WAGENINGEN UR
For quality of life

Watersaving greenhouse technology for the Gulf region

Trip report January 2009

Jouke Campen

landbouw, natuur en voedselkwaliteit

Report 243

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Wageningen UR Greenhouse Horticulture, Wageningen
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Table of contents

1 Summary

A visit was made by Jouke Campen to the United Arab Emirates from 16th till 23rd of January 2009. This visit is part of the BOCI project **Water saving greenhouse technology for the Gulf region.**
The goal of the mission was

1. Discuss with stakeholders in the public and private sector in UAE water saving techniques for the Gulf region.
2. Identify the current status of protected horticulture in UAE
3. Participate in the water delegation including ZKH Prins Willem Alexander.

The major conclusions of the mission are:

- Agriculture is the main consumer of water in this region. This makes it essential to apply water saving techniques on this sector.
- Policy makers have to be convinced of the urge to deal with the extensive water use in agriculture. A strategy (or strategic policy) has to be written to regulate the water use in agriculture. As long as water is free , water saving will not have any priority.
- The closed greenhouse concept is a good alternative for the pad&fan system from an economical point of view and more important from a water saving point of view. The evaluation has to be discussed with the stakeholders.
- A demonstration center and training center is needed to show the discussed techniques work for the Gulf region.
- All companies involved in protected horticulture (builders, seed companies, biological control etc.) should be able to demonstrate their products in this center. Showing products also work in the climate conditions of the Gulf region is very important.
- Changing the growing system to hydroponics is the first step to save water provided that the transition from open field to protected cultivation is already made.

These conclusions resulted in the following actions for the coming months:

- The findings in this report will be discussed with the stakeholders (growers, policy makers, companies, investors).
- The closed greenhouse concept has to be proven for the Gulf region. Firstly the economic perspective of the system should be determined based on the evaluation proposed in this report. Secondly an experimental site has to be developed in the region where the concept is tested and demonstrated. This site can be combined with the international research center. Through demonstration and presentation, growers and policy makers have to see to potential of the system. Moreover this location can be used by industry to demonstrate and test their products in this region.
- Together with the Dutch ministery, KSA/UAE ministery, AVAG, ICARDA and WUR the establishment/creation of a GCC-wide research International centre on protected cultivation is pointed out in the previous bullet should be discussed.
- Publish an article in a local magazine on water saving techniques and theory discussed in this report.

I thank Philip de Jong and Samar Kadri for their hospitality and great help before, during and after my visit.

Wageningen, February 2009.

Jouke Campen (jouke.campen@wur.nl)

2 Introduction

This report is part of the project "Water saving greenhouse technology for the Gulf region", funded by The Netherlands Ministry of Agriculture, Nature and Food Quality with project number BO-10-006-124.

2.1 Problem statement

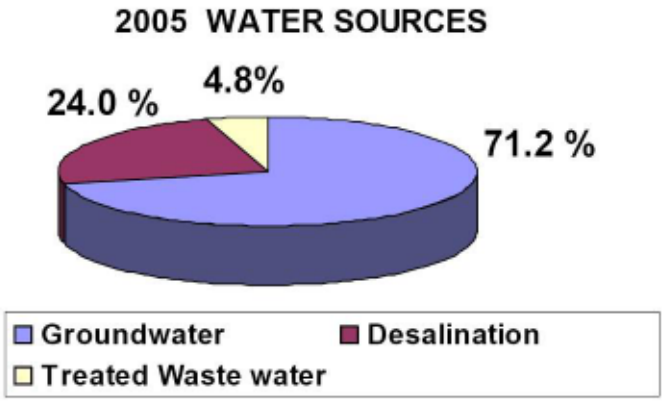

Figure 1. Water sources for UAE in 2005 source: Abu Dhabi water resources statistics 2006, Environmental agency.

Fresh water is becoming a rare commodity in the Gulf region. With an annual rainfall of around 35 mm and temperatures up to 50°C, fresh water reservoirs are rare. The main source of water in UAE is coming from groundwater. This source is especially used for agriculture en forestry. Domestic water is produced mainly from sea water using reverse osmosis.

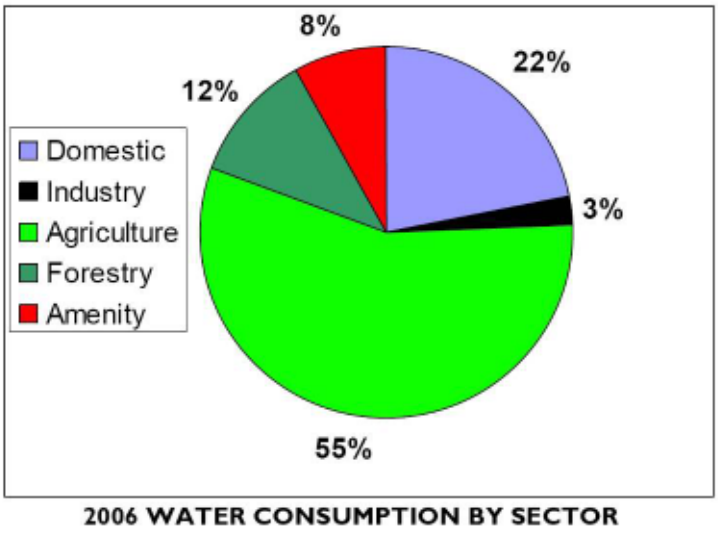

Figure 2. Waterconsumption by sector in UAE.

