

Quicksan of fresh water pearl culture feasibility in Blue Gold areas in Bangladesh

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*'I am an oyster. In the warmth of my heart,
a particle of heavenly light through drawn-out days
and in the dream anthology of night,
with painful joy I create the elegance and lustre of pearl'*

-- from Mother of Pearls and other poems by Sufia Kamal --

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Summary

The Blue Gold Program focuses on sustainable development of several selected polders in the southwest of Bangladesh. Introducing sustainable pearl culture (pilot scale) in Blue Gold areas is potentially interesting, because it can provide an additional source of income in rural areas. The aim of this project was to perform a short study to provide more insight in pearl culture potential and identify possible pilot opportunities in Blue Gold areas.

Traditionally, pearls are collected from freshwater mussels in Bangladesh. This is mainly done by rural women, who are also involved in trading them (Choudhury, 1998). This study shows that several experimental pearl culture trials have been carried out by Bangladesh Fisheries Research Institute (BFRI) and the Food and Agriculture Organisation (FAO) too. However, no evidence of current commercial pearl culturing activities in Bangladesh were found during this study. Major bottlenecks are lack of knowledge and capacities for successful culture and availability of proper sites with year round freshwater conditions and a natural and adequate supply of mussels.

Introducing pearl culture on pilot scale aimed at training local people could address these bottlenecks and test culturing techniques in the field. This should be done in close cooperation with Blue Gold experts, stakeholders (collectors, traders etc.), farmers and pearl culturing experts (e.g. BFRI, Bangladesh Agricultural University, FAO). The Blue Gold areas in Patuakhali seem best fit for a culture pilot, as fresh water is available here year round. However, some questions still remain on identification of suitable areas, suitability of environmental conditions, availability of mussels, market structure, trading, etc. It is therefore recommended to follow a two-step approach. The first step concerns a field inventory in Patuakhali that is aimed at determining if executing a pilot is feasible/desirable. If this field inventory results in a positive outcome that the pilot phase (second step) can be started. Below the two step approach is described.

- **Step 1 - Field inventory (several months):**
 1. Field study: gather as much information possible on Blue Gold polders in Patuakhali (maps, land use, environmental conditions), prepare questionnaires aimed at exploring pilot feasibility, describe "terms of reference" for a local expert that could perform a field inventory.
 2. Field inventory: The aim is to determine existence of mussel species, environmental conditions (e.g. water quality), information on market and trading availability of suitable ponds of pearls etc.
 - a. Blue Gold trainers (12 people) in Patuakhali will take questionnaires with local people to gather information.
 - b. A local expert (from Blue Gold or otherwise) will be employed to perform a field inventory in Blue Gold polders in Patuakhali. Selection of this expert will be done in consultation with Blue Gold based on the "terms of reference" formulated during the field study phase. It is important this person has good knowledge of the area.
 3. Field visit by wur-expert to verify information, determine pilot feasibility (**go/no go**) and select a possible pilot site.
- In case of a "go":
 - **Step 2 - execution of a small-scale pilot (two years):**
 - Formulate and execute a practical pilot plan on freshwater pearl culture.
 - Employ a freshwater pearl culturing expert that can educate a team of Bangladeshi candidates that are educated in the field of aquaculture/shellfish biology.
 - Organise community meetings and a training programme with farmers aimed at operation techniques, culturing techniques (management of ropes and cages) and pond maintenance. Monitor bio-environmental parameters (e.g. water quality, shellfish mortality).

1. Introduction

Research motivation

The Blue Gold Program focuses on sustainable development of several selected polders in the southwest of Bangladesh. The project started in 2012 and has a time frame of 2013-2019 year (www.bluegoldbd.org). Water management, climate change adaptation, food production and business development are important aims within this program. Introducing sustainable pearl culture (pilot scale) in Blue Gold areas is potentially interesting, because it can provide an additional source of income.

