Mauritius Research and Innovation Council

INNOVATION FOR TECHNOLOGY

Experimental Seaweed Farming at Vieux Grand Port

Report

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Mauritius Research and Innovation Council

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This report is based on work supported by the Mauritius Research and Innovation Council. Any opinions, findings, recommendations and conclusions expressed herein are the author's and do not necessarily reflect those of the Council.

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FAO	Food and Agriculture Organisation
US	United States
MRC	Mauritius Research Council
AFRC	Albion Fisheries Research Centre

PROGRESS REPORT

1.0 Introduction

Seaweed and the plethora of commercial products derived from seaweed form the pillars of the economy of many countries, such as Japan, China, Indonesia, Philippines, among others. Seaweed derived products are essential in the food & beverage, pharmaceutical, cosmetics, agricultural and many other industrial sectors. The world market for the seaweed industry has an estimated total annual value of more than US$ 7 billion (FAO, 2010), growing at a rate of about 15% annually. The main importers are the developed countries, US and Europe. Major exporters include China, Japan, Indonesia, Philippines and some Latin American countries such as Chile and Peru. The absence of Africa as a major player in this market is recognized, though seaweed production and commercialization has been reported in Zanzibar and Madagascar to some extent. This is an indication of a potential African niche market.

Mauritius is a Small Island Developing State with limited land resources but with an extensive Exclusive Economic Zone of about 2.3 million km^2. Despite the reported presence of 435 species of seaweeds in Mauritius and Rodrigues and the potential market for seaweed derived products, no local research has been conducted to investigate the commercial exploitation of these resources. Hence the initiative of the MRC to set-up a research programme to investigate the potential of developing an economically, technically and environmentally viable seaweed industry in Mauritius and Rodrigues.

The National relevance of this programme is emphasized by section 195 of the Government Programme 2010-2015 which states that 'the Cultivation of Seaweed with a view to developing an Industry based on Value-added transformation of seaweed for human consumption, cosmetic application, medical and pharmaceutical research' will be conducted.

Development of small scale seaweed culture in Mauritius and Rodrigues is also mentioned under the project 2 (b) development of a comprehensive aquaculture development and management policy that builds on the Aquaculture Master Plan, Fisheries Master Plan for Mauritius, Rodrigues and the outer Islands, 2011.

2.0 Objectives

1. To set-up an experimental farm in Vieux Grand Port in collaboration with the local fisher groups
2. To cultivate *Gracilaria* species in the experimental farm and monitor the growth rate over a period of one year.
3. To evaluate and adapt different farming techniques for local seaweed production
4. To build up local capacity in seaweed farming

3.0 Permits and Approvals required

Clearances have been obtained for Experimental Seaweed Cultivation from the following institutions - Prime Minister's Office, Ministry of Housing and Lands, Beach Authority and Ministry of Environment and Sustainable Development

Scanned copy of the area for cultivation authorized by Ministry of Lands and Housing is attached.

4.0 Activities undertaken

The following activities were undertaken to achieve the objectives of the project, that is, setting up the experimental seaweed farm in Vieux Grand Port -

1. Community Mapping with Stakeholders
2. Bio Assessment
3. Workshop for setting-up of the farm
4. Monitoring of the Experimental Farm
5. Harvesting
6. Community Involvement

The details on the above activities along with the results and discussions from the data obtained from the experimental farms are elaborated in the following chapters.

4.1 Scoping for site selection

The scoping for site selection was done in March 2012 with the fisher groups and the representatives of the National Coast Guard. The site was selected because the fisher group of Vieux Grand Port approached MRC to venture into this culture.

Another major reason for selecting Vieux Grand Port as an experimental site for seaweed farming was that the fisher group there would help in maintaining the farm free of cost.