Agriculture consumes most of the water used in UAE as can been concluded from the figure. These wells are usually privately owned and no restrictions or costs are related to the use of these wells.

Figure 3. Photo of a pad wall in a greenhouse located near Riyadh,

Traditionally greenhouses in the Middle East are cooled using pad and fan systems. Warm dry air is forced through a wet mattress making the air humid and thereby cooler. Since for the majority of the Middle East the air is very dry this method can be applied. But the main disadvantage of this method is the fact that it consumes an enormous amount of water (more than 8000 liters per square meter of greenhouse in Saudi Arabia). Water is, as in most countries in the world, scarce in the Middle East. Efficiency in water use is considered one of the most important future issues of protected agriculture. By adopting more efficient new growing systems and techniques, protected agriculture can reduce environmental degradation. The quantity and quality of water required to produce high value crops is practically impossible to obtain in a dry regions. The underground water level has rapidly declined and the water has increasing salt content, as can be seen from the figure above. Expensive desalination is necessary for good quality fresh water.

2.2 Context of this project

It was concluded at the international workshop on investment in protected cultivation in GCC countries held in May 2006 in Abu Dhabi (http://www.icarda.org/aprp/APRP-AE/pawsabu/index.htm) that a GCC-wide research centre on protected cultivation has to be established. This centre has to take away the obstacles for protected cultivation and horticulture in general in GCC countries. The obstacles focus mainly on:

1. Greenhouse cooling and ventilation
2. Greenhouse management
3. Water use efficiency
4. Adoption of new technologies and production techniques.

A recent study by Wijnands and Maaswinkel (2008) also stressed the importance of a demonstration and training centre which should also collaborate with local universities and research centers. The main conclusions of this study was

"The authorities of the Kingdom of Saudi Arabia (KSA) and the United Arab Emirates (UAE) are making great efforts to diversify the economy, since in the longer term they wish to develop other sources of income to compensate for declining oil revenues. The scarcity of water gives cause to the need for its more efficient use, and for this reason protected horticulture is receiving a great deal of attention in both countries. The greenhouse industry contributes to sustainable development, creates appealing jobs for the indigenous population, and is compatible with the trend towards an increased demand for higher quality and safe food. Dutch knowledge and technology could provide support to the required developments in both countries."

As a result of this study a project proposal was formulated by the dutch industry (AVAG) called "The Riyadh greenhouse: Seeing is believing". This proposal included a 3 ha greenhouse where with the application of existing techniques 30% water saving was reached. The proposal was submitted to the ministery of KSA.

2.3 Research objectives

The objective of the project "Water saving greenhouse technology for the Gulf region" is to evaluate in what way Dutch industry and research centers can facilitate the Gulf region in the area of horticulture to reduce the water use of this sector. This goal can be met by providing information on techniques through workshops, discussions and demonstations.

3 Visits, workshops, meetings

This paragraph describes in detail the visits and meetings made in UAE. A schematic itinerary is given as an appendix.

3.1 Water Seminar: 18 January 2009

Date: 18th of January
Time: 9:00 till 14:30
Location: Mamoura building in Abu Dhabi

The program of the seminar as it was distributed.

Programme set up

High Level Water Seminar
"Creating a sustainable water chain in a dense coastal zone"

The seminar discusses the challenges that the UAE faces with regard to water management and to see whether (and where) the Netherlands can contribute to combat these challenges

Following aspects of the water sector will be addressed in the seminar:
- Knowledge exchange / Research & Development: demand driven research
- Design and construction of water infrastructure in densely populated coastal zones
- Innovative water technology developments
- Environmental aspects and legislation
- Centralized and decentralized solutions
- Efficient Water use and food security (agriculture) in the UAE

Programme set up / time table

09.30 – 10.00 hrs Arrival of participants and registration

10.00 – 10.45 hrs Seminar part 1: tbc by EAD
Present; PvO, Minister Heemskerk, 2 UAE Ministers
- Keynote Minister Heemskerk
- Keynote UAE Minister tbc
- Presentation Dick van Dijk, Regional Coordinator NGWP
- Presentation Joop de Schutter, Unesco-IHE tbc

