Dear Mrs. Emeka,

Mission Report Carrying capacity cage farming Nigeria
Dr. ir. J.W.M. Wijsman

Summary
From 7 to 12 December 2014, Jeroen Wijsman from IMARES (the Netherlands) visited Nigeria. The purpose of this visit was to carry out site visits to aquaculture farms and organisation of a workshop on carrying capacity of cage farming in Nigeria. A total of 5 cage farms were visited in order to get insight in the opportunities and problems that the sector is facing. A 2-day workshop was given on carrying capacity of cage farming at the University of Agriculture in Abeokuta. The main observation is that at present there is dearth of knowledge on the impact of cage farming in reservoirs in Nigeria. Upscaling should be done very gradually and structured monitoring is required to increase the knowledge base in order to come to a sustainable aquaculture industry. Upscaling of the aquaculture sector should also be focused on other techniques and species.

Sunday December 7th 2014.
Flight from Amsterdam to Lagos. Arrived at 20:00. Pick-up from the airport by Prof. Bombata and Dr. Taiwo. Transfer by bus to the Stop-Over Motel, International Airport Road in Lagos, Nigeria. During the ride we were accompanied by a police officer for safety reasons. Dinner in the Hotel with Prof. Bombata who was hired as a local consultant. He is head of the Epe campus of the Lagos State University and 2nd vice president of the Fisheries Society of Nigeria. Prof. Bombata is a respected specialist on (cage) aquaculture in Nigeria. He runs a research station in Badagry where students from the University perform experiments. He cultures catfish, but also works on the culture of an endemic species of Tilapia. Prof. Bombata partly studied in the US. He helped to organise the visits to the aquaculture sites. He made the appointments with the managers of the aquaculture farms and planned the field trips. During the whole week he accompanied Jeroen Wijsman and together they discussed a lot on the opportunities of cage farming in Nigeria. Dr. Taiwo, senior scientist Aquaculture at the Institute of Food Security, Environmental Resources & Agricultural Research (IFSERAR) of the Federal University of Agriculture in Abeokuta helped to organise the workshop and joined the field trips.
Monday December 8th 2014.

Pick-up at the Hotel at 8:00 transfer to Badagry. Traffic was very bad due to a strike action by students at Agbara. During the trip there was telephone contact with Sonia Odije from the Dutch Embassy and Mr. Ariibi, the manager of the Fish N Fish in Badagry since he could not personally be present during the visit. We also made a short tour on the campus of the Lagos State University. Around noon we arrived at the Fish N Fish farm of Mr. Ariibi. The farm has about 50 ha ponds and about 27 cages that are placed in a small stream. They mainly produce catfish. On a yearly basis they produce about 150 tons of fish (mainly catfish). In the cages 50 grams fingerlings grow in 6 months (2 months in fingerlings hapa and 4 months in cages) to 1kg. They also have a market for smaller fish (450 gr). They state that amount of wastages are reduced in the cages compared to the pond systems. Besides commercial food they also use alternative resources to feed the fish.

![Feeding the fish in the cages at Fish & Fish in Badagry. The cages are located in a small stream](image)

At 12:30 we arrived at the aquaculture research centre managed by Prof. Bombata. This station is located next to the Badagry lagoon. At this location, the lagoon has mainly freshwater, but experience brackish conditions for about three months a year during marine incursions. Water quality problems occur due to sand mining in the lake and the presence of the invasive water hyacinth that blocks the waterways. At the station, experiments are carried out with tilapia fingerling production potentials of the endemic species. This species of tilapia is a mouth breeder and reproduction is not easy. The experiments are targeted on selection increasing the quality of the fingerlings. At the facility there is a lab where experiments can be conducted with fingerlings and where the fingerlings are nursed in 125 indoor tanks.
After the visit we went to a neighbouring farm Dr. Tomi Afinni that produces mainly catfish in ponds, but is also doing experiments with tilapia in cages in the Badagry lagoon. This farmer is not very positive on tilapia farming and is planning to quit for a while (weeks/months). The main problems are the high prices for the commercial feed and the low prices for the tilapia. Also he has problems with mortality in the cages.