Aim of this study

The aim of this project is to perform a short study that will provide more insight in pearl culture potential and identify possible pilot opportunities in Blue Gold areas. The study will therefore focus on the following questions:

1. What is the state of the art of pearl culture in Bangladesh concerning abundance, scale, used techniques, market value and structure and social sustainability?
2. What are current bottlenecks and possible measures for improvement and optimisation of pearl culture in Bangladesh?
3. What are opportunities to address current bottlenecks and improve and optimise pearl culture?

Approach

To gain insight in the pearl industry of Bangladesh several steps were taken to acquire information:

- Scientific and grey literature study and internet survey
- Interview with Dr. Harunur Rashid of Bangladesh Fisheries Research Institute (BFRI) and Prof. Harunur Rashid of Bangladesh Agricultural University (BAU).
- Survey pearl shops: ask for information on prices, origin, market structure etc. of pearls.
- Discuss pilot opportunities with Blue Gold experts: fisheries expert Dr. Shamsul Huda en Tanvir Islam Deputy Component Leader C4 – Value Chain Expert .

Blue Gold areas

The Blue Gold Program focuses presently on 12 polders in the southwest coastal areas of Bangladesh in the districts Satkhira, Khulna and Patuakhali (Figure 1). More polders will be selected in the same districts over the next couple of years.

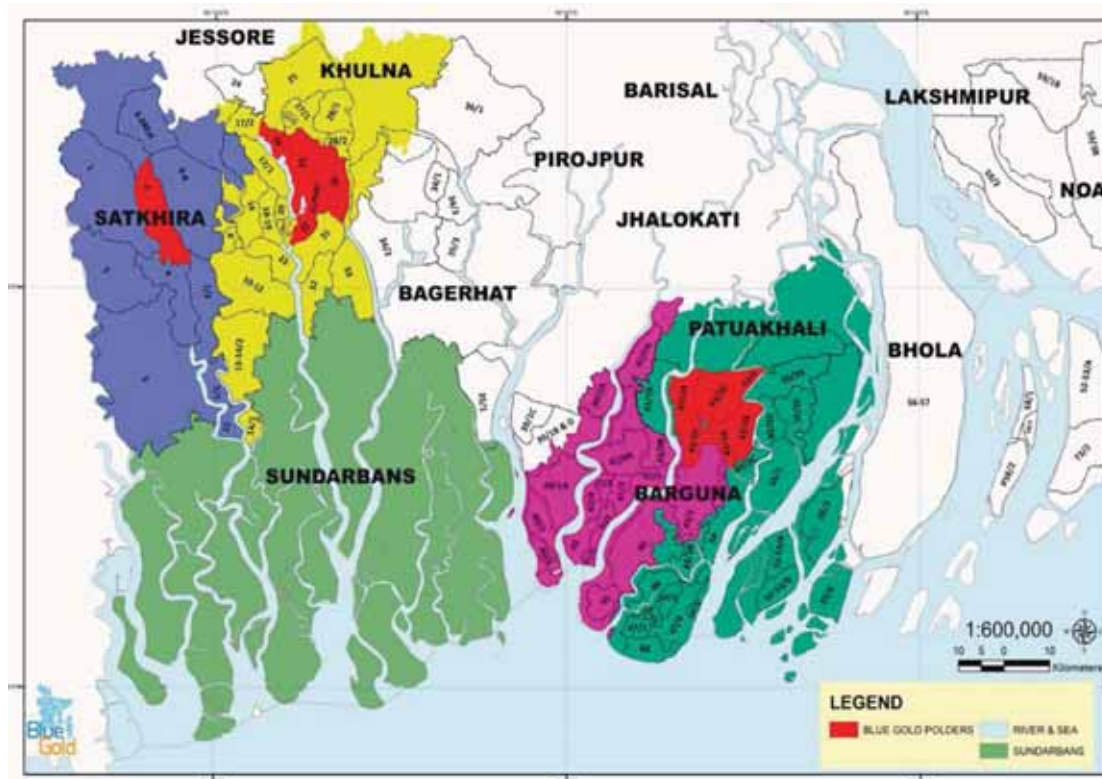


Figure 1. Blue Gold Program polder map. The red color shows the areas that are presently included in the Blue Gold program.

