs and researchers should / could be supported (Water Mondiaal and Egyptian Government).

On piloting:
- Do piloting together with the private sector (Wadi Food, Hamada farm, Farm Frites, others) to ensure that research, experience and economics are integrally taken care of
  - Start with the lower salinity range of the available brackish groundwater resources.
  - Build on existing experience:
    - Wadi Food experience with extensive Recirculating Aquaculture Systems (RAS) and biofloc technology.
    - Wadi Food experience with growing Salicornia, Suaeda and Atriplex on the effluent of fish farming.
  - Upcoming experience with the cultivation of salt tolerant potatoes and inventory of suitable brackish water reserves in Egypt (Partners for Water - STOP project).
  - Experience of potato growing in desert environments (Partners for Water project together with Farm Frites).

On November 27, 2013, a meeting was organised by NWP/Wageningen UR in Wageningen to present the results of the feasibility study to a group of private companies from both the aquaculture and agriculture side. About 20 people participated in the meeting, which gave good insight in the possibilities and interests of Dutch companies to participate in development of IAA in Egypt.

2.1 Crop and fish selection

The different fish species have a highly variable score on a number of aspects (Table 1). Production of Nile Tilapia in ponds is suffering from rising prices for feed and decreasing profit margins. Red Tilapia has just been tested on the Egyptian market and fetches very good prices in certain locations and under certain conditions. Certain marine fish species currently have a good market. Farming marine species in cages has just started in Egypt but will eventually be the way forward in up-scaling the production. This way of production in cages is obviously much cheaper than farming in land-based systems. This characteristic of cage farming will remain a competitive edge in the future. Availability of stocking material should never be a bottleneck at the start of the project. Nile Tilapia is highly available, for other species (including red tilapia) this is more of a problem. For most fish, a market for

export could be developed if fish has the right quality and food safety could be guaranteed. Input from Dutch companies in terms of knowledge, hardware or stocking material differs. There is one Dutch company which has an unique strain of Natural Male Tilapia (NMT) Red and Black Tilapia which are exported world-wide.

Salt tolerance will be one of the main criteria to select crops for the integrated aqua- agriculture systems. Another important criterion is the year round growth of crops. This requires also the ability to grow during the hot summer temperatures in the desert environment when the drainage water production is highest. Potatoes are obviously a good choice for the lower salinity range. Jojoba and Quinoa are relatively unknown crops in Egypt, but have a high marketing potential for the medium salinity tolerance range. These two crops have a relatively high potential, but have also a high need for testing under Egyptian circumstances, further processing and development of the market. In the upper salinity level, the halophyte Salicornia is a high potential crop, but both the optimal growing system under dry circumstances and the market still need to be developed. There is an export opportunity to Europe during the winter period.

Table 1

Indicative scores of the different fish species and crops on several aspects. – negative, lacking to ++ very positive, abundant.

Fish	Technical knowledge	Profitability	Future competition	Stocking material	Possibilities for export	Input NL
Sole	-	?	++	±	+	++
Mullet	±	+	+	±	±	-
Sea bass	+	+	-	±	+	±
Sea bream	±	+	-	±	+	±
Meagre	+	±	±	+	++	±
Tilapia	++	±	±	++	++	+
Red Tilapia	++	++	+	±	++	++
Crops						
Potatoes+	++	+	+	++	++	+
Tomato	++	+	+	++	-	±
Broccoli	+	+	-	+	?	±
Peas	++	+	-	++	++	+
Garlic	++	+	-	++	-	-
Jojoba	±	++	+	-	++	±
Date palm	++	+	+	++	±	-
Sugar beet	+	+	-	++	-	-
Quinoa	-	±	±	-	+	+
Tamarix	-	-	-	-	?	±
Atriplex	-	-	-	-	?	±
Salicornia	-	-	-	-	?	±

With regard to fish it can be concluded that red Tilapia has high potential. But good quality fingerlings for red tilapia are difficult to obtain in Egypt and import of live fish is probably restricted. For crops we propose to consider potatoes and Quinoa as annular crops and the desert crop Jojoba as a perennial plantation.

Tolerance for salinity differs widely between fish species and crops (Figure 1). Few commercial crops have high tolerance for salinity and most possibilities for combinations are in the low range of salinities.

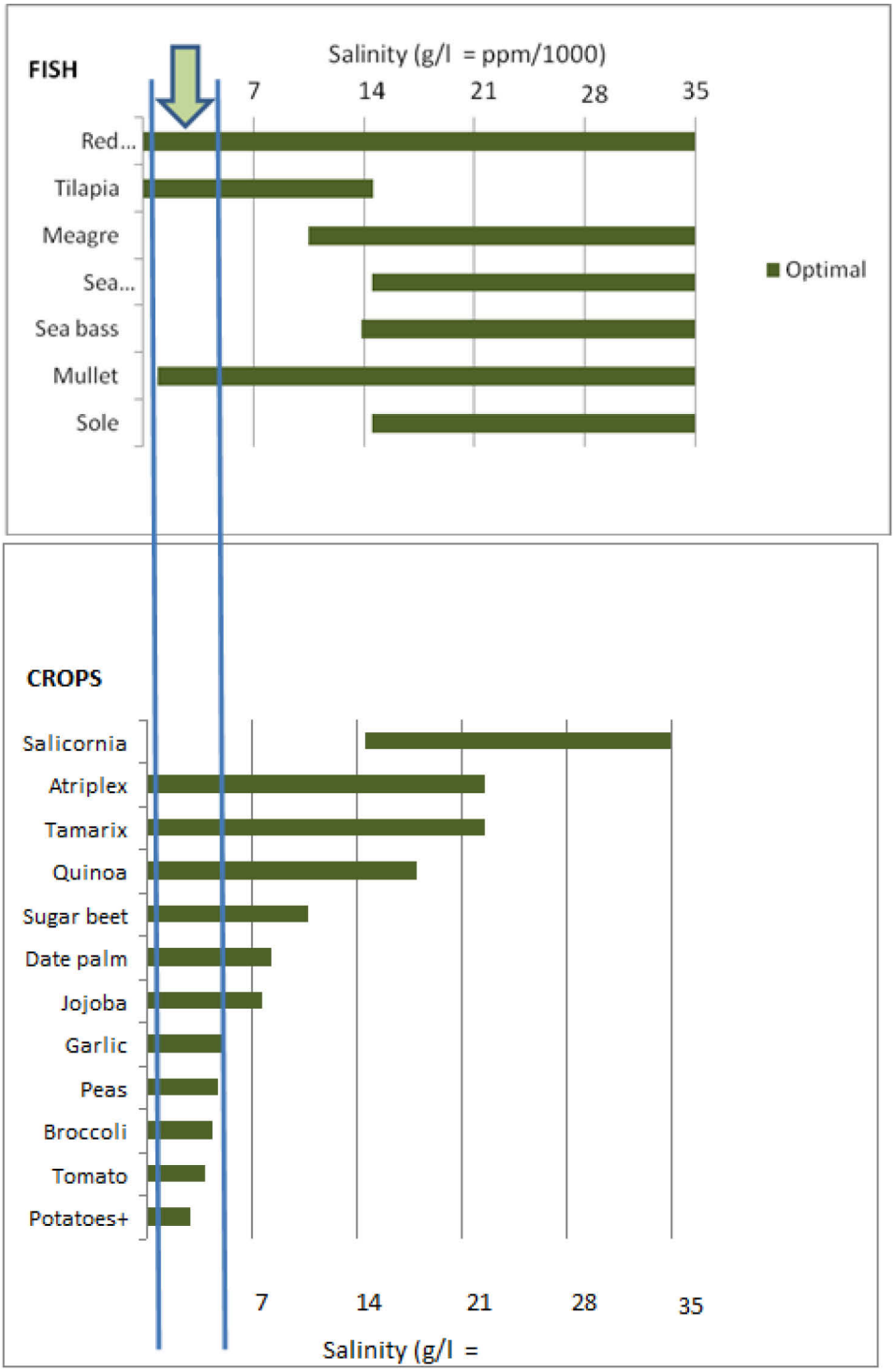


Figure 1 *Salinity tolerance of fish and crops. Between the blue lines the range (1-5.5 g/l) for maximal integration possibilities of fish and crops is indicated (after Moen et al., 2013).*

2.2 Feasibility

Integrating a fish farm with crop production has the advantage that the water needed and the large part of the fertiliser is available from the effluent of the fish farm.

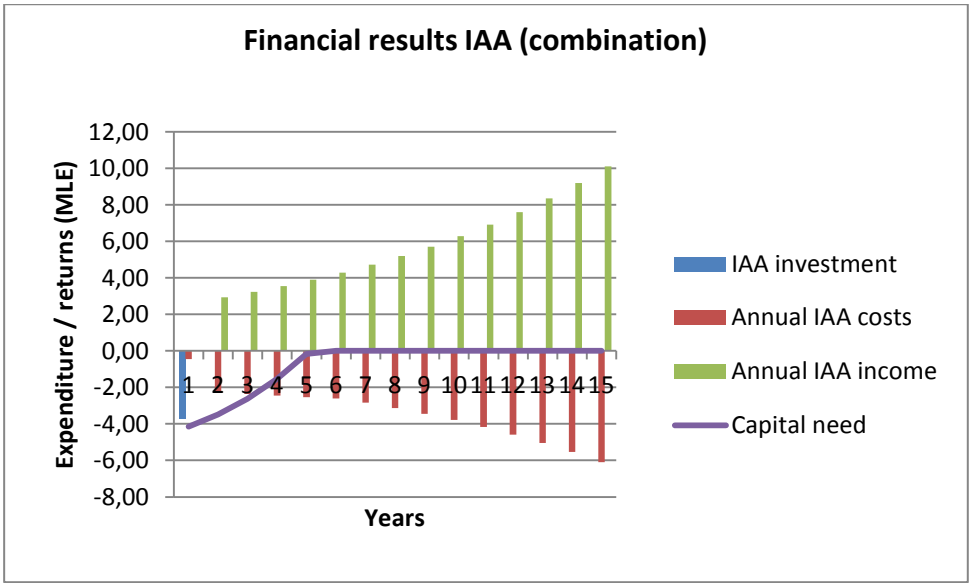


Figure 2 *Economic performance of the IAA building block producing 100 tonnes of Red Tilapia annually in an extensive RAS system and a 50 feddan farm to process the generated drainage water and nutrients by growing potatoes and Quinoa (after Moen et al., 2013).*

Desert soils are poor in nitrogen and generally speaking nutrients are provided with the water (fertigation). Costs for fertiliser will differ between crops. For example for potatoes these costs can amount to 15-20% of total production costs (personal communication. Mr Tarek Tawfik, Farm Frites). Not all nutrients will be available in the effluent of the fish farm and some elements will have to be supplemented. This supplementation and associated costs would have to be investigated in a pilot system. However, it is obvious that economic gains are possible from the perspective of crop production in having an integration with a fish farm (see Figure 2). Saving 10% of the annual production costs in the 50 feddan farm (one feddan covers 4,200 m^2) that we need to prevent the fish drainage water to flow to the vulnerable oasis environment would be a saving of LE 50,000 annually and would further improve the economic feasibility.