From Badagry we went to Epe at the other side of Lagos. On the trip we passed Lagos Lagoon, which is connected to Lekki Lagoon and Badagry Lagoon. The Lagos Lagoon is a large area with potential for aquaculture activities. However, it is polluted due to urban and industrial activities in Lagos with a population of about 20 million people. We arrived around 6:30 in Epe station, where we had a discussion with the chief of the village Mr. Banjo and Mr. Tiamiyu Nurudeen from Amolese Aquaculture. The site is an aggregation of cages from different fishermen in the harbour. The cage
Cage culture is a side activity of the fishermen that catch fish in the lagoon. The fishermen want to position the cages more offshore in the lagoon, but they fear problems with boat traffic and poaching.

In the evening we drove further to Abeokuta where we checked-in in Daktad hotel at about 22:00.

**Tuesday December 9th 2014.**

Pick-up at the Hotel at 7:00 and departure to Oyan. This is an artificial lake that is mainly used for irrigation. There is also a 3MW power station in the Oyan dam, but this is not in operation. Local fishermen catch fish in the lake. In the reservoir, the largest cage farm of Nigeria is located, operated by Durante Fish Inc. The farm has been in function for 3 years and produces 300 tons of tilapia each year. Fingerlings come from Oyo. With a boat, we were brought to the cages. The whole farm consists of a system of 28 cages with a dimension of 6x6x5 meter each. An extra net is placed around the farm to prevent predation by wild fish and escape of cultured fish. The cages are located on the deepest part of the lake close to the dam, which is 15 meter deep down from 27 meter when the dam was first constructed. Major problems occur during the rainy season, when much water is discharged through the dam. Mortality occurs due to low oxygen conditions and/or suspended particles in the water. Especially the fingerlings are sensitive. Storms also have effect on the operation of the farm. The farm is less efficient in feeding and more pellets are lost. After the farm, we visited a small fishing community at the borders of the lake. 

![Figure 4](image1.png)  
*Figure 4  Cage of various local fishermen in the coastal lagoon near Epe.*

![Figure 5](image2.png)  
*Figure 5  Commercial cages for tilapia culture an Oyan operated by Durante Fish Inc. This is presently the largest aquaculture site in Nigeria.*
Wednesday December 10\textsuperscript{th} 2014
Pick-up at the Hotel at 7:00 and transfer to Federal University of Agriculture in Abeokuta (FUNAAB). The workshop was hosted at the building of the Centre of Excellence in Agricultural Development and Sustainable Environment of FUNAAB.

![Banner of the workshop at the entrance of the Federal University of Agriculture in Abeokuta.](image)

Before the workshop we had a meeting with the director of the Center of Excellence, Prof. Okanlawon M. Onagbesan. After a warm welcome and introduction, a first presentation was given by Jeroen Wijsman about sustainable aquaculture. The main message of the presentation was: don’t focus only on increasing production, but always take sustainability into account. Capacity building, stakeholder participation and combining functions can increase sustainability. Also environmental impact analysis and monitoring are important tools. After the presentation a meeting was arranged with the Vice Chancellor of the Federal University of Agriculture, Prof. Olusola B. Oyewole. As a host to the workshop he gave us a warm welcome. A second presentation was given by Jeroen Wijsman on carrying capacity. Various definitions of carrying capacity were discussed, including physical, production, ecological and social carrying capacity. The main message was that there are several types of carrying capacity that should be taken into account with respect to cage farming in lakes and reservoirs. The farmers are very much depending on the water quality themselves and besides the short term effects of reduced productivity of neighbouring farms, the long-term effects due to ecosystem degradation is essential for a sustainable production. A third presentation was given by Jeroen Wijsman on the Depomod modelling tool. This tool is developed to estimate the (carbon) loading from cage culture to the bottom. With the model it is possible to define and run different scenarios and compare the results in term of carbon loading. In the afternoon the participants started to construct their own model. In groups of two, they worked in setting-up the model grid for a representative case site. The participants used a hard-copy map of the area and were asked to enter the bathymetry of the area into the computer.
Thursday December 11\textsuperscript{th} 2014

Pick-up at the hotel at 7:00 and transfer to FUNAAB. After a wrap-up and feedback discussion of the first day, the participants continued with setting-up the model. Every group placed a number of cages where they wanted and added monitoring locations. Feeding rates, feeding efficiency and feeding type was defined for each cage. Based on current velocity, water depth and intensity of feeding, the participants calculated the carbon deposition rates to the bottom with the Depomod software. Jeroen Wijsman assisted and initiated group discussions on factors that could have effect on carrying capacity. The results of the model calculations from each group were visualised with the open-source software R. Participants were able to make GIS maps of the model results that indicated the intensity and area of the impact. By presenting and comparing the results of the different scenarios by the participants for the whole group a discussion was raised on how impact could be minimized and carrying capacity with respect to organic loading could be maximised. The model results gave a good insight in relevant processes.