2. State of the art pearl culture in Bangladesh

Collection

Natural pink pearls of Bangladesh are locally known as “*mukta*”. Traditionally these pearls are collected from freshwater mussels (Figure 2), which are found in abundance in inland water bodies such as lakes, rivers, ponds and dams (Pagcatipunan 1984, Pagcatipunan 1986). Several species of pearl bearing mussels in freshwater bodies were identified (Pagcatipunan 1984). Freshwater mussel species are collected mainly by rural women (e.g. nomadic Shandar community (Choudhury, 1998)) who search for pearls. As only a fraction of all mussels are bearing pearls, a collector may open hundreds of wild mussels but if unlucky, may not get even one pearl. Natural pearls are formed spontaneous when a foreign material, such as a grain of sand, enters the mussel and settles on the fleshy part of the body. The tendency of the mussel will be to excrete it, but when it is unable to do so, the mussel will coat it by nacre secretion to lessen irritation. This results in the formation of natural pearls. Natural pearls are formed spontaneous and this is normally a rare event (FAO 1986). In saline areas in the south of Bangladesh, pearls are also found in oysters (personal communication Dr. Shahadat, Chittagong University).



Figure 2. Pearl bearing wild mussel of Bangladesh.

Development of pearl culture

Pearl farming is believed to date back a few thousand years to Japan and China where it was practised by a small group of Buddhist monks. Bead-nucleated freshwater based pearl culture techniques developed as early as 1900 in China, but did not become commercial until the 1960s (Scarratt *et al.* 2000). Freshwater pearl culture, however, is a growing source of income and employment in many southeast Asian countries (Ram, 1997). Presumably no commercial pearl culture exists in Bangladesh. However the government of Bangladesh had undertaken a pearl culture research project during 1984-1986 with assistance from Food and Agriculture Organization of the United Nations (FAO). After 1986 pearl culture was not continued due to lack of technical know-how. In 1999, Bangladesh Fisheries Research Institute (BFRI) formulated some pearl culture research projects in their freshwater fisheries research station at Mymensingh. Preliminary success was achieved to produce 10-12 pearls in the mussel *L. marginalis* through mantle tissue operation and nuclei operation. The survival rate of operated mussel with mantle tissue operation was highly satisfactory (82%). But, the pearl size, pearl production in an individual mussel and the shape of the pearl were not satisfactory. Further research was recommended to refine their technology. However, the pearl culture research program was subsequently discontinued in 2001 due to lack of governmental funding. Recently, the present Government directed BFRI to formulate research along this line and they have initiated a research program on the 'Development and Dissemination of Pearl Culture Technology' through the Bangladesh Fisheries Research Institute (GoB, 2014). It is planned for 5-years to develop of sustainable pearl culture and their breeding technology in Bangladesh. The project became effective on July 2012 and will be continued to June 2017. The main task of the project is to develop suitable technological packages of pearl culture, which will also cover on the availability of native mussels, pearly mussel operation, operated mussel culture and management. Propagation of pearl producing mussels is one of the key components of the project. In 2012 BFRI started a research project (2012-2017) at BFRI premises in Mymensingh and Cox's Bazar aimed at using experimental trials to investigate mussel reproduction and some pearl culturing techniques, funded by the Government of Bangladesh.

The main objectives of the project are:

- To innovate the sustainable technology on pearl culture
- To introduce artificial breeding techniques of pearl producing mussels (4 species of mussels) through establishing hatcheries in BFRI to make them available at farmer level;
- To disseminate the technology to rural women and farmers through extension services

Based on the information resources that were used in this study, culturing activity seems to be only done in an experimental setting and not (yet) on a commercial basis in the field. This critical next step could be realized as part of the Blue Gold project, on the basis of a proper site selection.