Photo 1 *Red tilapia for sale in shop of Wadi Food.*

3 Knowledge gaps, threats and opportunities

During the visits and discussions with company owners / managers and staff of research institutes in the field of dry-land agriculture and aquaculture the following knowledge gaps, threats and opportunities in relation to the application of Integrated Aqua-Agriculture with brackish water were identified:

Knowledge gaps (major)

- What methods are effective to address salt accumulation in the soil?
- How to irrigate drip irrigated crops based on soil moisture and soil salinity monitoring?
- How to match quantity and quality of brackish fish farm effluent with needs (volume, nutrients) and tolerance limits of various crops? Nutrient requirements of many crops change during the growing season but composition of RAS effluent may not change accordingly. How to adjust the nutrients for targeted crops?
- What are suitable combinations of brackish water tolerant crops and aquatic animals (fish/prawn/ shrimp) species within a certain water salinity range? In addition to quinoa and potato also jojoba, sugar beet and fodder beet seem to be promising crops because of their high salinity tolerance.
- What is the effect on (desert) soil structure such as porosity and permeability of application of sludge from fish farm as fertiliser?
- What is most suitable irrigation system (equipment) if fish farm effluent is used as irrigation water? Are technical adjustments needed when fish farm effluent is used for irrigation (clogging of drippers)?
- What are suitable IAA models (modules) for small and medium-scale farmers?
- What are the investments, operating costs and returns of the RAS systems and aquaponics systems as developed by Ismail Radwan and Morgan International and are they economically feasible? Under what conditions are these suitable modules for small farmers?
- What trees can be irrigated with brackish water and do well as wind fences in windy desert environment?
- What is the effect of high pH on the uptake of N and P by the crops under high salinity conditions?
- What are the effects of different Algae on soil and crops? What is the effect on the aquifer water quality?
- What is needed to earmark selected crops irrigated with enriched aquaculture water as organic agriculture?
- What type of well equipment is needed for high salinity groundwater to avoid corrosion?

Knowledge gaps (minor, expected to be solved relatively quickly)

- Is there indeed a difference in taste and flesh composition between red tilapia grown in fresh water and red tilapia grown in highly brackish (saline) water?
- Does jojoba seed meal contain anti-nutritional factors that may need attention when used in fish feed?
- What is the underground water quality for the five zones proposed by the Groundwater Sector of MWRI for aquaculture?

Threats

The legal and institutional framework and constraints affecting the Egyptian aquaculture sector in general are well summarised in a recent report by Goulding and Kamel (2013). Aquaculture using irrigation and Nile water may only lawfully take place in locations where a) it does not occupy land designated as agricultural land and b) where it does not use fresh water supplied from the Nile or from irrigation canals (unless the activity is hatchery operated by the Government). Additional constraints are placed on selection of sites by permit requirements applied by MWRI and Ministry of Environment, which will determine on a case by case basis whether the water use and discharge conditions conflict with relevant criteria. There is no legislation which covers the use of groundwater in infertile lands (Goulding and Kamel, 2013).

The main consequences of these restrictions are as follows:

- Aquaculture development is spatially limited to those sites which meet the criteria; these may not be optimal in terms of production criteria (for example energy costs in pumping, water quality, soil conditions etc.).
- Aquaculture operators utilizing seawater, or groundwater, or using marine cage production operate without a clear legal basis.
- Farmers are not free to use their land for any agricultural use (crops, livestock or fish production), leading to sub-optimal use of national resources.
- Water quality of 'drainage' canals may be a source of contamination of aquaculture products.
- The restrictions do not recognize the potentially advantageous use of aquaculture effluent to fertilize crop agriculture.
- Private sector hatchery businesses operate under greater restrictions compared to competing government operators.

Overall, the legal limitations distort the business environment for aquaculture and influence investment decisions. Of particular damage is the resulting uncertain or poorly defined legal status of many operators, which undermines incentives for investment, and limits availability of formal credit for development (due to lack of collateral). (I. Goulding and M. Kamel, 2013, p. 14).

Other threats that we saw during our field visits include the following:

- In addition to the poorly defined legal status, the lack of a clear legal definition of brackish water makes part of the companies that we met hesitant to be exposed in public meetings, workshops, and public fora. It also makes them reluctant to invest in brackish water IAA.
- We met companies that are starting with RAS in isolation and without proper background knowledge and training on aquaculture. In case of failure and disappointment, RAS will get a bad reputation in Egypt.
- The supply of red tilapia fingerlings in Egypt is restricted to only one government fish hatchery which has very limited capacity. The genetic base of the strain used by this hatchery is old and not of optimal quality. This affects in the short term the outcome of pilots with this tilapia variety that test the technical and economic feasibility. On the longer term it will affect the success of regular production of this fish for consumption.
- There is not one association and/or private organisation body that can claim to represent the interests of all fish farmers in Egypt. Existing organisations (approximately ten organisations) are either only representing a small number of companies, only a certain region or are dormant. This reduces the ability of the sector to influence policy development and to take part in policy dialogues. (This is more a weakness then a threat).

Opportunities

- Several agricultural companies that rely on using brackish groundwater are interested to integrate an aquaculture component for fertilisation of irrigation water and possibly also for food production for staff living in remote areas.
- Aquaculture companies using brackish groundwater with very low levels of pesticides, PCB’s, cadmium and other metals could in principle qualify more easily for an export license because they use a clean and safe water source. However, guarantees and checks will have to be put in place that firms that export the products of such companies do not mix this fish with fish from other sources (traceability).
- Egyptian companies are starting with RAS with little preparation and technical knowledge. This offers opportunities for Dutch companies and knowledge institutes to share or sell their knowledge and experience by means of exchange, training, consultancy and exposure visits to Dutch companies and institutes. Although it is unknown whether the Egyptian private sector is willing to pay for the Dutch expertise, the reputation of Dutch companies and research institutes as reliable providers of knowledge and expertise needs to be established.
- Red tilapia has been identified as a species especially suitable for culture on brackish (polyhaline) water but the strain available in Egypt is said to suffer from inbreeding, resulting in poor growth. Could a Dutch hatchery contribute to developing a new red tilapia brood stock for Egypt?

- There is a large demand for sugar beet to supply Egyptian sugar mills. Sugar beet is known to do well when irrigated with brackish water. The interest of sugar mill owners to become involved in developing IAA should be explored.

4 Stakeholder analysis

In this Chapter with a description of the main stakeholders in the Egyptian aquaculture sector we draw heavily from the excellent report by I. Goulding and A. Kamel 'Institutional, Policy and regulatory framework for sustainable development of the Egyptian aquaculture sector', Project report 2013-39 of WorldFish, Egypt (2013).

4.1 Government institutions

4.1.1 Ministry of Agriculture and Land Reclamation (MALR)

The Ministry is concerned with developing the overall policies for agriculture (including aquaculture) and land reclamation, in accordance with national development plans with the aim of developing agricultural resources, increasing the area of reclaimed land, and developing rural economies associated to the important use of solar energy. It is also mandated to conduct research and studies to develop agricultural, animal and fish production and use applications of this research to develop the sector. In addition, the Ministry is concerned with coordination among different authorities operating in the field of agriculture and land reclamation.

Under the Ministry the following organizations are relevant to fisheries and aquaculture development:

- GAFRD.
- The General Organization for Veterinary Services (GOVS).
- The Agricultural Research Center (including the Central Laboratory for Aquaculture Research (CLAR)).

4.1.2 General Authority for Fish Resource Development (GAFRD)

GAFRD, a subsidiary of the MALR, is the agency responsible for all planning and control activities related to fish production. It was established by Law No. 190/1983 with the aim of contributing to development of the national economy through fish resources, establishing horizontal and vertical expansion projects within the framework of general state policy and state plan. According to this Law, GAFRD is mandated to carry out the following functions:

1. Work on the development of fisheries and sources and overseeing the implementation of fishing laws and its implementing decisions and for aquatic areas to be determined by the decision of the President.
2. Conduct research studies to increase production and reduce costs and make use of specialized third party, whether national or foreign.
3. Establish pilot projects and models, and develop plans, and training and extension programs to obtain equipment and provide required technical labour in the field of fisheries.
4. Regulate the exploitation of fishing areas and fish farms in surface waters specified by the President and issue licenses for fishing, their maintenance and development and administrative enforcement against infringements and irregularities in these areas.
5. Plan projects, fisheries and fish processing and implement projects in collaboration with Governorates.
6. Work on the development of fishing craft; disseminate mechanization and modern fishing methods; spread awareness and technical training among fishermen and propose draft decisions necessary to prevent gears and activities harmful to fish resources.
7. Conduct field survey of fishery resources.
8. Cooperate with international and regional bodies in matters related to preservation and development of fisheries in accordance with requirements of technical and economic cooperation agreements in this regard – and follow up the implementation of these agreements.

9. Establish public sector companies specializing in fisheries or participate in their creation and contribute to joint projects in accordance with the Arab and Foreign Capital Investment Scheme Law.
10. Propose marketing and pricing policy of local and imported fish in conjunction with the Ministry of Supply and Internal Trade.
11. Provide technical opinions – within its competence – on public projects undertaken by other entities that involve use of surface water or pollution of water.
12. Provide technical expertise and advice on designs and drawings, and carry out technical studies and economic feasibility studies for fishery projects.

The Chairman of the organization has the authority of a Vice Minister and, accordingly, is authorized to issue relevant fisheries and aquaculture decrees and regulations. The headquarters of the organization is in Cairo and branches are located in the major fisheries regions: Central Delta, Damietta area, Western region, Suez and Red Sea region, Ismailia region, The Nile Valley region and Aswan region. GAFRD is also in charge of extension and support activities.

Under the current institutional setup, GAFRD is therefore the main authority concerned with overseeing aquaculture. It is responsible for monitoring and controlling fish farms through GAFRD branches in each Governorate. It also oversees aquatic cooperatives as it sits on the board of the Union of Fisheries Cooperatives (UFC) which is the umbrella organization for fishermen and aquaculture cooperatives regulated by Law No. 123/193 (see Section 4.2.1). Through this link, between GAFRD and the Union, GAFRD engages with sector representatives.