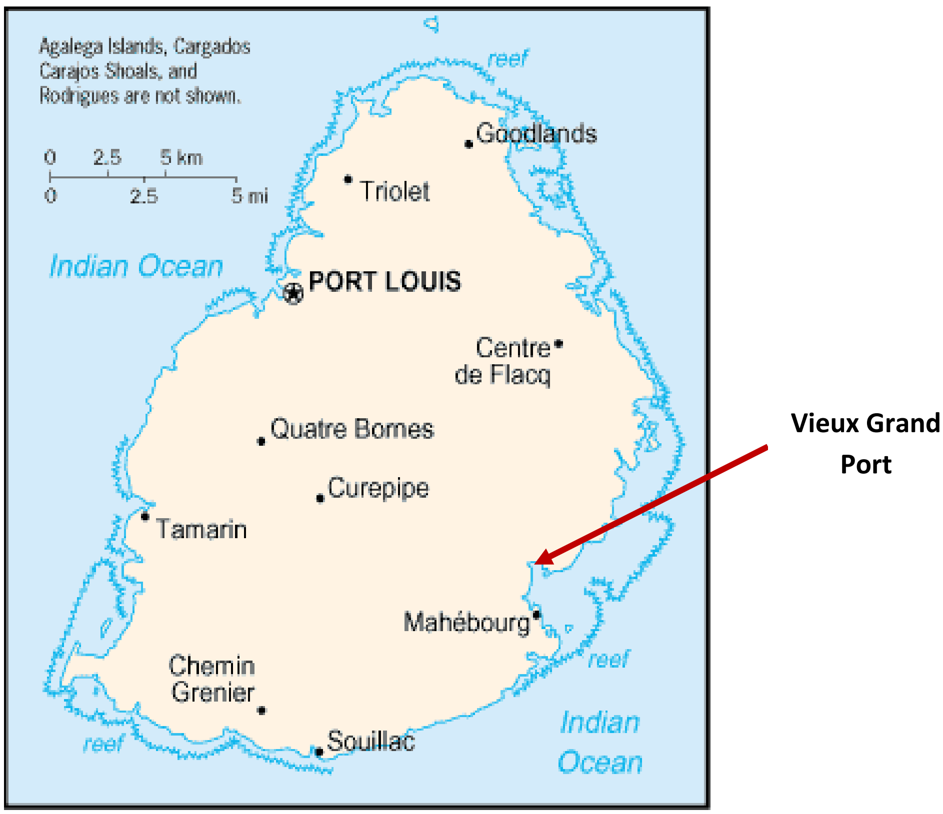

Figure 1: Location of Experimental Seaweed Farm in Vieux Grand Port.

4.2 Meeting with Fisher Groups

A meeting with the fisher groups was organized on Wednesday 14th March 2012 at the Vieux Grand Port Village Hall.Around 20 fishermen were present along with officer from the Ministry of Fisheries and the officials of MRC and AFRC were also present.

Figure 2: Meeting with Fishermen of Vieux Grand Port.

4.3 Community Mapping

Community mapping is a participatory process of creating maps or visual representations of the intervention community as seen by community members. In this particular case, the research area was the marine environment and the community members were the fisherman community of the region from Vieux Grand Port (Refer to satellite Imagery). Community mapping was done in order to identify a potential site for experimental seaweed farming and to seek background data on the marine environment.

Community mapping also encourages the participatory concept, promotes the bottom- -up approach and involves the community in the project planning from the start.