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{figure7.png}
\caption{Result of the modelling. Two cage systems are modelled (black circles). One in a deeper area and one in a more shallower area. The calculated deposition rates are also plotted. Note that in this plots blue is high deposition and red is low deposition. In the deeper area organic matter deposition is more dispersed.}
\end{figure}

After the discussion Jeroen Wijsman gave a presentation on the present status and the future of aquaculture in general and specifically the economic feasibility of tilapia culture in Nigeria. At the end of the workshop a discussion was organised on the future of aquaculture and specifically cage culture in Nigeria. Topics that were addressed were: Should the development of aquaculture be focussed on large international companies or small scale farmers. Large international companies will probably be more cost-efficient. However, one of the reasons to stimulate aquaculture is also increase labour. Moreover, small scale farmers will probably have more concern to the natural environment where they are living and working. It is raised that the interests on the bank loans are too high in Nigeria for small-scale enterprises which makes it very difficult for potential farmers to start a business. Also cage culture versus pond culture was discussed. Cage culture seems to be more costs-efficient while pond culture will have less impact on the environment. Finally,
the quality of tilapia fingerlings was addressed. The poor quality due to inbreeding and bad water quality control results in poor production. A controlled and certified hatchery will result in better opportunities for tilapia culture. Each participant received a signed certificate.

Figure 8 Group photo of the participants of the workshop.

Friday December 12th 2014
In the morning writing the mission report. Pick-up at the hotel at 12:00 and transfer to Lagos Airport. In the evening there was a meeting planned with the vice ambassador of the Netherlands. However, he was not able to make it to the airport. Departure to Amsterdam at 23:00

Concluding remarks
- There is a huge potential for aquaculture in Nigeria. There are 917 reservoirs (about 300,000 ha; 30 billion m³) across the country. Besides that there are rivers, floodplains and brackish lagoons. Moreover, due to the demand of fish, Nigeria is importing 800,000 tons. Since the population is growing, the demand will increase. Growth of the aquaculture sector is a solution, but only if this is done in a sustainable way.
- Feed can be produced locally, but the quality should be improved in order to get a profitable sector and to lower the amount of organic waste into the environment.
- Small scale farmers should be better organised to share their knowledge and experiences. The communication between government, scientists and farmers could be improved if there is a good functioning producers organisation. There are good scientists in Nigeria who know the sector well.
- Cage culture is very efficient, however, the impact to the ecosystem is high due to the enrichment with organic matter. Important factors that have effect on the carrying capacity of cage farms is water depth and current velocity. The reservoirs are generally characterised by low current velocities, and thus the carrying capacity for cage culture is low compared to marine waters, where tidal currents disperse the organic matter quickly. The potential for cage farming in the marine waters are probably low due to the dynamic conditions, but it could be studied is sheltered areas exist in the sea.
- The advice is to develop cage farming in the basins very gradually and combine this with structured monitoring programs in order to monitor the impact and get more knowledge of the effects. Also the farm of Durante Fish
Inc in Oyan should be monitored. This is the largest cage culture present in Nigeria, and Nigerian scientists can learn a lot from the ecological effects.

- Shellfish culture (mussels and oysters) is not present in Nigeria. This could be a promising market, especially in the coastal waters and estuaries. This culture should be done with indigenous species that are valued by the Nigerian market for consumption. Shellfish aquaculture is an extensive form of aquaculture that can also provide ecosystem services such as filtering water, nutrient regeneration and coastal protection. It is advised to start a feasibility study on shellfish aquaculture.

With kind regards,

Dr. Ir. Jeroen Wijsman
Senior Scientist Delta Ecology