4.1.3 General Organization for Veterinary Services (GOVS)

The Organization was set up, under the Ministry of Agriculture, by Presidential Decree No. 187/1984 with the aim of protecting livestock (and human health) through preventive care against infectious and epidemic diseases. The ultimate goal is to develop national economy through increase of animal production rate to reduce gradually dependence on imported meat. The Organization supervises quarantine facilities for live animals in accordance with Minister of Agriculture Decree No. 47/1967.

GOVS is the Competent Authority nominated by the Government to be responsible for certification of food safety conditions for export of fishery products to the EU. The Fish Inspection Unit is the body in the Organization responsible for supervising, revising, and enforcing conditions and procedures pertaining to exporting fish and marine products, in coordination with the Central Administration of Veterinary Quarantine and Inspections. In this respect it is responsible for implementing the Joint Ministerial Decree No. (1909/2001) Regarding Regulations and Procedures Related to Fish and Marine Products Exports to European Union Countries.

4.1.4 Central Laboratory for Aquaculture Research (CLAR)

The CLAR is located at Abbassa and forms part of the Egyptian Agricultural Research Centre. Its main aim is to 'design and carry out the research strategy for sustainable development of aquaculture and fisheries in Egypt, in accordance with the national agricultural strategy of the country and integration with animal and plant production, in order to satisfy the food requirements from fish protein, to reach self-sufficiency from fish protein sources, keeping in mind environmental and socioeconomic aspects.'

CLAR has 52 hectares of production (162 ponds for production plus small experimental ponds) and a complex with offices, training facilities, laboratories and accommodation. It has been extensively supported with assistance from JICA. It is staffed by 130 scientists working in ten research departments as follows:
1. Fish genetics and breeding
2. Fish hatchery and reproductive physiology
3. Fish production and aquaculture systems
4. Limnology
5. Nutrition and feed technology
6. Fish health and zoonosis

7. Fish biology and ecology
8. Economics of aquaculture
9. Extension
10. Fish processing and quality control

The annual research budget from the Government is approximately LE1.5 million, excluding special projects (externally funded). The budget is allocated across all departments (with approximately 75% allocated to research and 25% to training and extension activities). Research covers a wide range of areas such as aquaculture methods, fish processing, breeding and genetics, nutrition and feed technology, health and diseases, and aquaculture economics.

4.1.5 WorldFish.

For more than fifteen years Egypt is hosting the regional centre for Africa and west Asia of the international organisation World Fish, which is one of the institutes under the Consultative Group of International Agricultural Research Centres (CGIAR). WorldFish is involved in aquaculture research and has among others developed recently a new, more productive Nile tilapia strain that is now tested in dozens of fish farms. Under the new government in Egypt much effort is needed to address persistent high unemployment and limited economic opportunity for the poor but WF also invests in the country's already well-established aquaculture industry.

A recent value chain assessment carried out by WorldFish highlighted the potential to improve the efficiency and productivity of the aquaculture industry. The assessment recognised opportunities to expand the industry in Upper Egypt and to benefit women fish traders and processors. Its findings were the basis for this three-year $6.6 million project named 'Improving Employment and Income through the Development of Egypt's Aquaculture Sector', in short IEIDEAS, which started in December 2011 with $4.3 million funding from the Swiss Government. IEIDEAS is carried out in collaboration with CARE Egypt. The goal of this project is to increase employment in Egypt's aquaculture sector, and it will achieve this by realizing the following objectives:

1. Increased industry sustainability and labour demand by improving profitability through:
   a. Superior breeds of tilapia and best practice methodologies for pond production;
   b. Higher capacity of farmers to use these improved technologies.
2. Improved effectiveness of producer organizations, particularly through support to farmers in target governorates.
3. Increased employment of women in fish retailing.
4. Increased employment through the expansion of aquaculture in Menia Governorate.
5. Assistance to government agencies to develop policies that support an efficient and sustainable value chain.

See Annex 1 for more details about the IEIDEAS project.

Photo 2 *Hatchery facilities of WorldFish in Abassa.*

In cooperation with CARE Egypt WorldFish attempts to improve the situation regarding aquaculture policies through supporting the establishment and strengthening of existing organisations and creating platforms for policy dialogue between industry, government and other stakeholder.

4.1.6 Ministry of State for Environmental Affairs

The Ministry is the authority mandated with formulation of environmental policy and necessary plans for the protection of the environment. The Egyptian Environmental Affairs Agency (EEAA) under the Ministry is responsible for implementation of legislation. To get a license, fish farmers have to obtain the approval of the Agency after submitting an EIA study. Fish farms also have to abide by conditions related to discharge of water as set out in Law No. 4/1994.

4.1.7 Ministry of Water Resources and Irrigation (MWRI)

The Ministry is mandated to develop irrigation system to achieve optimal use of water whilst meeting the needs of all sectors both in terms of quantity and quality. Technical advice to the Ministry is provided by the National Water Research Centre under the Ministry. To obtain a license, land-based fish farms need to obtain approval of the Ministry, represented by inspection departments affiliated with the Ministry.

4.1.8 Other Ministries

In addition, other authorities that have oversight over aquaculture sites, and whose approval may be required (depending on circumstances), include: Ministry of Archaeology, Ministry of Tourism, the Authority for Shore Protection, and Border Guard (affiliated with the Ministry of Defence).

4.1.9 Desert Research Centre

The Desert Research Centre falls under the Ministry of Agriculture and Land Reclamation MALR. Its main objective is to investigate the potential of Egypt's arid areas for agricultural development. Besides from its central office in Cairo with 1,200 staff the DRC has eleven research stations spread over Egypt. See Annex 1 for more details. It is possible that many technical questions in relation to brackish water agriculture in Egypt's arid regions are or may already have been investigated by DRC or one of its stations. However, the results of such research may have been reported mostly in technical reports or scientific papers. Special efforts are needed to retrieve this knowledge to the advancement of IAA in brackish water.

4.2 Egyptian Private Sector representation

The Egyptian aquaculture sector consists of several thousand small, medium and large-scale fish farms covering between 104,000 ha (Alterra, 2010) and 159,191 ha of ponds (FAO, 2010). Approximately ten organisations of fish farmers have been established but these are mostly regional in scope (membership). There is at this moment not one organisation that can claim to represent the majority of Egypt's fish farms or the farmed fish value chain as a whole.

4.2.1 Union of Aquatic Cooperatives (UAC)

Law No. 123/1983 on Aquatic Wealth Cooperatives describes the role and conditions pertaining to aquatic cooperatives, covering fisheries and aquaculture activities. It defines local cooperatives and the role of the UAC. The law states that judicial persons may not participate in cooperatives (Article 2) thus excluding participation of companies. Cooperatives must also be formed by not less than 20 individuals (Article 7). The law is highly prescriptive with cooperatives only permitted to perform prescribed functions (Article 10); and distribution of surpluses also according to a specified formula (Article 17). Incentives to join cooperatives are provided by their tax exemptions (Article 57), discounts on goods and services purchased from state enterprises, including a 10% discount on energy (Article 58) and preferential consideration in tenders (Article 59).

There are ten aquaculture cooperatives in place, out of a total of 99 fisheries and aquaculture cooperatives. The total number of individual members registered was 1,796 in 2011. The largest are in Kafr el Sheikh and Damietta, each with over 400 members, followed by Fayoum with 339 members. Fayoum is reported to be the most active of these organizations, with the remainder only participating in sector issues to a limited extent.

The cooperatives are collectively represented by the UAC (whose role is also defined in Law No. 123/1983), which now has three aquaculture members on its Board (of fifteen members). The UAC represents the sector to Government, and has a seat on the Board of the GAFRD. It is consulted on policy issues. The UAC was asked for example by GAFRD to comment on the proposals of the MWRI for a stricter regime regarding licensing of water use for aquaculture.

4.2.2 Egyptian Fish Producers and Exporters Association (EFPEA)

In 2007, the Egyptian Fish Producers and Exporters Association (EFPEA) was established as an association under the procedure defined by the Ministry of Social Affairs for NGOs. Membership has fallen from 47 initially to 26 at present (2013). The annual membership fee is LE 1,000/year. Its members include aquaculture producers and a number of feed suppliers. Membership is open to individuals and corporate members, and can include wholesale and retail operators, as well as inputs suppliers. Its representation is therefore potentially wider than the Cooperative movement. The Association has several aims, but mainly to represent the sector to Government and to improve the image and brand identity of Egyptian aquaculture products. However, until now the EFPEA has not developed its institutional structure and is only existing as a Board. It has no paid staff to undertake many of the detailed tasks required.

4.2.3 Egyptian Fish Council

The Egyptian Fish Council was formed in 2006. It is under the Egyptian Agribusiness Association EAGA and aims to offer education and training for its members, do advocacy work on behalf of the sector to the government and give support to pilot projects and studies. It published the full-colour magazine 'Asmak' in English and Arabic language. Conferences and workshops were organised that were attended by private sector, academics and government officials and which stimulated debate on various issues affecting the sector such as the policies with regard to the use of fresh water for fish farming. In 2007 a seminar was organised which focussed on the requirements for export of farmed fish to Europe. EFC also organised study visits for selected members to China, the Netherlands and Greece. Until 2012 EAGA received support from the Netherlands embassy but when Dutch funding stopped EFC and EAGA were not able to maintain their activities.

4.2.4 HEIA - Horticultural Export Improvement Association

Established in 1996, HEIA expanded in a very short time to reach currently 500 members who represent producers, exporters, suppliers of horticultural products, and companies working in agricultural equipment and packaging material supply. It is an industry-driven association supporting the Egyptian horticultural community (producers, exporters and suppliers). HEIA's objectives are the increase of exports of fresh produce through continuous improvement of:

- Quality Production
- Marketing
- Policy Advocacy
- Training
- Management Assistance

and by ensuring Egypt's international quality reputation and raising the agricultural labour force standards.

HEIA operates a fruit and vegetable terminal at Cairo Airport.

HEIA members benefit from:

- Technical support services
- Access to most up-to-date practices and technologies
- State-of-the-art production and post-harvest handling practices
- Consultancy and support regarding international standards and certificates
- Up-to-date market information, latest research and best-practices
- Networking amongst HEIA members through regular council meetings, observational study tours, joint field days and HEIA events
- In-house and on-site trainings
- Visits by international experts, etc.
- Weekly weather forecasts to all members.