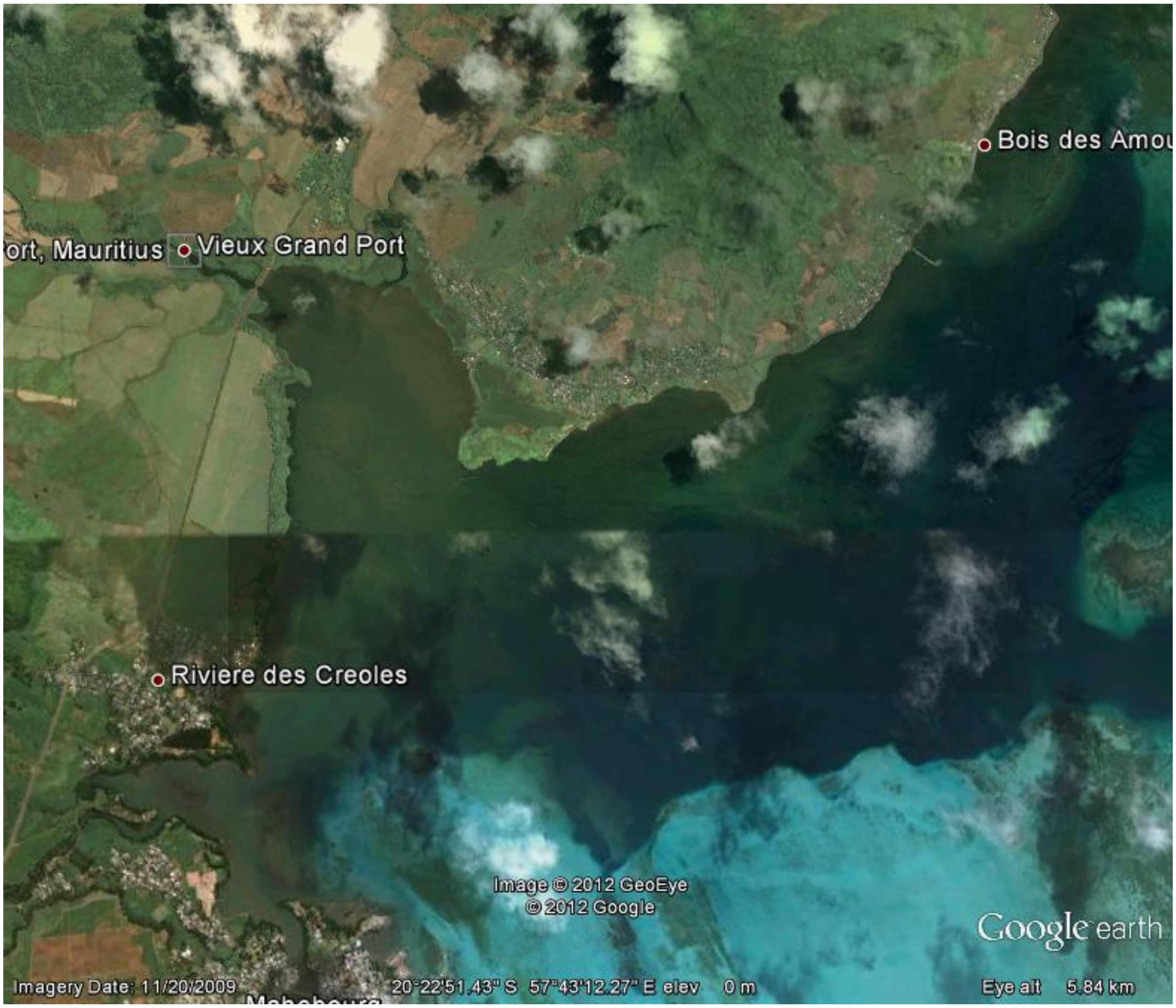

Figure 3: Satellite Image of Vieux Grand Port

4.3.1 Purpose

Community mapping was done in order to record all the activities, physical components and biodiversity that are present in a specific area like the lagoon, for instance, and to identify a specific site of the lagoon for setting up an experimental seaweed farm.

4.3.2 Community Mapping Exercise – Process

The primary approach to designing a Community Map involves having a construction of a version of the map using a central starting point for reference. Once completed, ideas can be brought to the larger map for construction. Map-makers work in collaboration to develop the map of the community.

1. Decision on what type of map to be drawn. Architectural papers were mounted and placed on the A3 Google maps. The outline of the lagoon was drawn.