10.45 – 11.05 hrs Coffee / tea break

11.05 – 12.15 hrs Water seminar:
Creating a sustainable water chain in a dense coastal zone
- Demand driven research: organization, developments, cases
  Mr. P. (Paul) Buijs, Managing Director Global Membrains / Wetsus
- Design and construction of water infrastructure dense coastal zones
  Mr. R. (Rene) Hoeijmakers, Director Water Haskoning, Dubai Branche
- Innovative water technology developments
  Mr. H. (Harry) Futselaar, Business Development Manager, Norit
- Efficient Water use and food security (agriculture) in the UAE
  Mr. J. Hadders, Dacom

Chair / moderator: Mr. J. v.d. Sommen, Managing Director NWP

The first part of the second session (after 11:05) mainly focused on water treatment. The reaction of the audience on this subject was minimal. The main reason for this being that most of the techniques presented are already used in UAE. The presentation by Jan Hadders did result in a discussion with the audience since it showed that agriculture is the main consumer of water as indicated in the introduction of this report. People seemed to be very interested in technology to reduce the water use for this sector.
Dr. Zara Khatib (technology manager at Shell) expressed her concern that the energy consumption needed to apply water saving techniques is often not mentioned though it is a rather substantial amount. I contacted the Dutch companies participating in the seminar. The director of Water resources and Dams (Salim Akram) was very interested in the technologies presented during the seminar.

3.2 World Future Energy Summit

Date: 19th of January
Time: 9:00 till 17:30
Location: Exhibition center in Abu Dhabi

The summit had the topics of energy and environment. A keynote was given by Royal Highness Prins Willem Alexander. The speech contained a paragraph on 'green' greenhouses. The prince stated that new greenhouses produce food, electricity, heat and cooling. The energy can be used for 200 homes. The greenhouses also produce biogas for electricity generation. For me it is not exactly clear to what greenhouses the prince is referring. To some extend he refers to the energy producing greenhouse but this concept is not applicable in the Middle East since heating is hardly needed in this region. But the speech rose interest by Sheikh Mohammed and Masdar City and they want to know more about these technologies which can be good if the correct information is given.
In Holland Pavilion around 15 Dutch companies are represented.

People met at the summit

Dick van Regteren from the GENAP folieconstructies. He supplied Mr Alrasheed (KSA) with a couple of water basins.
M. Mathews Mathew from the magazine Agriculture. I discussed with him the possibilities of publishing an article on water saving in the gulf region. They are very interested in an article.
Mr. Carl R.E. Staudt for LedNed. They make LED light for buildings. But they are also interested in the field of horticulture.
Mr. Takayuri Yoneda for Mitsubishi chemical. They were planning on setting up a growing facility under artificial light. As shown in the picture below. They claim to have higher production due to the use of LEDS with spectrum in range with the photoactive radiation.

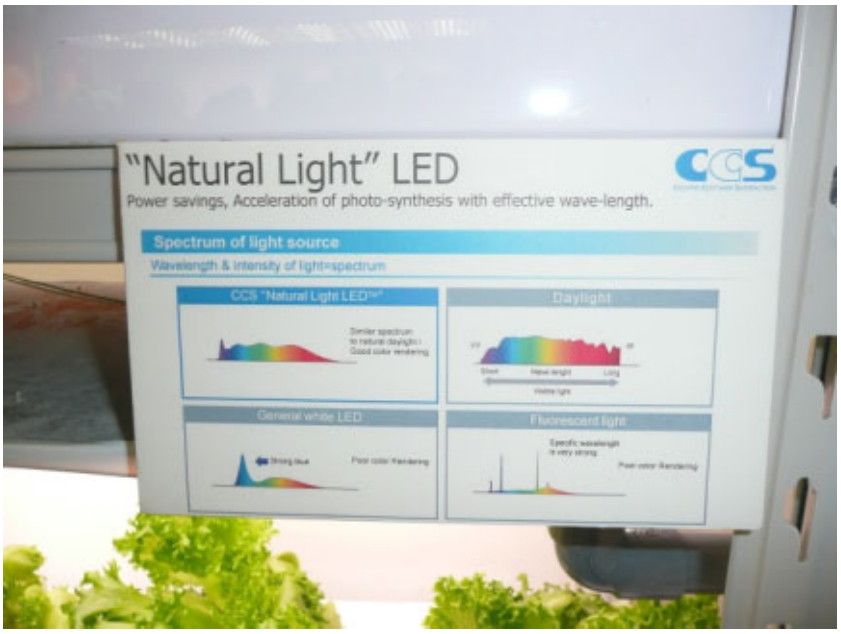

Figure 4. Photo of the light distribution of the LED light.