Culturing techniques

When culturing pearls, the natural formation of pearls by mussels is manipulated by inserting a 'nucleus' that will serve as substrate for nacre formation. There are several methods applicable to freshwater mussels (FAO 1986). Insertion of a nucleus (usually a small bead made of plastic or shell material) into

the mantle tissue of the mussel will result in a pearl. A more widely used technique in freshwater culture is to graft small pieces of live mantle tissue from donor mussel into the mantle tissue of a donor mussel without using a nucleus. The outer layer of mantle tissue has the capacity to rearrange and regenerate itself and remain viable when disturbed or removed from its original position and transplanted in other tissues of the animal (Alagarswami & Dharmarah 1984).

One mussel can bear over a dozen grafted pieces, these will result in pearls (Figure 3) (Scarratt, Moses et al. 2000). The pearls can be harvested after two to three years of the initial operation depending on the desired size and quality (FAO 1986). After the pearls are harvested the mussel can be re-grafted up to about 4 or 5 times (especially mussels that produce good quality pearls) producing larger pearls each time, due to the growth and expansion of the original pearl sacks. Pearl mussels can be cultured in ponds, portions of lakes, rivers, irrigation canals or dams. A pond, as a culture site, will have an advantage as water quantity and quality can be controlled. Seven species of pearl mussels from two genera were identified from freshwater bodies of Bangladesh (Pagcatipunan 1984), these species are (*Lamellidens marginalis* and *L. jenkinsianus* var. *obesus*, *Perreysia daccaensis*, *P. wynegungaensis*, *P. (Radiatula) pachysoma*, *P. favidens* var. *assamensis* and *P. favidens* var. *deltae*). The species *Lamellidens marginalis* is best fit for culturing because of its larger size and common existence in inland water bodies (FAO 1986).



Figure 3. Left: the tissue nucleation technique involving operating a small square strips of mantle tissue into the mantle of a mussel. Right: yield of seed pearls (<4mm) in a *C. plicata* mussel in China. Source: Scarrett et al., 2000

Pearl market

Through enquiry with local traders in 2014 in Dhaka it was found that around 150kg of natural fresh water pearls are collected annually in Bangladesh. As amounts are not reported and pearls are also imported it is unknown if this figure is correct. There are several types of pearls according to FAO (1986): natural, cultured and artificial. Artificial pearls are manufactured in the factory and are not a product of living oysters or mussels. They may be plastic, processed in a way that makes them shiny like natural pearls. They may also be made of rounded material such as glass or plastic, then painted with pearl essence, a silvery extract made from fish scales.

The quality of the pearls determines the economic value (information derived from www.ebay.com). Also salt water pearls found in marine oysters are more valuable than freshwater pearls because they are more rare. Size, shape, lustre, colour and surface imperfections are all factors that will influence the pearl value. For example a >10mm round shaped pearl of pink, white or creamish colour is more valuable than a darker shaped seed pearl (<4mm). On the international freshwater pearl market (e.g. www.youpearl.com) a 15" strand of 4 mm seed pearls costs around \$7 (around 95 pearls), whereas a 15" strand of 10mm round pearls costs around \$37 (around 40 pearls). A 15" strand of 10mm rice shaped pearls (elongated) costs around \$22 (around 40 pearls). The prices give an impression of the international value of freshwater pearls. It is, however, unknown how the market chain is organised and what a collector or farmer at the beginning of the chain will earn for collected or cultured pearls.

Investigation among pearl sales persons in Dhaka showed that in general, the sales person will indicate that the pearls sold are from Bangladesh origin. However, further inquiry reveals, that also imported pearls are sold. The exact amount of imported pearls could not be known. In general it is indicated that the price of pearls has gone down after cultivated pearls became more easily available. These are imported cultivated pearls, as no evidence was found on cultivation in Bangladesh. The demand for pearls is stable.