Source: http://www.heiaegypt.com

4.2.5 UPEHC

UPEHC is a branch organization for small and medium enterprises dealing with horticulture, either growers, processors or exporters. UPEHC provides services to its members such as inputs, trainings and export facilities.

Source: http://www.upehc.org/

5 Private sector interested in participation in Research & Development

While in Egypt the mission has met with several company representatives who expressed to be interested to join a network that aimed to develop Integrated Agri-Aquaculture using brackish water further by sharing experiences, identifying research questions, designing studies and pilot trials and facilitating input from Egyptian, Dutch and other researchers. These organisations or individuals are:

- Morgan International, a company already operating a RAS fish farm that uses the fish farm effluent for irrigation of fruit trees. Morgan International is building three new RAS aquaponics units and offered a field and effluent from a tilapia hatchery for testing and implementation of pilots. See Annex 1 for more details about Morgan International.

- Dr. Ismael Radwan owns a tilapia hatchery which includes a RAS unit for outgrowing tilapia. This unit was built with support from the Netherlands Embassy. Dr Radwan also operates the Egyptian Aquaculture Centre that offers practical, hands-on aquaculture training for an Egyptian and foreign audience. On a second piece of land (13 feddan) in El Bustar, Nubareya. Dr Radwan has built in 2013 a simple RAS unit of which the effluent and sludge are used to fertilize 6 feddans of wheat. Dr. Radwan is open to join a network as described above and share his very valuable experiences.

- Rula for Land Reclamation (RfLR, part of Wadi Food) has from 2011 to 2013 been involved in development of the culture of Salicornia, Atriplex and Suaeda using brackish (26 ppt) fish farm effluent as irrigation water. In addition a for Egypt new and water-efficient fish culture technique called biofloc system was tested, using the same brackish fish farm effluent. This development took place in collaboration with Wageningen UR (PRI and CDI). The results were shared with private sector representatives, academics and government officials during a seminar organised by RfLR in May 2013.

- Egyptian Company for Land Reclamation (Masereya). This company with an office in Cairo has developed 4000 feddan of desert land south of El Alamein (southwest of Alexandria). The land is irrigated with underground well water and a drip irrigation system. Twenty solar power driven pumps are the hearts of the irrigation system. The land was planted two to three years ago with jojoba trees and is sold in lots of 1.25 to 5 feddan to small farmers. The company is very interested to collaborate in the above described network and asks for advise on how to integrate a fish farm which would fertilise the water and grow food for the people living and working in the remote plantation.

- Al Wanas Masr company is based in El Tal El Kabeer close to the Cairo – Ismailia highway. In the past the company was involved in drying grain (besides from other activities) but is now focussing on the production of wind mills and solar panels for application at home, granite and marble cutting. It started in 2014 with construction of a small fish farm applying RAS. The effluent will be used to irrigate a hydroponics vegetable unit. The company also builds backyard (rooftop) aquaponics units consisting of a 1 m^3 fish tank plus 1 m^2 gravel bed that serves to grow vegetables and as sand filter. Being very new and inexperienced in the aquaculture business the company is interested to learn by attending meetings that are organised by the IAA network.

- International Company Agricultural Production and Processing (ICAPP) has several farms in the Wadi Natrun area that, depending on the location, make use of either Nile water or ground water. We were informed that the company is interested to investigate the inclusion of fish farming in a farm located at Wadi El Natrun that uses brackish groundwater. ICAPP being also the owner of a chain of fish restaurants ('Fish Market') and a fish cannery offers interesting perspectives for sale and processing of fish produced at other farms.

- Skretting (Nutreco) is an internationally operating fish feed producer with main office in the Netherlands and a branch and fish feed factory in Egypt. The company has expressed interest to take part in developments that stimulate the application of RAS in Egypt.

- Plant Systems is an Egyptian company that is specialised in irrigation systems and equipment. It is at present collaborating with Wageningen UR in the STOP-project that is testing the salt tolerance and productivity of various potato cultivars in Wadi El Natroun, Egypt.

- Domiatec Group for investment and agricultural development, Cairo. Domiatec Group is an import-export company working mainly in investment and agriculture development for over 30 years. The core business is importing seed potatoes from Europe. The company is specialized in delivering top quality service, production and new techniques as well as technology transfer to the agriculture sector. Since the early nineties Domiatec Group has ranked among the major potato importers over the past few years and has managed to dominate the market with 40% market share. It has collaborated in 2013 -2014 with Dacom and Wageningen UR in the STOP project, exploring salinity tolerance of various potato cultivars.

- Rens Kuijten is agricultural consultant who is working to establish a Dutch quinoa value chain in collaboration with foreign producers to supply the growing demand for quinoa in western Europe. He has expressed interest to explore the western European market for quinoa produced in Egypt.

- TilAqua is a tilapia hatchery owned by Eric Bink that produces all male tilapia fingerlings and breeders in a natural way, meaning without using male hormones in the juvenile stage to create all-male tilapia. As a producer of red tilapia he is interested to play a role in supplying fingerlings of this fish to Egypt.

- Dacom is a company that is based in Emmen, the Netherlands, and is developing and selling precision irrigation systems making use of sensors that are placed in the field and measure the moisture content of the soil. The company is collaborating with Wageningen UR in the STOP project that is testing the salt tolerance and productivity of various potato cultivars in Wadi El Natrun, Egypt.

- In addition to the above mentioned companies that have either been visited or expressed their interest in IAA during other occasions we learned of more Egyptian agricultural companies using brackish groundwater that were said to be interested to try the inclusion of fish farming in their farm. We did not have the time to visit these companies and their farms. Companies that have expressed interest in starting with IAA and that have indicated they want to invest in it includes amongst others Juhayna, ICAPP and Chipsy. More companies will be approached in the future in case the network as described earlier is started.

6 Road map

Integrated brackish agri-aquaculture systems could become common practice in isolated desert areas in Egypt where water is scarce and brackish. IAA is also a potential solution for the small and medium scale fish farms in the northern Nile Delta. The main driver for this development is the scarcity of fresh water in Egypt. The integration of both agricultural activities closes the nutrient and water cycles of both systems rendering the combination profitable. In that sense Egypt follows the successful developments in other arid countries such as Australia, Israel, South Africa, USA and Mexico. In 2020 the IAA systems can provide employment to the many poor people living in the oases (Farafra, Siwa, Bahariya, Dahla and Khargah) as well as in the northern Nile Delta in the traditional fish producing areas.

Before the target year 2020 different fish production systems for the different groundwater salinities need to be developed to become successful. The fish processing industry can produce by-products that are used in agriculture or again serve as fish feed. Different production systems have been developed for the different brackish ground water salinities.

Irrigation systems for these agricultural production systems are highly efficient and have only a minimum of leaching. The water of the fish farms that is drained because it contains too much nitrogen is used for irrigation – after filtering the water. The water is then conditioned for fertigation before it is given to the crops through drip irrigation systems. Due to the very low leaching, the salts are retained in the soil and the unsaturated (vadose) zone below the root zone and above the groundwater and the groundwater is not polluted. The nutrients in the fish drainage water are completely used. The downstream oases and touristic sites are no longer spoiled by the excess drainage water of upstream agricultural activities.

Implementation of the above procedures in practice is not as simple as it sounds. In addition, precision irrigation requires nerves from the farmers to wait with irrigation until really needed and not to give the 10% more than required as an insurance against failure.

We have identified three actions to bring IAA to the national scale (Figure 3):

1. A knowledge development and exchange component (KDEC) to prepare the private sector for the future and solve immediate problems. This is for the short term and financing is requested from the Dutch and Egyptian Government through Water Mondiaal.
2. An investment opportunity to link IAA to small and medium enterprises in Egypt through one of two Dutch Sustainable Development Funds. We will do our utmost to prepare a proposal for one of these two funds. The KDEC component would merge with this investment project after two years.
3. A suggestion to develop an EU twinning project to introduce the necessary arrangement and procedures to gain access to the European export market for cultured fish.

A fourth action could have been to identify and visit some of the International Financing Institutions active in Egypt such as the EBRD, EIB, IFC, WB, IDB and others. Upon consultation with the Agricultural Attaché (See Annex1), this action received a lower priority than visiting as much private sector parties as possible.

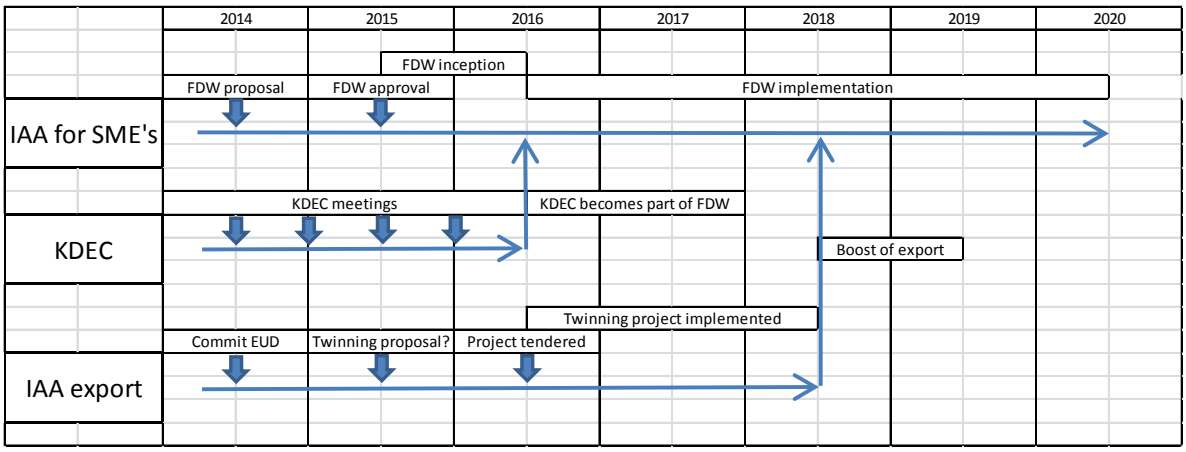


Figure 3 *Integrated road map until 2020 for the three identified potential actions.*

6.1 Knowledge Development and Exchange Community (KDEC)

In order to quick-start learning from the different IAA pilots that are already operational and new pilots that may start in the near future and to avoid duplication of mistakes, knowledge exchange between pilots is needed. For such experimenting by the Egyptian private sector with participation of the Dutch private sector and facilitated by the Egyptian and Dutch research organisations about 240 k€ (excluding VAT) would be needed for a period of two years. After two years the project Knowledge Development and Exchange Community (KDEC) would be merged with the pilot project opportunity mentioned below in 6.2 (see Annex 2 for more detailed information about KDEC).