At the summit Jouke and Philip met Mr. Rasheed. We discussed the fact that a lot of suppliers do not have facilities here in the Gulf. Mr. Alrasheed thought it would be wise to have that to show that their products also function in the gulf climate. Seed companies, constructors, fertilization producers etc. Mr. Rasheed told about a new project he is doing in UAE and we made arrangements to visit this location near Al Ain the next morning.

3.3 Farm visit with Mr. Alrasheed

In the morning of the 20th of January I was picked up by mr. Alrasheed from the hotel in Dubai at 7:00 am We drove to Al Ain to meet up with Philip de Jong.
During the trip we discussed the following issues:

1. The application of a new type of pad system (Coolnet AK150 by Jes products in Maasdijk NL) which is based on plastics instead of paper. It is for this reason easier to clean. Mr. Rasheed studied the pad but did not yet decide on using it. I will contact the firm producing the material so they can send a sample of the material to test it is a greenhouse here. Mr. Rasheed wondered if this pad can hold enough water.
2. The application of a closed greenhouse. Mr. Rasheed asked me of a closed greenhouse could be feasible in the Gulf area. At the current stage this can not be said with certainty. The operational costs are not exactly know and the price of the products are also not exact know. WUR Horticulture made a excel sheet where in a very simple form the economics of a closed greenhouse can be calculated and compared to the conventional method of growing using a pad and fan system. This excel sheet will be send to Mr. Rasheed so we can discuss on the figures used as a reference.
3. The distinction between all the cooling methods applied in horticulture like Filwihex or Innogrow concept where explained by Jouke. The concepts are in principle all the same. They cool the greenhouse air. The differences are in the field of central (using air ducts) or decentralized cooling and the heat exchanger used.
4. Mr Rasheed manages 75 hectares of glasshouses in total he manages 400 hectares of greenhouses in KSA. More greenhouses will be constructed in KSA. The project visited near Al Ain is the first project in UAE.

Figure 5. Photo of the new farm near Al Ain.

The farm is located on the highway between Al Ain and Dubai (GPS decimal coordinates 24.67 N 55.74 E). The total surface area is 300 ha (3 by 1 km). 100 ha will be used for open field production. In total 30 ha of greenhouse will be constructed. Already 10 ha have be construction as a multispan plastic greenhouse. The remaining 20 ha will be constructed using glass.
The main problem they face at this location is wind which moves the sand. Water comes from 76 wells with 600 million gallons per day. The size of the reservoir is not known. So they do not know how long they can grow at this location. We told Mr. Alrasheed about the application of Fugro where the size of the reservoir can be measured with electromagnetic waves. The was very interested in the application and Jouke send the personal information of Job Nijman for Fugro to Mr. Alrasheed.

Figure 6. Photo of the existing farm visited on the 20th of January.

We also visited a existing farm in the region. The greenhouse was a pad&fan greenhouse. The crop was planted in the soil as can be seen on the photo.

Mr. Al rasheed will visit the Netherlands in beginning of February and then he will also visit Wageningen and Bleiswijk to see the new greenhouse concepts. Mr. Alrasheed will be provided with some photos of the ZoWaKas in Bleiswijk.

3.4 Visit ICBA

Date: 20th of January
Time: 11:30 till 14:00, including lunch
Contact persons: Dr. Shawki Barghouti (Director General) and Dr. Ahmed A. Almasoum (deputy director general)
Location: International Center for Biosaline Agriculture, Dubai

Philip and Jouke first had a discussion with Dr. Barghouti and Dr. Almasoum on water management. Dr. Barghouti stress that water is spilled on the farms because it does not cost anything and because the manager of the farm is

not always present. This could be avoided by education or to let growers pay for the water. Dr. Barghouti also pointed out that there is not good knowledge transfer between the private sector and the growers.
Dr. Almaoum said the number of farmers is decreasing due to the high salinity of the water coming from the wells.
According the Mr. Barghouti the horticulture can become less water using when:

1. Subsidies are given when growers apply water saving techniques
2. The investments will be rewarded by a higher yield.
3. The export can increase.

ICBA thinks sewage water should be used more for horticulture. It is a waste when it is flushed to sea.
Together with WUR and the Dutch government ICBA wants to give a training program for private companies, farmers and policy makers to communicate the message of the need of water saving.

In the past farmers received subsidy from the government. Now they do not receive this subsidy anymore.

Biological control cannot be done in a pad and fan system.
Coco peat from Sri Lanka is banded in UAE because the salinity was too high. From Europe they still allow coco peat in but it is too expensive for them.
ICBA has the facilities to train students from all over the world and they welcome them to work at the institute. ICBA want to set up a training program for growers, farmers and dealers and agents on horticulture.
A Swiss fund can provide money for the training of students for poor countries. Also ICBA has money for these trainings.

A lot of research is done in the field of the effect of salt on production. Seed companies can provide ICBA with their products so they can do the research.

Locals pay 0.05 AED per kWh.