Integrated culture

Integrated aquaculture is aimed at combining fed aquaculture (e.g. fish, shrimp) with extractive aquaculture (e.g. shellfish, plants) to create a balanced system for environmental remediation, improved economic benefits (improved output, lower costs, product diversification and risk reduction) and social acceptability (better management practices) (Chopin et al., 2001). Integrated culture of pearl mussels and fish may be used as an efficient way of recycling farm wastes and producing high economic returns (Prabu et al., 1991). In an integrated culture the rest product of one culture are used as a resource for another culture. In the combination of pearl-fish culture inorganic fish excreta can be a resource for phytoplankton growth, that is food for the mussels; organic waste may also be valuable as a resource for the mussels. As a consequence water pollution is prevented, and space utilization is optimized. Integration of fish-freshwater pearl mussel is practiced in Taiwan, where culturing of koi carp varieties in combined with fresh water pearl culture (Prabu et al., 1991). No evidence was found of such practices in Bangladesh.

Valorisation of rest products

Mussel meat can be used as animal and/or shrimp feed and shells to manufacture lime or crush them for poultry feed (Chakraborty et al., 2012) and produce an extra source of income. Flesh of mussels can also be used for medical purposes (Tapiador et al., 1976; Chakraborty et al., 2012).

3. Bottlenecks

The main problems of pearl culture in Bangladesh are as follows:

Lack of skilled manpower: operation of mantle tissue and inserting the nucleus in live mussels and culturing the mussels to maturity requires specific skills. It is critical to avoid mortality after surgery through infection, disease, shell boring and biofouling (Alagarswami & Dharmarah 1984).

Maintenance of culture conditions: based on availability of mussel's foods in farming water, commercial grade pearls may be harvested by 24-36 months after operation. Stable phytoplankton production in adequate amounts needs to be ensured. During dry months sufficient availability of fresh water can be a problem (Alagarswami & Dharmarah 1984).

Supply of adequate numbers of mussels: pearl must be cultured with specific mussel species. Sufficient numbers of adequately sized mussels are not always at hand. Due to the existing wild collection of mussels for pearl production, stocks are becoming depleted.

No information was found on market organisation and trading of pearls. Possibly insufficient knowledge of market opportunities could also be a hampering factor for starting culturing activities. This has to be further investigated.

4. Pearl culture feasibility in Blue Gold areas

Environmental factors

Culturing pearls in fresh water mussels is mainly done in ponds, parts of lakes or rivers. For this culture, availability of freshwater throughout the year is an important prerequisite. Salinity tolerance of freshwater mussels is species specific (Bowersox, 2003). No information was found on the salinity tolerance of fresh water pearl mussel species in Bangladesh. Studies on other fresh water mussel species show that some species can endure salinity levels up to 8 ppt before mortality occurs (Mills et al., 1996). Salinity levels above 0.5-1 ppt will influence metabolic rates of the mussels, that may affect the pearl formation capacities. Especially during dry season, salinity levels may rise. Figure 4 shows an overview of the maximum salinity levels in rivers in Bangladesh (Dasgupta et al. 2014). It also shows where Blue Gold areas are situated. Satkhira and Khulna areas prove to be brackish with a maximum salinity of 15-20 ppt. The Patuakhali area, however, seems suitable based on this map with maximum salinity levels not exceeding 1-2 ppt. The salinity levels have been increasing over time, due to diminished runoff and climate change. This is, however, a complex phenomenon based on subsidence, tectonic movement, subsidence, sedimentation (tidal), sea level rise and (reduced) runoff. It is expected that the areas of Satkhira and Khulna will continue to face higher salinity levels than Patuakhali (Dasgupta et al, 2014).