KDEC is a smart approach and uses a similar powerful mechanism that made the Dutch greenhouse sector very advanced, internationally well-known and competitive. It mobilises the knowledge and inventiveness of entrepreneurs and links it to the formal knowledge of research institutes and universities. This approach prevents lengthy research projects and takes economic and financial sustainability of innovations on board right from the beginning. The majority of the project cost for KDEC will be provided by the participating private sector companies (front runners). Only a small proportion of the costs (small subsidies for the experiments and financing of the knowledge exchange) would be financed by Water Mondiaal.

6.2 Investment opportunity for Small and Medium Enterprises (SMEs)

Both extensive RAS systems as well as precision irrigated agriculture, which are both included in IAA, are labour and capital intensive and less suitable for large scale mechanization. The Netherlands has a good track record in the knowledge intensive RAS systems as well as in precision irrigation. This brings the Small en Medium Enterprises to the forefront for the further development and rolling out of IAA.

This year (2014) there are two open calls for proposals for projects on Sustainable Water Use (FDW) and Sustainable Entrepreneurship and Food Security (FDOV). For both calls a subsidy of maximum of four million Euro (or 60% of the total eligible cost) is available for projects that may have a maximum duration of seven years. Consortia requesting subsidy must consist of at least one private sector party, one government party and one Non-Governmental Organisation (NGO) and at least one party should be from the receiving country (Egypt) and one party from the Netherlands. An important condition of the subsidy request is that the small and medium enterprises (such as the fish farmers in the Northern Nile Delta) are included in the project.

We suggest to bring partners together from three types of private sector organisations for such a project:

1. Large investors and agricultural companies who can benefit from the introduction of IAA on their establishments and /or through links with small and medium enterprises, for example contract farming of crops and fish.
2. The current front runners in developing the IAA technology under Egyptian conditions. These are the innovators that deserve some support from the Government for the fast development and exchange of knowledge on IAA.
3. Small and medium enterprises that can learn from the experience of the front runners and benefit from the investment capacity of the large investors and private companies.

6.3 Expand the export opportunities

Entrepreneurs would have more marketing opportunities and flexibility if also the export market for farmed fish from Egypt would be wider, including the EU. The European Union has an extensive twinning program running through which Government Authorities and institutes of EU countries can exchange and train their Government counterparts in the European Neighbouring Countries.

References

ALTERRA (2010) Interim findings of the APP-study on water requirements for fish farming in the Delta (draft version). Alterra, Wageningen, the Netherlands (10 pp).

FAO (2010) National Aquaculture Sector Overview. Egypt. National Aquaculture Sector Overview Fact Sheets. Text by Salem, A.M.; Saleh, M.A. In: FAO Fisheries and Aquaculture Department [online]. Rome. Updated 16 November 2010. [Cited 27 March 2014]. http://www.fao.org/fishery/countrysector/naso_egypt/en

Goulding, I. and M. Kamel (2013) Institutional, policy and regulatory framework for sustainable development of the Egyptian aquaculture sector. Project report 2013-39 of WorldFish, Cairo, Egypt. 24 pp plus annexes.

Moen, H., K. Roest & A. Kamstra (2013) Feasibility of the Use of Brackish Groundwater in Integrated Aqua-Agriculture systems in Egypt. Study Report by Dienst Landelijk Gebied, ALTERA, Wageningen UR and IMARES, Wageningen UR. 46 pp plus annexes.

Zon, H. van, and A. Rahman El Gamal (2010) Towards a common strategy for fish farming in Egypt. Report (draft version) of mission commissioned by the Advisory Panel Project on Water Management, Ministry of Water Resource Management, Egypt (43 pp plus annexes).

Annex 1 Notes of visits and meetings

March 9: kick-off meeting of Koen Roest, Dr Sherif Sadek, Faris Farrag, Hakiem ElWageih and Peter van der Heijden, Hotel
After a round of introductions the background and expected output of this mission were explained. Discussion focused on bottlenecks for obtaining permissions for export of farmed fish from Egypt to EU. One important factor is the absence of consistent lobbying due to the absence of one strong organisation representing the interests of fish farmers towards the government. Now there are ten fish farmers associations registered (with 1455 members, according to GAFRD statistics, 2012) but all are dormant. Producers organisations find it difficult to maintain activities without paid staff members.

An important issue to clarify for this mission: what is according to the Egyptian authorities the minimum salt content to call water brackish?

Medium- and long-term prospects for fresh water availability in Egypt is affected by the Millennium Dam, Ethiopia. Especially during the reservoir filling phase (six years) less water is expected to reach the White Nile.

Candidate farms and institutions to visit during this mission were listed. The following facts were mentioned:
- Farm Frites drains brackish water to low-lying areas in desert and is interested to use this for fish farming (reverse sequence). ACO has had business contacts with Farm Frites.
- GAFRD will build three or four intensive tilapia farms in Sinai region, one is soon to be opened.
- Some companies are using ground water without proper licences, they are reluctant to be exposed by our mission and fear consequences by regulating authorities.
- Many companies with salinity problem and interest in fish are located West of the delta. Besides from large companies we have to focus also on the involvement of SMEs (small farmers). In El Gouna, Red Sea coast, is a tourist resort that uses 8 ppt groundwater to create potable water and has 15 ppt waste water. The management of the resort is interested to use the saline waste water for halophytes and fish culture. Issue is here that the desalination taking place is highly seasonal (because of high demand for potable water in tourist season and holidays) and the company is mostly interested in ornamental plants (for landscaping of tourist facilities), which is not completely matching with More Crop per Drop.

March 9: J. Geijer, Agricultural counsellor, Netherlands Embassy
Mr Geijer stresses that the importance of delivering a proposal in which companies are involved/ interested. Don't let yourself be curtailed by water permit issues of private companies. Water Mondiaal prefers involvement of SMEs. Which size of farm is minimum for economic feasibility? DG Agro (NL) has 'Programma Internationale Agroketens' that could possibly be a source of project funds. Mr Geijer informs that IMARES will receive a contract to assess in April 2014 what capacity building on the side of responsible government authorities and fish processing companies is needed in relation to export of farmed fish to the EU.

March 9: Rula for Land Reclamation (RfLR): Khalil Nasrallah (Chairman), Ayman Khalil (Agriculture executive manager of RfLR) and Salah Taher (Aquaculture executive manager of Wadi For Fish Production)
We explained the objective of the mission and sketched a possible target: a network or platform of companies and associations all involved in different pilots, salinity levels and crop/fish combinations that is open to exchange and share experiences. RfLR is interested in trying quinoa, potatoes (both seem to have good market perspectives) and animal fodder crops (to supply roughage for an animal feed company) irrigated by brackish water. Prices fodder: LE 400 (roughage) to > LE 1500/ton (berseem). Wadi Food has planted 40 feddan with date palms at Rula for Land Reclamation farm, Wadi El Natrun. The company is also interested to explore solar energy for pumps. (The diesel shortage last

year summer brought them into severe problems). They also expect gradual rise of cost of grid electricity because of expected reduction of the Government subsidy. When red tilapia is used Salah proposes to make first an economic feasibility study. Koen will send him last year's feasibility study for IAA. RfLR is a member of Horticulture Export Import Association HEIA, that now exists and is active mostly with member fees, some outside support and payment for services such as HEIA-owned terminal in the airport. Key factor for successful producer organisation: clear and concrete objectives. The weak connection between universities/researchers and private sector was mentioned as a factor constraining agricultural development. It is also mentioned that not many companies have an open attitude and are willing to share results and processes. RfLR is interested to be part of a network as sketched above.

On involvement of SMEs in a project: RfLR could supply seeds, fingerlings to smallholders. Small farmers already supply RfLR plant a part of the olives for grading.

The marine fish farm operated by Rula for Land Reclamation, Wadi El Natrun.

Test fields with Atriplex, Sueada (left) and Salicornia (right) irrigated with 26 ppt effluent from Rula for Land Reclamation's marine fish farm.

March 10: Egyptian Dutch Advisory panel Project on Water Management. Dr Samia El Guindy and Dr. Magdy Salah Eldeen

Dr. Magdy mentions that the ToR for this mission was not discussed with the APP secretariat. There was a long discussions on the cut-off point between fresh and brackish water. For human health, salinity should be below 400 ppm (WHO) International definitions call water with salinity of 500 and 3,000 ppm oligohaline; 3,000 – 16,500 ppm is called mesohaline, and 16,500 – 30,000 ppm is called polyhaline. Over 30,000 ppm is categorised as marine or saline water. But there is uncertainty about where the Egyptian law (Law 48, Law 12) places the cut-off point between fresh and brackish water. For agriculture up to 3000 ppm is still useful, and Dr Samia recommends fish farming to use water > 3000 ppm. But in the end it was agreed to choose a range that is practical for our own purpose since

the law is not clear on this. It is important for promotion of the IAA concept to mention what crops can be grown on the brackish water. We were also advised to involve the MWRI authorities in any coming project to stimulate buy-in: you prove the IAA principle and show the benefits of integrated agriculture and aquaculture.

Dr. Magdy stresses the need to share the knowledge through big conferences for many participants from all layers and branches (companies, ministries, universities, newspaper articles). Dr Samia notes that companies like Wadi Food are high tech and large and may not be a good model for SMEs . Discussion developed on how to involve small farmers when pilots take place at large companies. Dr Ismail Radwan's farm is a good example for SMEs.

MWRI (groundwater division) has targeted five areas with abundant brackish water resources: Wadi Natroun, Qatara depression, Sahel (Northwest Mediterranean Coast) and North Delta. A general map indicating these regions is available.

It is mentioned that decision makers at MWRI should be enlightened on the efficient water use by RAS. Dr Sherif mentions plans by GAFRD to start three intensive farms in the Sinai area, one near Al Arish is soon to be opened (to supply the market when Bardawil Lake fishing is closed for four months/year).

Knowledge gap with regard to IAA in brackish water: how to avoid salinization of the soil? It is mentioned that this is not a serious issue in sandy soils / deserts.

Dr Sherif mentions that we should select fish species that can be reproduced in hatcheries for sustainability purposes (avoiding conflicts with fishermen about depletion of fry from the wild stocks).