Around 18th of March their will be a seminar at ICBA where industry and ministries are coming.

3.5 Meeting with mr. Khoory

Date: 21st of January
Time: 12:00 till 13:00
Contact persons: Mr. Najieb A. Khoory director Mirak
Location: Central Fruits & Veg. Market, Block No. 1 - Shop no. 7 , Dubai

Samar Kadri and Jouke Campen met with Mr. Khoory in his office. The Mirak farm consist of more than 150 ha of which 5 ha is greenhouses. Mirak produces lettuce, tomatoes, lilies, strawberries and numerous other products. The products are exported and sold on the local market. The greenhouses are equipped with evaporative cooling. Mirak consists of various farms. On all farms hydroponics is applied, a mixture of perlite and coco peat. This is done since the water quality is poor and desalinization is needed. All water is recycled in the process. In summer a farm of 5000 m2 uses 30 m3 of water daily. In the view of Mr. Khoory organic is not possible. He claim to have clean farming which results in a good quality since Japan even approves his products. The greenhouses are from France. Expansion is not done at the moment due to the crisis and the market being less attractive.
Mr. Khoory initiated the Desert Rose concept. There will be a centre where all companies involved in horticulture can participate. Companies can have their offices at this location and research is also done at this location. The area will consist of 30 ha. HAS (University of applied sciences in Den Bosch) from the Netherlands will also be involved. The current status of the project was not clear.
Mechanical cooling of greenhouses can never be feasible according to Mr. Khoory. The costs are too high.
There is no contact between ICBA and Mr. Khooy. He has been in contact with ICARBA in the past (Mr.Moustafa) but he claims he does not need any organization to help him.

3.6 Visit supermarkt

Date: 21st of January
Location: Dubai

Figure 7. Photo of tomatoes in a top-end supermarket.

In order to get a idea on the prices of vegetables paid for high quality products a visit to supermarkets was made. The vegetables at a high quality supermarket are coming from the Netherlands as can be seen on the photo. Also the capsicum, cherry tomato and lettuce came from Holland. Prices paid for tomato range between 4 and 5 EURO per kg. For capsicum 5 EURO/kg is paid, for lettuce 4.5 EUR/kg.

Figure 8. Photo of vegetables in a normal supermarket.

In a cheaper supermarket vegetables coming from UAE, Egypt and Oman. Tomotoes are price around 2 EURO/kg, and capsicum at 1.5 – 2 EURO/kg. The quality of these products was less than seen in the high end supermarket.

3.7 ICARDA

Date: 22nd of January
Time: 12:00 till 17:00
Location: Dutch Embassy in Abu Dhabi

Philip and Jouke met Ahmed T. Moustafa for the international center for agricultural research in the dry areas (ICARDA) in Abu Dhabi. ICARDA gets it funding from several funds all over the world. Funding of research in the Gulf area is usually difficult since this region is rich. But showing the benefit of training people from other Islamic countries in the Gulf region on projects can help to get finance for this region.
Mr. Moustafa asked our opinion about ICBA. We mentioned the institute looks very modern which all facilities available. Their focus of the research is very narrow though. They mainly concentrate on the research on the reaction of various plants to salinity. Mr. Moustafa agreed.
ICARDA is thinking of establishing a international research center for protected horticultural in the Gulf region. This center should do research especially for this region. There are numerous other research centers in the Gulf region but Mr. Moustafa does not see anything coming out of these centers. The application of solar power should be one of the research topics for this center. They want to involve research institutes like Wageningen UR and AVRDC (Breeding varieties research in Taiwan) as well in this center. People like Mansouri (also in the board of ICBA) and the wife of the emir of Qatar should be involved in setting up a center like this and arranging the financial support.
Mr. Moustafa draw a picture of a closed greenhouse in a circular form how he thinks the current design of greenhouse can be transferred to closed greenhouses. The closed greenhouse is to only way for horticulture in the Gulf area according to Mr. Moustafa.
Three activities will link WUR with ICARDA in the coming period:

1. Setting up a joined research program on IPM, closed greenhouses, solar energy.
2. Building of a international center for protected horticulture where techniques can be studied and presented. UAE is a good country to locate this center since visa limitations do not apply here.
3. Offering a workshop on protected horticulture in dry areas in Syria. ICARDA is planning on organizing this workshop.

4 Protected horticulture for the Gulf region

Protected horticulture

Numerous studies have been done on the effect of protected horticulture compared to open field in terms of production. The figure below clearly indicates protected horticulture substantially increases productivity.