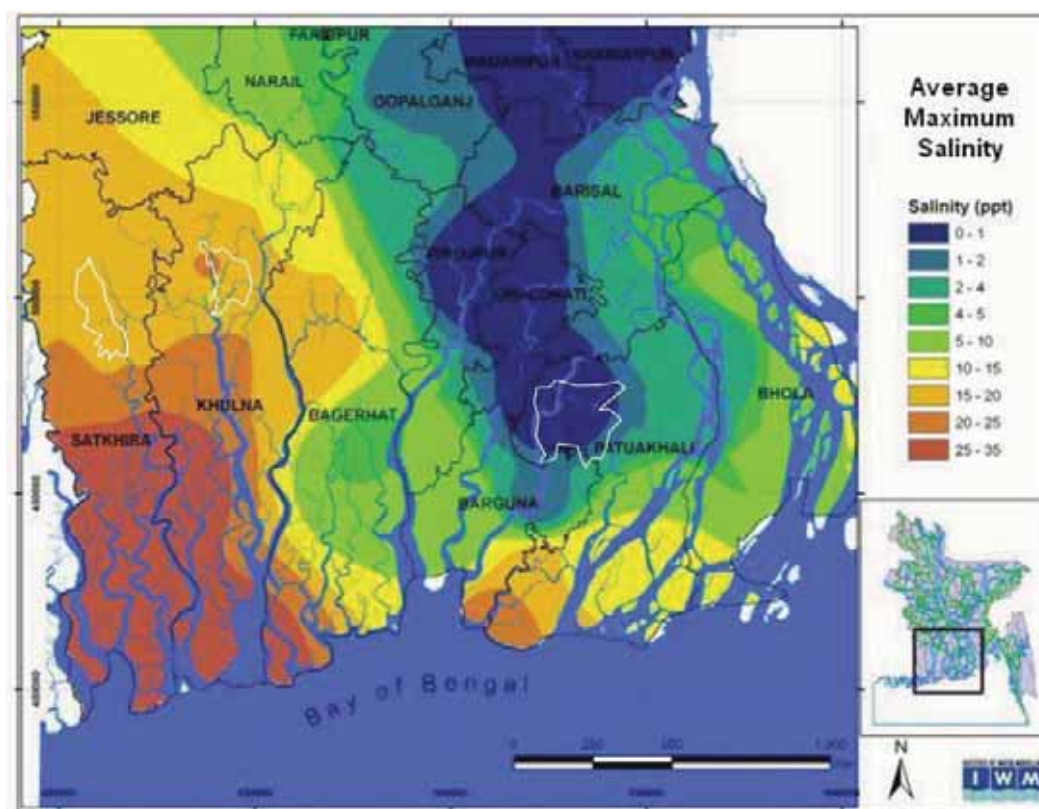


Figure 4. Map of Average Maximum River Salinity in the Southwest Region of Bangladesh produced by Institute of Water Modelling (Dasgupta et al. 2014). In addition to the original figure the location of Blue Gold areas in Satkhira, Khulna and Patuakhali are outlined in white.

Discussion, conclusion & pilot opportunities

This study shows that Bangladesh certainly has environmental and biological resources for pearl culture practices under freshwater conditions concerning existence of pearl bearing mussel species and availability of fresh water. At the same time culturing activities up until now seem to be limited to experimental trials under controlled, isolated conditions executed by BFRI over the last decennia. No evidence of commercial culturing activities in Bangladesh were found during this study. Lack of knowledge and skilled manpower seems to be the main explanation for this. Furthermore supply of an adequate number of mussels and maintenance of culture conditions also plays a role.

Developing pearl culture in Bangladesh could provide an additional source of income and employment in particular for rural women. Interventions at the field level will only have an optimal impact when the preconditions for success either exist or are created. Preconditions include field characteristics (e.g. availability of good quality water, depth of the pond, low salinity levels) but also, accessible knowledge and availability of skilled workers (operation techniques), a well as an organised supply chain and sufficient market demand. Executing a pilot scale practical study in the Patuakhali area, where research findings are tested in real field situation, is needed to identify the opportunities and threats in practice.