March 10: Farm of International Desalination & Water Treatment L.L.C. (Nabil and Omar El Maraghy, Dr. Samy El Zeini)

The farm is located along the Cairo – Alexandria Desert Road and consists of 200 feddan with grapes and mango trees. It has a big desalination plant where 3 ppt groundwater is reduced in salinity to 40 ppm, and next enriched with nutrients to 120 ppm. Desalination capacity is 42 m^3/hr. the company was able to reduce irrigation needs of plants with 85% (no need of leaching, providing complete nutrient mix.). They claim that by doing this the water requirement is only 550 m^3/feddan which caused much surprise (130 mm/year). They take salt out of brackish water and sell various salts (fertilizer) and brine (for pickling, production of cheese). Cost of water desalination is 0.20 USD/m^3. The farm has two basins for raising tilapia, six basins for growing marine fish (30 ppt salinity) and two hyper-saline basins in which they plan to grow algae and brine shrimp (Artemia). The effluent from the tilapia basins will go to a hydroponic unit placed on the roof of the desalination plant. A second hydroponic plant is planned when a new storage shed is built. For this company the fish farming component should be cost recovering.

International Desalination & Water Treatment L.L.C: grapes and mango trees irrigated by desalinised water (left) and ponds with saline water for culture of marine fish (right).

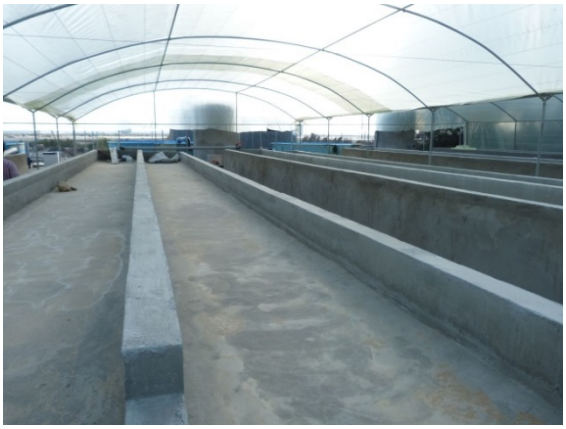
March 10: Farm of Morgan International, Mr. Ayman Aniss, Haitham Radwan and Mohamed Kamal (Wadi Natrun region)

Mr Aniss is IT specialist by training, he lived in California but returned two years ago to Egypt. The farm we visited consists of traditional tilapia hatchery designed and formerly owned by Prof Nagar (University of El Shams). This hatchery consists of 91 basins with a total volume of 2500 m^3 plus four earthen ponds with total volume of approx. 1500 m^3. The farm is a flow-through system that uses and drains 500 m^3 of water/day and can produce 4 million fingerlings/year. Beside this hatchery an automated fish farm with aquaponics and irrigated fields is under development (R & D unit). Mr Aniss developed his own electronic input-output switchboard to regulate feeding, drainage, water quality parameter, magnetism and music. He also developed software and hardware for complete automation of feeding and water quality monitoring.

Three aquaponics (tomatoes, lettuce) units are under construction, each unit consisting of one round tilapia tank (30 m^3) plus sediment remover, bio trickling filter and four hydroponic canals of 17 m length and 1.25 m wide. The farm uses 1.7 - 2 ppt groundwater. The biofilter medium consists of corrugated fiberglass roof material. The specific surface is unknown but Mr Aniss believes that 120 m^3 of media will be enough to treat 1000 m^3 production basin volume. Aeration takes place with an air blower. He expects a Feed Conversion Ratio of 1.2, the fish density at harvest to be 40 kg/m^3 and a production of 30 tons of lettuce for each ton of fish. Each 50 gr of fish feed will fertilise 1 m^2 of plants in aquaponics. There is one pump per system which has the capacity to move the total water volume of the system 1 x/hr. The biofilter consists of one round tower of 3 m high and 1.5 m wide filled with 1.5 m substrate material. Expected replenishment of water is expected only 3-4%/day. Has 2 greenhouses with tilapia hatchery and nursery and tanks for breeders.

Mr Aniss designed a 3000 m^2 fish farm that can produce 160-180 tons of tilapia in four production cycles, 250 gr tilapia (fish is stocked as 30 gr fish). Fish density will be 40 kg/m^3 at harvest. A unit like this has been started two years ago at Orabi and contributes to the irrigation of eight feddan of fruit trees. This farm was visited on March 13.

Large sedimentation tanks are under construction, the waste water will be used for open irrigation of neighbouring fields. The farm has one feddan of free land with drip irrigation system installed that can be used for tests, growing crops with water supplied from aquaculture units or from the hatchery nearby. Mr Aniss also designed a new fish feed based on local ingredients that costs only LE 1.5 /kg (normal retail price now: 4.5 to 5 LE/kg). Mr Aniss is advised on RAS by Canadian consultants.



Small recirculating fish culture unit of Morgan International (left) and basins to grow vegetables in aquaponics system (right), both under construction.

Mr Aniss hopes to find investors to fund a town/village (target: 4 x 15 km area near Al Qatara depression) based on small units of 5–10 feddans irrigated by small automated fish farm in the desert (The area still has mines from WW II but is partly cleared by the army). The plan is to have two young graduates to run one five feddan unit (fish plus crops integrated). Expected investment is estimated at LE 180.000 /unit. He plans to start a solar panel plant for electricity generation.

Mr Aniss is very open and interested to collaborate in a platform/network of IAA pilot companies. He is willing to share his experience.

March 10, International Company for Agricultural Production and Processing ICAPP, strawberry farm, Nubareya

Mr Kamal El Dadak is in charge of strawberry production at this farm. This farm has 200 feddans of strawberry. Water is drawn from irrigation reservoir (10.000 m^3) and passes through sand filters before being used for irrigation. Water is 400 ppm salinity, after adding fertilizers salinity is 1200 ppm. Cost of fertilizer: approx. 8000 LE/fed. Mr Kamal has hot considered growing fish in the reservoir, he is willing to consider to include fish as long as it does not lead to problems for his strawberry production. In another farm some fish were stocked to clean the walls of the reservoir, not for serious production. The water and fruits are regularly analysed for nutrients etc., to know what nutrients to add. In another farm in Delta the company has contracted small farmers to grow strawberries, Mr Kamal considers doing the same near this farm. He would like to teach small producers to learn how to raise quality standards. In the Netherlands the company VitalBerry buys the strawberries from ICAPP. In winter (November - February) they export fresh fruit to Europe, in summer Individual Quick Frozen (IQF) fruits are exported to USA and Japan. Receives on average 28 LE/kg for export quality. Costs: 11 LE shipping, LE 5 for packing. He is willing to consider collaboration but wants to see feasibility study first and adding a fish farm component should not cause problems to the regular strawberry production process.

In Israel (another country with very limited freshwater resources) there is a rule: 1 m^3 water should generate at least 1 US $ of income.

ICAPP owns chain of fish restaurants called 'Fish market' and a fish cannery.

ICAPP strawberry farm: a part of the harvest (left) and irrigation water reservoir (right)

ICAPP has another farm in Wadi Natrun where saline water is used (3 ppt). This would be fitting well in scope of our IAA assignment. Mr. Kamal El Dakak is ready to participate in a cooperation project and to finance part of the costs whether in Nubareya or Ismailia where there is another farm of 200 feddans of strawberry and 50 feddans of vegetables.

March 11, Dr Ismail Radwan

Dr Radwan has a thirteen feddan farm near El Bustan, Nubareya, where he grows citrus with large beans in between. He has six feddan of wheat which are sprayed with water & sludge from a small fish farm (180 m^3) with water recirculation system. The water in this basin is connected to a pump that pumps 150 m^3/hr. The biological filter beside the fish basin consists of canal with 10 m^3 of beads (700 m^2/m^3 specific surface) hanging in 10 fine-meshed cages which are aerated. Sludge collects under the beads and is drained regularly and sprayed over the wheat fields. Dr Radwan applies staggered harvesting and already four tons of tilapia was harvested and sold in the neighbourhood, now three tons of fish remaining. Dr Ismael believes this system (one fish basin of 30 x 10 x 0.6 m) can produce ten tons/year (almost 50 kg/m^3/year). He stocked 100 fingerlings/m^3 in March 2013.

Water source is subsurface water of 10-15 m deep, approximately 1 – 1.5 ppm. He uses this water before it drains to the drain discharging process water from a milk factory. The location is near Shaikh Zayed Canal near PS No 3.

Investments: transformer 150.000 LE. Building fish basin plus filter: LE 200.000 (but can probably be reduced to 150.000 LE). Beads: 10 m^3/filter, 200 kg/m^3, LE 20.- / kg (total: 40.000 LE).

He believes cost price for tilapia is approx. LE 10/kg, composed of

Feed: FCR = 1.3 , costs LE 5.50/kg (--> LE 7.15 / kg fish)

Electricity: LE 1,- / kg fish

Labour: LE 1,- / kg fish

Total operating costs: LE 9.15/kg tilapia. He sell for LE 15.- / kg (life) of LE 13.- (dead) at nearby markets.

We computed that the investment is earned back in four years.

Cost of land in this area is 150.000 – 200.000 LE/feddan.

Left: wheat field of Dr. Radwan with in front fish basin (under plastic) and biofilter. Right: fish basin with tilapia being fed.

Dr Ismail is also building a backyard RAS system, of approximately 6 m^3 fish basin, small trickling filter; sediments settle under trickling biomass and are regularly drained. One small electric pump with capacity of 22 m^3/hr drives the system. Filter substrate material consists of plastic boxes with rolls of plastic fencing material as substrate material. This backyard system is still under construction.


Left: new biofilter and fish basin (under plastic) under construction. Right: small back-yard recirculation system with trickling filter tower at the rear and fish basin in front.

Dr Ismail does not believe red tilapia has much advantage in Kafr El Sheikh: people don't pay more for it, the fish has low fecundity (due to inbreeding) and it loses its red colour in fresh water. Dr Sherif notes that colour stays in saline water and that salinity enhances the flavour of the fish.

Other promising fish species:
- African catfish (if salinity < 3-5 ppt), price in the market is LE 11/kg.
- Seabass (if salinity > 5 – 10 ppt)

Eel was tried by Dr. Radwan but is difficult: most escaped.

Payment of income tax is a difficult issue for fish farms because most farms do not have all permits required. This makes also obtaining credit from the bank problematic, so most farms are funded with informal credit/investors.

In Badr City Fish Basket has a large fish processing plant under construction. Owner: Ali Haded.
Dr Ismail is open to join the network to develop and exchange knowledge and experience on IAA (KDEC).

The Egyptian Aquaculture Centre that is owned and operated by Dr. Radwan is open for training courses from June – November. There are three hands-on modules: Tilapia reproduction and fingerling growing, catfish reproduction and fingerling growing, Pond management and bit of RAS. Minimum of five persons per training.