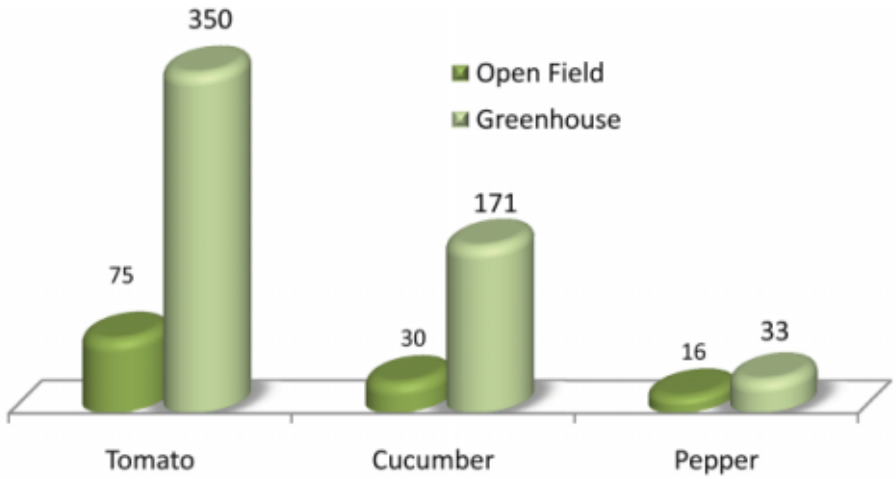

Figure 9. Productivity of 1 m3 of water in protected agriculture and open field (source: A.T. Moustafa).

From these number it can be concluded that protected horticulture should be stimulated over open field growth. This should be the first priority.

Hydroponics

Growing in the soil is still common practice in UAE. Only growers where water is becoming brackish, are shifting towards hydroponics. The hydroponics systems consist of perlite and coco peat. During our visit we heard from ICBA that coco peat from Sri Lanka is not permitted in UAE due to the high salinity of the material but this was not confirmed by the growers.

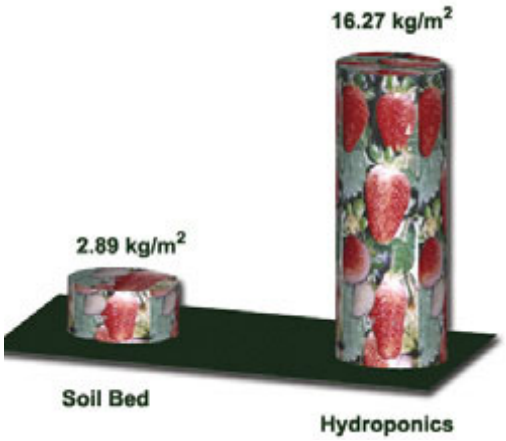

Figure 10. Yield comparison between soil bed and hydroponics (source: A.T. Moustafa).

Not only is the water use efficiency increased through the application of hydroponics but also the production as indicated by the above figure.

CO_2 enrichment

CO_2 can increase production by 40% given the proper climate. CO_2 can be supplied by pure CO_2 and by burning natural gas. The burning of natural gas can be combined with the generation of electricity to power for example the chiller. The excess heat can also be used to drive an absorption heat pump in the ideal case. CO_2 enrichment is no option when applying pad&fan since the supplied CO_2 directly exits the greenhouse through the fan.
CO_2 is currently the limiting factor for production specially in winter time when the climate is good.

Water resources

Currently most growers have wells which supply their farms with fresh water. The size of these wells is decreasing rapidly by the extensive use though. The quality of the water is decreasing as well as a result of the empting of these wells. Alternatives have to be provided for this reason. Several growers stopped production due to bad water quality as was mentioned by ICBA.
The first method which can be applied to make fresh water is reverse osmosis. Saline water is pumped through a membrane which filters out the minerals. A cubic meter of water can be produced at a cost of around 1.75 dollar. 70% of the costs are resulting from energy costs. The process can be made more sustainable by the application of solar radiation, in terms of economics this will not be successful. New techniques where excess heat is used to power the process have been developed like Memstill (http://www.emf.nl/pdf/brochure_memstill.pdf)
Alternatively solar radiation can be used to desalinate water. Numerous studies have been done in this field. A pond of saline water is ceiled of for its environment. Due to solar radiation the water in the pond evaporates. The covering over the pond is relatively cold so condensation occurs. The condensate is fresh water. In the case of cooling by mechanical means the heat produced during this process can be used to heat the pond increasing the amount of evaporation and thereby condensation. Provided an efficiency of 50% and a solar radiation of 7GJ around 1.4 m3 of fresh water can be produced this way per square meter of pond.

Closed greenhouse

A closed greenhouse is closely ceiled of from the outside in terms of air exchange. The humidity and temperature inside the greenhouse are controlled by air treatment units.

Figure 11. Photo of the ZoWakas in Bleiswijk being a completely closed greenhouse.

The figure above shows an example of a closed greenhouse located in Bleiswijk The Netherlands. The air treatment units are installed above and below the crop to provide the optimal climate. No vents are installed in this greenhouse.