In conclusion, the following answers to the research questions can be formulated:

What is the state of the art of pearl culture in Bangladesh concerning abundance, scale, used techniques, market value and structure and social sustainability?

This study shows that information resources on fresh water pearl culture in Bangladesh are very scarce. No evidence of commercial culture was found during this study and seems to be limited to experimental trails. The stable market demand for pearls is accommodated with collection of pearls from wild fresh water mussels, which is mainly done by rural women. Investigation among pearl sales persons in Dhaka showed that in general, the sales person will indicate that the pearls sold are from Bangladesh origin. However, further inquiry reveals, that also imported pearls are sold. The exact amount of imported pearls could not be known. In general is it indicated that the price of pearls has gone down after imported cultivated pearls became more easily available. It is unknown how the market chain is organised and what a collector or farmer at the beginning of the chain will earn for collected or cultured pearls.

What are current bottlenecks and possible measures for improvement and optimisation of pearl culture in Bangladesh?

Major bottlenecks are lack of knowledge and capacities for successful culture and availability of proper sites with year round freshwater conditions and a natural and adequate supply of mussels .

What are opportunities to address current bottlenecks and improve and optimise pearl culture?

This study shows that the absence of pearl culturing activities in Bangladesh are mainly related to lack of knowledge on culturing techniques (operation of mussel) and maintenance and finding suitable environmental conditions (salinity, adequate number of mussels, etc.). Introducing pearl culture on pilot scale aimed at training of local people could address these bottlenecks and test culturing techniques in the field. This should be done in close cooperation with Blue Gold experts, stakeholders (collectors, traders etc.), farmers and pearl culturing experts (e.g. BFRI, BAU, FAO). Some questions still remain, however, on suitable areas, environmental conditions and availability of mussels, market and trading, etc. It is therefore recommended to a two-step approach. The first step concerns a field inventory in Patuakhali that is aimed at determining if executing a pilot is feasible/desirable. If this field inventory results in a positive outcome that the pilot phase (second step) can be started. Below the two step approach is described.

- **Step 1 - Field inventory (several months):**

1. Field study: gather as much information possible on Blue Gold polders in Patuakhali (maps, land use, environmental conditions), prepare questionnaires aimed at exploring pilot feasibility, describe "terms of reference" for a local expert that could perform a field inventory.

2. Field inventory: The aim is to determine existence of mussel species, environmental conditions (e.g. water quality), information on market and trading availability of suitable ponds of pearls etc.
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 - b. A local expert (from Blue Gold or otherwise) will be employed to perform a field inventory in Blue Gold polders in Patuakhali. Selection of this expert will be done in consultation with Blue Gold based on the "terms of reference" formulated during the field study phase. It is important this person has good knowledge of the area.
 3. Field visit by wur-expert to verify information, determine pilot feasibility (**go/no go**) and select a possible pilot site.
- In case of a "go":
 - Step 2 - execution of a small-scale pilot (two years):**
 - Formulate and execute a practical pilot plan on freshwater pearl culture.
 - Employ a freshwater pearl culturing expert that can educate a team of Bangladeshi candidates that are educated in the field of aquaculture/shellfish biology.
 - Organise community meetings and a training programme with farmers aimed at operation techniques, culturing techniques (management of ropes and cages) and pond maintenance.
 - Monitor bio-environmental parameters (e.g. water quality, shellfish mortality).

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Justification

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The scientific quality of this report has been peer reviewed by the a colleague scientist and the head of the department of IMARES.

Approved: Dr. Arjo Rothuis
Senior scientist aquaculture and business developer



Signature:

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Approved: Dr. Robert Trouwborst
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Date: 21st January 2015