His farm in Kafr El Sheikh is re-circulating the drainage water after (natural) purification in the (local) drainage canal system. Sugar beet production in Kafr El Sheikh area could bring an income of about 7000 LE/feddan.

March 12, Desert Research Centre, Cairo (HQ). Dr Raafat Kidr, President; Prof. dr. Hassan Shaer, Ex-Vice president
DRC is the oldest and top arid area research institute in the region. A pamphlet with info about DRC was received. Besides from HQ in Cairo (with 1200 staff) there are eleven DRC stations in the desert region, all well-staffed and well equipped (four are in Sinai, one in Siwa, one in Mariut, one in New Valley, one in Matruh, etc.). Each station has its own ecological system to do research in: dry, rainfall, saline soils, etc.). DRC has a plant gene bank, lab, etc. DRC consists of four divisions: Water Resources & desert Soils; Ecology and Dry Land Agriculture; Animal and Poultry production; Socio-economic studies. DRC has mandate to explore the productive use of brackish groundwater. The mandate to give permission to use groundwater is with MWRI.

Water resources and Desert Soils division has 200 professors. The Centre is organised like a university. The budget comes from Ministry of Finance, private companies, international funding (FAO, IFAD, Islamic Bank, etc.).

There is special station that looks into fodder crops production from marginal lands (in Southern Sinai): pearl miller, fodder beet, alfalfa. In North Sinai 250 farmers are collaborating in DRC's development program. Water comes from Salem Canal. DRC uses Farmer Field Schools model for training & exchange. Model farmers are given seeds, fertiliser, support etc. and they should train their neighbours. Of the 50.000 fed made available for agriculture in Northern Sinai 40.000 fed were transformed into fish ponds (without permit) because the soil was saline and farmers could not farm as they were used to in the delta.

For Dr Shear brackish water is water that animals cannot safely drink anymore (> 2 ppt).

1-3 ppt is good for traditional agriculture on soils with a light texture.

Pearl millet, sorghum can stand up to 7 ppt salinity. Fodder- and sugar beet can tolerate salinity up to 8 ppt.
250 km west of Alexandria there is EU-funded project with private sector. There is desalination unit powered by solar power, makes 100 ppm water from 7 ppt groundwater. Look into what is done with the brackish wastewater.

The DRC field station closest to Wadi El Natrun is in Mariut.

DRC has research on Quinoa at Rashid station (South Sinai), they are now multiplying seeds for sowing on 1 feddan, seeds came from Peru. There are three feddan planted in Sahal El Teena growing successfully for seed production.

Dr Shaers' choice (selection) for brackish agriculture crops: sugar beet, pearl millet, sorghum, fodder beet, sugar beet, triticale, barley, rapeseed.

DRC is now more and more into development projects and will develop commercial products for small farmers that will generate employment and income. They are very willing to collaborate in KDEC, 'just send us the format'.

March 12, Masreya, Egyptian Company for Land Reclamation, Eng. Hossam Abd El-Kader (president), Prof Dr Saad Ahmed Mustafa (Senior Advisor), Prof. Dr. Sameh Hassan Sayed, Fish nutritionist, CLAR
The company has 4000 feddans planted with young jojoba trees (south of Al Alamein). Groundwater of 2000 – 3000 ppm salinity is used for irrigation. Company started with jojoba a few years ago. Jojoba was chosen for high oil content of its seeds (50%). The remaining part after oil extraction is a high quality feed ingredient (30% CP, no anti-nutritional factors). It has been tested as ingredient to partly replace soymeal in fish feed and gave same result as feed with soymeal. Use of jojoba cake would reduce the cost of feeds to 4000 LE /ton (a reduction of 1000 LE/ton). (Soymeal makes up roughly 50 – 60% of the fish feed). (Later we were informed that some anti-nutritional components may be present in the jojoba seed meal.)

The company is interested to add a fish farm as fertiliser unit for the jojoba. 'We are keen to start the fish farm.'

Company has installed 20 solar-driven pumps. One pump irrigates 200 fed of trees. Pump: 30 HP, capacity is 900 m^3/day, powered by 70 m^2 of solar panels. Jojoba needs at least 4.2 m^3/feddan. One unit of pump plus panels plus transformer costs 400.000 LE .
Cost of fertiliser: Year 1: LE 150/fed, 50 kg N/fed needed. Year 2: double gift, LE 300. Requirement will grow when the trees grow larger.

The present minister of MARL recommended this company to include fish production after visiting the jojoba plantation. He commented favourably on the project.

Business model: trees start to give seeds at year 3, stable production will be reached in year 7. Tree needs 4 litre/day in summer, and 2 litre/day in winter (minimum). On cloudy days 50% less water is needed. 525 trees planted / fed. Jojoba oil costs 7000 LE/ton. The company bought land for LE 2000/fed, installed irrigation system, sunk wells, planted trees. The company sells the land to small farmers in parcels of 1.25 to 5 fed for LE 20,000 / fed. Farmers should start payment of the land after 3 years (payment is not connected to volume of the harvest or income from the sale of jojoba seeds).

Knowledge gap: what are water quality requirements of jojoba (nutrient requirement may change when tree starts flowering & developing seeds).

Knowledge gap: what is effect of fertilisation with fish farm effluent and sludge on soil quality?
Knowledge gap: which tree species are suitable as wind fences in desert?

They are considering planting pomegranates besides from jojoba.

Company already cooperates with Dr ElShear (DRC) on quinoa.

They proposed one aqua culture unit for each 200 feddans in the area where they grow now 4000 feddans of jojoba, with a future plan of 14000 feddans.

March 13, Morgan International, Orabi farm. Mr Ayman Aniss
Mr Aniss operates since 2012 one fish + trees unit at Orabi (Cairo – Ismailia Rd, near Abassa). The unit consists of ten 25 m^3 tanks (tilapia, recirculation) that has an effluent of 20-25 m^3 water/day that irrigates eight feddans of young pomegranate trees. Planted 415 trees/fed. The farm produces 20 tons of fish in three months (250 gr fish, starting of as 30 gr fish). Needs 10 m^3 drainage water/feddan in summer, so 25 m^3 is not enough for eight feddan. He currently mixes the effluent with incoming Nile irrigation water in order to irrigate the entire farm. In winter the exchange water is enough to cover 85% of the farms' need. In summer the effluent is covers 15% of the water that is needed. Added benefit: much lower chemical fertiliser requirement.

Water was before treated with Reverse Osmoses. Now the farm only uses sand filter that takes out heavy metals. He has oxygen generator but this is not applied now. The farm is now in 4th fish production cycle; the trees are still too young to give fruits. He stocks 8000 fish of 30 gr per basin, harvest 2 tons of 250 gr fish after three months (four cycles/year). The effluent is separated when leaving the fish basin, one part has most of the sediments and only this part (20%) passes through the drum filter. The rest goes straight into the submerged bio-filter with corrugated glass fibre material as substrate, which is aerated.

Morgan International. Left: fish farm (in greenhouse) with pomegranate trees at the rear. Right: basins stocked with tilapia.

March 13, WorldFish : Dr Kamal El Naggar, Dr Malcolm Dickson, Dr Ahmed Nasr Allah, Dr Mohamed Yahia, Dr Nabil A. Ibrahim

WF came in 1998 to Egypt as regional centre for Africa and West Asia. It is funded as CGIAR centre by International donors. The Swiss-funded IEIDEAS project was explained by Malcolm Dickson.

Components:

1. Improve existing aquaculture in Egypt;
2. Improve livelihoods of women fish retailers (is implemented through CARE);
3. Improve aquaculture production in Upper Egypt;
4. Improve policy environment.

Sub 1. The approach is to train farmers to become trainers. Twelve are now active, so far 1450 farmers were trained (in little more than one year). WF developed Best Management Practices (on paper and ten video films, see YouTube). A survey on how trained farmers apply what was taught is on-going. WF developed improved Abassa tilapia strain that has been given to seven hatcheries who will sell the fingerlings. Hatcheries sold already to 45 farmers, the target is 200.

Sub 2. Approach is developed while going. Main implementer is CARE. Committees of lady retailers are formed. Possible technical improvements: ice boxes, transport (tricycles), concrete slabs. Success has been achieved in Shakshouk. It is a slow process.

Sub 3. Pro-poor aquaculture. WF tried backyard aquaculture of catfish (Nigeria style) but was not very successful (due to unclear genetics of catfish used: pure or hybrid?). 26% of Egypt's population qualify as poor (< $ 2.50/day). Poorer segments of society prefer smaller fish (tilapia 100-150 gr). There is demand for this and WF will this year stimulate production of such small fish in certain are to test. This would allow farmers to grow two crops/year.

Sub 4. Policy development: study concluded that there are 10 organisations of fish farmers but most/all are dormant and none represents all farmers. Approach is to build organisations. CARE Egypt is involved. Aim is to create platforms for policy dialogues between industry, government, donors, other stakeholders.

Other important issue for Egyptian aquaculture is market development, finding new markets, development of cold chain, traceability of the fish.

WF is open to build a RAS system on its premises. This would allow comparison of production in RAS with ponds (economics), can be used to do nutritional research, research on off-flavour of fish, comparison of genetically different strains.

RAS for production of marketable fish in EGYPT has to compete with cheap production in open ponds. Possible advantages of RAS: it can offer fish in all seasons (possibility to warm water in winter) and it can produce larger fingerlings.

Factors affecting sale price of fish: dead or alive; big or small; time of the year; quality.

Aquaculture is used to make saline soils productive; there are 380.000 ha of salinity-affected soils in Egypt.

WF is interested to take part in the KDEC on condition of full cost recovery. When asked what research issues they think of for IAA the requirements of crops for certain nutrients was mentioned. DRC could possibly answer this question.

March 13, Al Wanas Masr company, Mr. Eng Kamal Wanas, President

The company is based El Tal El Kabeer close to the Cairo – Ismalia highway. It is involved in granite and marble cutting, drying grains, bicycles, vegetable and fruits, wind mills and solar power installations for households. Mr Wanas became interested in aquaculture because there was spare 1260 m^2 of spare land when he stopped with the grain drying business. The company developed and

sold its own grain dryers. Recently the company bought fish farm design (drawings) from US company through internet. They have no personnel that is trained in aquaculture, he studies the subject himself and started three months ago. Has built five elongated steel tanks of 15 m^3 each, plans filter (screen filter for particles, submerged filter with any PVC material as medium). He plans to use the effluent to irrigate a hydroponic unit with vegetables. The company also makes 1 m^3 hydroponic units made from 1 m^3 plastic fluid containers with 1 m^2 vegetable unit. Such units he will offer for sale ('rooftop or backyard aquaponics'). Mr Wanas plans to use well water (fresh) but has also access to tap water and the Ismailia canal.