The advantages of a closed greenhouse are:
- Minimum water use
- Controllable climate
- Homogenous climate
- High CO_2 concentration
- Minimum use of pesticides
- Biological control is possible

These advantages will result in a higher production and a better quality.

The disadvantage of a closed greenhouse is:
- High investment costs
- High operational costs
- Trained operators needed
- High energy consumption
- Still in development.
- Not tested in the Gulf region yet

The main advantage of a closed greenhouse in relation to this project is the fact that a closed greenhouse drastically reduces the water consumption. This advantage has to compensate for the fact that the technology is costly and energy consuming.

4.1 Economic comparison between a pad&fan and a closed greenhouse

The closed greenhouse was compared to the pad and fan system economically.

Table 1. *Table of the assumptions made for the economical evaluation of a closed greenhouse compared to the traditional pad&fan system.*

Assumptions

Prices				
Price of water (desalinated)	1.1	EURO/m3	5.50	AED/m3
Price of Electricity	0.01	EURO/kWh	0.05	AED/kWh
Price CO2	1	EURO/kg	5.00	AED/kg
Price labor	3	EURO/hour	15.00	AED/hour
Price gas	0.1	EURO/m3	0.50	AED/m3

Production		
Pad and fan	40	kg/m2
Closed greenhouse	100	kg/m2

Investments				
P&F	80	EURO/m2	400	AED/m2
Fogging	10	EURO/m2	50	AED/m2
Air distribution	10	EURO/m2	50	AED/m2
Chiller	150	EURO/m2	750	AED/m2
CO2 supply	15	EURO/m2	75	AED/m2
Greenhouse low tech (P&F)	50	EURO/m2	250	AED/m2
Greenhouse high (CLOSED)	100	EURO/m2	500	AED/m2
Interest, maintaince etc.	20	%/year		

Use	Electricity [kWh]	CO2 [kg]	Water [m3]	Labor (hours)
P&F	30	0	8	1
Closed greenhouse	519	20	0.5	2.5

Conditions			
Solar radiation	7.0	GJ	
transmissivity	80	%	incl. heat for outside
Currency rate	0.20		EURO/AED
COP chiller	3		incl. pumps

The figures in the tables are based on the information gathered from growers and other resources. These figures should be part of the discussion with stakeholders involved. The production level in a pad&fan system is for a modern well organized farm. Usually production rates are around 25 kg/m2. The production in a closed greenhouse is based on the experiments in closed greenhouses in the Netherlands. Provided that the amount of solar radiation is twice the amount we have in Northern Europe the production level can be justified.

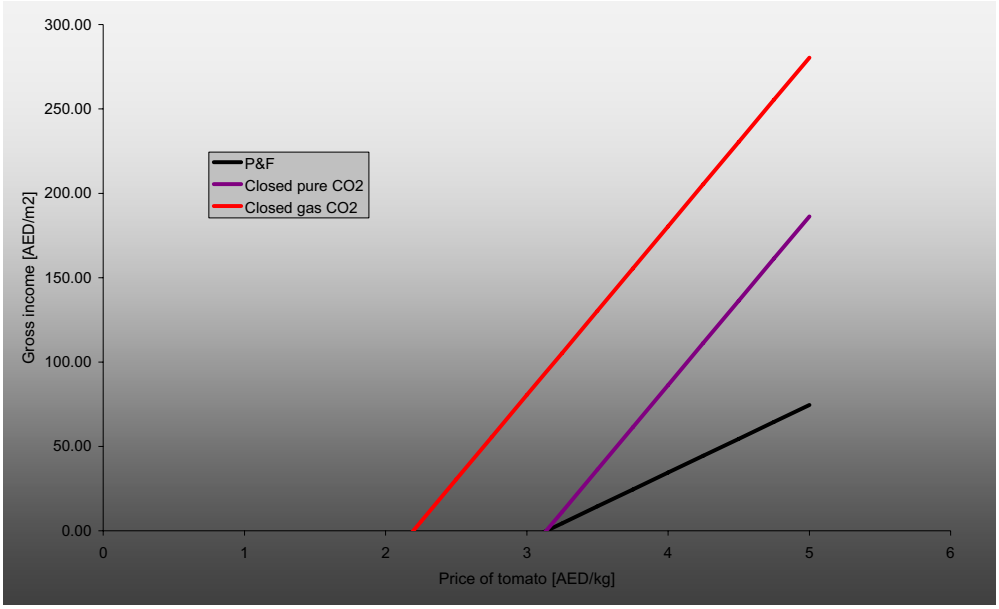

Figure 12. The gross income per square meter of greenhouse as a function of the price of tomato.

Based on these figures the gross income of the grower per square meter of greenhouse can be determined. This is indicated in the graph above as a function of the price of tomato. The figure indicates that the production in a pad and fan system becomes viable when the price of tomato is more than 3.2 AED/kg. By coincidence this is also the point where the closed greenhouse supplied with pure CO_2 becomes viable. The closed greenhouse is more profitable with increasing tomato prices since the production is higher. If the CO_2 supply can be done by gas burning the closed greenhouse is even more attractive than the pad and fan system.
So the closed greenhouse is with the assumptions made not only promising in terms of water saving but also in terms of economics.

5 Conclusions and the way forward

From this visit, the previous visit to KSA and all the other information the following conclusions can be drawn:

- Agriculture is the main consumer of water in this region. This makes it essential to apply water saving techniques on this sector.
- The growers are not really concerned by the fact that fresh water is running out. They do not have to pay for their water so financially there is no reason to use less water either.
- Policy makers have to be convinced of the urge to deal with the extensive water use in agriculture. A strategic policy has to be written to regulate the water use in agriculture. As long as water is free , water saving will not have any priority.
- The closed greenhouse concept is a good alternative for the pad&fan system from an economical point of view and more important from a water saving point of view. This analysis has to be discussed with the stakeholders.
- A demonstration center and training center is needed to show the discussed techniques work for the Gulf region.
- All companies involved in protected horticulture (builders, seed companies, etc.) should be able to demonstrate their products in this center. Showing products that also work in the climatical conditions of the Gulf region is very important.
- Solar energy should be considered for all processes (electricity supply, desalinization process, absorption heat pump system etc.) in order to make the sector sustainable
- Changing the growing system to hydroponics is the first step to save water provided that the transition from open field to protected cultivation is already made.
- The coastal area in the Gulf region has a warm and humid climate during summer making it impossible to have horticulture in this region. Only by using active cooling (closed greenhouse) protected horticulture can be implemented in this region.

The way forward is through dialogue with the stakeholders. The methods described in this report should be discussed and demonstrated so that the stakeholders are willing to invest in these methods and see their potential. This can be done through:

- A course has to be developed for policy makers, farmers and bank personnel which gives inside in the current situation of protected horticulture and the challenges for the future. Subjects to be addressed should be:
  - Basis greenhouse management
  - Advantages of hydroponics
  - Production in relation the investment and operational costs → return on investment
  - Policy and regulation on water use
  - State of the art technologies
- The closed greenhouse concept has to be proven for the Gulf region. For this an experimental site has to be developed in the region where the concept is tested and demonstrated. Through demonstration and presentation grower and policy makers have to see to potential of the system.
- The demonstration project can be the start of the establishment/creation of a GCC-wide research centre on protected cultivation. This was recommended after the “First workshop on investment in protected cultivation in GCC countries” held in 2006. Possibly this centre can be combined with the facilities for industry to demonstrate and test their products for this region.
- Publish an article in a local magazine on water saving techniques and theory discussed in this report.

Annex I.

Itinerary visit UAE January 2009

Draft itinerary for trip to UAE: the visit Jouke Campen, UAE (16-23 January 2009).

Date/Time	**Activity**	**Location/venue**	**Purpose**	**Remarks**
16 Jan (Fri)	arrival by BA78 Journey to Dubai	Abu Dhabi Int. Airport Spings, Dubai	Visit friend	I will stay at his place
17-jan 17-jan evening	See Dubai Travel to Abu Dhabi	Dubai Check in Grand Continental Flamingo Hotel	Visit palm project	
18-jan	Join Delegation from the Netherlands	Abu Dhabi	Meet policy makers.	Check out
19 Jan morning 19-jan 19 Jan evening 19 Jan evening	Checkout from hotel Visit World future energy summit Reception check in hotel	Abu Dhabi Abu Dhabi Dubai Dubai	Visit fair Meet Dutch companies active in UAE	I will receive a ticket for the reception in Dubai in the Holland Pavilion Did not select a hotel yet. But plenty of rooms in Dubai
20-jan	Meet with Dr Barghouti and ICBA	Dubai, the campus of Ziad University	Learn about their current research activities	
21 Jan morning 21-1-2009 12:00	Visit farms? Meet with Najieb Khoory	 His office in Dubai		I did not get a response from the growers yet. I will phone them this week Mirak Agricultural Services is the Pioneer and leading grower of Strawberries and many other high value vegetables in the U.A.E. and exports more than 65% of its production to world markets. Mirak also has developed and is currently operating the Largest open field Hydro-phonic growing system in the world.
22 January 2009 12:00:00 22-jan evening	Meet with Dr. Ahmed Moustafa Return car to airport 22:00	Abu Dhabi at the Royal Netherlands Embassy - Agricultural Counselor Office Hamdan Street, Masaoud Tower 6th floor Tel. 02-6320712 Abu Dhabi Int. Airport	Learn about ICARDA and the role they can have in the project	
23-1-2009 2:30	Flight back to Europe			