We promised to involve him when workshops or conferences are organised in Egypt.




Al Wamas Masr: row of metal fish tanks (top) and back-yard aquaponics units (below).

March 14 Dr Sherif office in Maadi
Whole team: working to prepare the presentation for the Water Mondiaal Panel meeting

Annex 2 KDEC project proposal

KDEC for IAA: Knowledge Development and Exchange Community (KDEC) for Integrated Agriculture – Aquaculture, Egypt.

Rationale

Using brackish ground water first for intensive aquaculture and irrigating trees and crops with the fish farm effluent (IAA) is an efficient way of using natural resources: water is used twice for food production and the amount of fertilizer is reduced because the plants makes use of the plant nutrients added to the water by the fish farm. In addition the pressure on Egypt's limited freshwater resources is reduced. IAA (or elements of it) with brackish groundwater is already taking place at large and medium-scale enterprises in Egypt but the mission that looked into IAA in March 2014 found that the pioneers often work in isolation, meeting difficulties and making mistakes that can relatively easily be remedied or avoided if they had known what is already learnt and done elsewhere. The mission also noticed that there is much interest in agricultural companies that use brackish water to learn more about applying aquaculture as a way of fertilizing (fertigation) their crops. There are questions, initial apprehensions and misconceptions existing with regard to intensive aquaculture and using the brackish effluent for agriculture that can be overcome by being part of a network where experiences and knowledge is shared and new knowledge is developed. For famers that are interested in (or already) growing fish IAA could be an efficient way of using their effluent productively, turning a negative environmental impact into a valuable agricultural resource. The mission also noticed application of solar power to operate groundwater and interest and 'spontaneous' starting of aquaculture in Recirculation Aquaculture Systems (RAS). RAS requires rather advanced knowledge to design and operate installations properly and such knowledge seems to be insufficient at this moment. It is important to avoid that the rather large investment in capital, time and energy to build a RAS system is not wasted and leaves investors and pioneers frustrated and disappointed in this water-efficient method of growing fish.

In IAA using brackish water there are several issues and knowledge gaps that need to be addressed, studied and tested both on the agriculture side (crops, soil) as well as on the (intensive) aquaculture side.

The mission concluded that there is an urgent need to bring the pioneers, the companies interested to start and scientist working on (integrated) aquaculture and agriculture together regularly to share experiences and learn what has been discovered and tried elsewhere in farms and research institutes. Without such regular sharing and learning capital is wasted and much enthusiasm and energy are used to overcome obstacles that could be avoided, possibly resulting in disappointment if the initial attempts fail. The network we propose would be a learning community that starts off with mostly medium-size and larger Egyptian and Dutch companies and members of relevant scientific institutes as members. The working title we chose is KDEC Knowledge Development and Exchange Community. KDEC will lay the foundation that will enable SMEs to embark on IAA with brackish groundwater with a higher chance of success because larger companies took the first and most risky steps and overcame initial difficulties. In the third year of KDEC's existence groups of small farmers (SMEs) will benefit from KDEC by learning from the experiences of the pioneers who can function as suppliers of seeds, fingerlings or other farm inputs and/or as buyers of the crops and fish produced by such SMEs (possibly in a contract farming arrangement or otherwise). The formation and involvement of such groups of small and medium size farmers will require more time and funds. This will be a larger project for which a separate proposal will be developed.

Impact for the stakeholders directly involved: KDEC will bring the pioneers, scientists (in crops, irrigation, aquaculture, soil, etc.) and participating government institutes twice yearly the opportunity to learn from each other, to discuss technical and legal issues and make proposals for pilots that will address technical problems and outstanding issues. There will be input from scientists and sharing

relevant experiences from outside Egypt (capacity development and knowledge exchange). KDEC will support the dialogue between the private sector and the government and between the Ministries of MALR, MWRI and the Ministry of Environment.

Impact for Egypt and the Netherlands: Support to KDEC for IAA means development and maintenance of a network of energetic Egyptian entrepreneurs. For companies from the Netherlands (a country with a modern and well-known advanced horticulture sector and 30 years of experience with RAS in practice) being close to and involved in this network offers opportunities for business development (sale of designs, equipment, knowledge, buyers of Egyptian fish and agricultural products). For Egypt as a nation the structured development of a IAA based on science and experience existing on the side of Egyptian and Dutch companies and scientific institutes means support to economic development in desert regions, production of food and a for more efficient use of its brackish groundwater resources than would be the case when agriculture develops in aid regions without the link to aquaculture.

Proposal

We propose to give financial and technical support for two years to the establishment and start of an informal network (called Knowledge Development and Exchange Community, KDEC) of Egyptian and Dutch:

- Aquaculture or agricultural companies that have already started with, or are seriously interested to apply IAA using intensive aquaculture systems (RAS, biofloc or otherwise),
- Scientific institutes working in the field of arid agriculture, aquaculture, irrigation and soil & water management and
- Representatives of MWRI and GFARD.

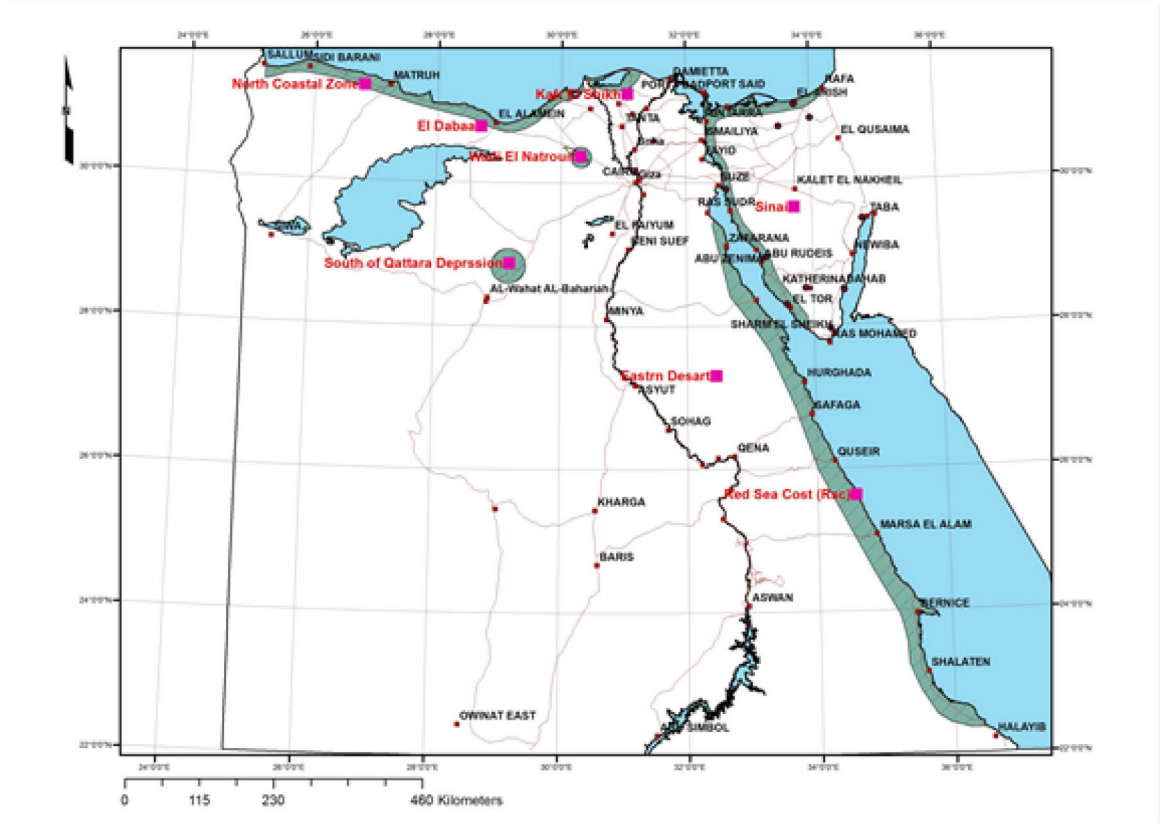
The network would meet twice/year (four times during the two years period covered by this proposal) with the objectives to share and learn from each other's experiences, to identify technical issues within the realm of IAA using brackish water for study and testing in on-farm pilots and institute-based research, to give technical support to the pilot projects to solve some of the technical issues and to learn from similar experiences in the Netherlands and elsewhere. In addition the results of the pilots will be published and the concept of IAA will be promoted to a larger Egyptian audience. During the existence of KDEC models to involve groups of SMEs (through contract farming, as independent companies, etc.) will be discussed and developed.

In the first two years the Community will probably exist primarily of medium and large companies who will learn to work together while developing the IAA concept further. Within this starting period of two years ways to involve small farmers (SMEs) will be developed. The SMEs will benefit from this, avoiding the initial mistakes and benefitting from the experiences and support of the larger companies (farms, food processing factories, sugar mills, etc.).

Budget indication, per year

Two meetings of 40 – 50 people, 1 day/meeting, 2 x 5000	€	10,000
Coordination of KDEC by Egyptian expert (part-time), travel costs	€	2,500
Supervision/support backstopping from Wageningen UR (crops scientist, irrigation, aquaculture) for backstopping and input in meetings	€	40,000
Training sessions in Egypt about dealing with salinity, RAS, fertigation, Integrated Agri-Aquaculture Systems	€	30,000
Pilot studies: (to be co-funded by participating companies), average per pilot € 15,000, four pilots per year	€	60,000
Promotion of IAA in media and among companies, investors in Egypt and Netherlands (publications, short films, etc.)	€	7500,00
Subtotal per year:	**€**	**150,000**
TOTAL for two years (excluding VAT):	**€**	**300,000**

Annex 3 Brackish water aquifers appointed by the Groundwater Sector for aquaculture



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Alterra Wageningen UR is the research institute for our green living environment. We offer a combination of practical and scientific research in a multitude of disciplines related to the green world around us and the sustainable use of our living environment, such as flora and fauna, soil, water, the environment, geo-information and remote sensing, landscape and spatial planning, man and society.

The mission of Wageningen UR (University & Research centre) is 'To explore the potential of nature to improve the quality of life'. Within Wageningen UR, nine specialised research institutes of the DLO Foundation have joined forces with Wageningen University to help answer the most important questions in the domain of healthy food and living environment. With approximately 30 locations, 6,000 members of staff and 9,000 students, Wageningen UR is one of the leading organisations in its domain worldwide. The integral approach to problems and the cooperation between the various disciplines are at the heart of the unique Wageningen Approach.

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