2. Identification community members or target group members who are familiar with the location and the subject matter and who are willing to share their knowledge. The aim is to gather a diverse group of community members to gain greater insight into the community. This has been done with the help Mr. Ho Kam and of the officers of the Ministry of Fisheries (AFRC)

3. Location was selected along with the community members for community mapping exercise. The location chosen was Vieux Grand Port Village Hall.

4. Keys were devised for the community mapping exercise.

5. The map should show:
    a. Major physical structures
    b. Prominent biological Features
    c. Major activities in the lagoon and surroundings

6. The community mapping exercise was done in a brainstorming manner where the participants were asked a set of question pertaining to Biodiversity, Physical components and Activities carried out in the lagoon.

Detailed questions were:

I. Biodiversity

The biodiversity category comprises questions like:

1. Where do seaweeds grow?
2. Where does sea grass grow?
3. Where do corals occur?
4. Where do you find sea cucumbers and sea urchins?
5. Where do you usually find fish?
6. Where do you find shells?
7. Where do you find starfish?

II. Physical components

The physical components were:

1. Where do you find sand as main substratum?
2. Where do you usually find the presence of mud?
3. Where do you always find the presence of water whether in high and low tide?
4. Where do you find rocks?
5. Where do you find rivers inlets?
6. Is there any presence of outlets like sewages?

III. Activities carried out in the lagoon

The activities that were carried out in the lagoon were:

1. Where are the fishing grounds for line, basket, net and octopus
2. Where do boats anchor?
3. Where are the spawning and nursery areas for fish?
4. Where are the tourism activities like snorkel, diving, etc…?
5. What are the pathways of the currents?

6. Where are the small and big passes?
7. Indicate the places that are mostly affected by:
    - heavy rains;
    - run off;
    - pollution – agriculture;
    - Wastes.
8. Where is the traffic lane?

Once the Community Mapping Exercise was completed the various map generated by the community members were transferred on a single map.

4.4 Result of Community Mapping

<u>Meeting and community mapping with Fisher group at Vieux Grand Port</u>

The fishermen's community of the region of Vieux Grand Port was convened to a meeting at the Vieux Grand Port Village Hall on the 14th March 2012. Around 20 fishermen were present along with officer from the Ministry of Fisheries.

Figure 5: Introduction by MRC Staff

Figure 4: Community Mapping

A brief introduction was made on the Experimental Seaweed Farming Project by officers of the Mauritius Research Council and fishermen were solicited for their help and contribution through their knowledge of the site.

Relevant information were collected and discussed during the meeting. The proposed site for the experimental seaweed farm was Vieux Grand Port Lagoon. Three sites were identified by the fishermen present.

The reasons put forward by the community for this are as follows:

1. There is a not much fishing activity in the site proposed
2. The proximity of these site will allow the fishermen to help maintain the farms
3. There are no tourist activities in the proposed sites
4. There is no specific traffic lane in those areas but the farms have to be demarcated to prevent boats passing on them
5. The sites have a depth of about 7 foot (2m) and is ideal for seaweed cultivation

6. The water in these region are clear and free from mud
7. At low tide these site do not get dry.
8. There is presence of sand in this region
9. Natural predators of seaweeds are absent in these sites

The fisher group at Vieux Grand Port drew the outline of the lagoon and made a community map containing Biodiversity, Physical features and activities in the Lagoon. Once the Map was completed, a consensus was reached amongst the community members. They all agreed that to confirm this map a bio assessment exercise should be conducted with their help.

4.5 Findings of Community Mapping

The information given by the fisher group during the community mapping exercise was very helpful in having an insight of the proposed site for the seaweed farm. However to have a precise idea of the biological status and surrounding of the site, a bio assessment should be conducted. The fisherman community in this region seem keen to the idea of implementing a seaweed farm. They also proposed their help and contribution in implementing the project. The next step would be to conduct a bio assessment to confirm all the features discussed in the meeting.

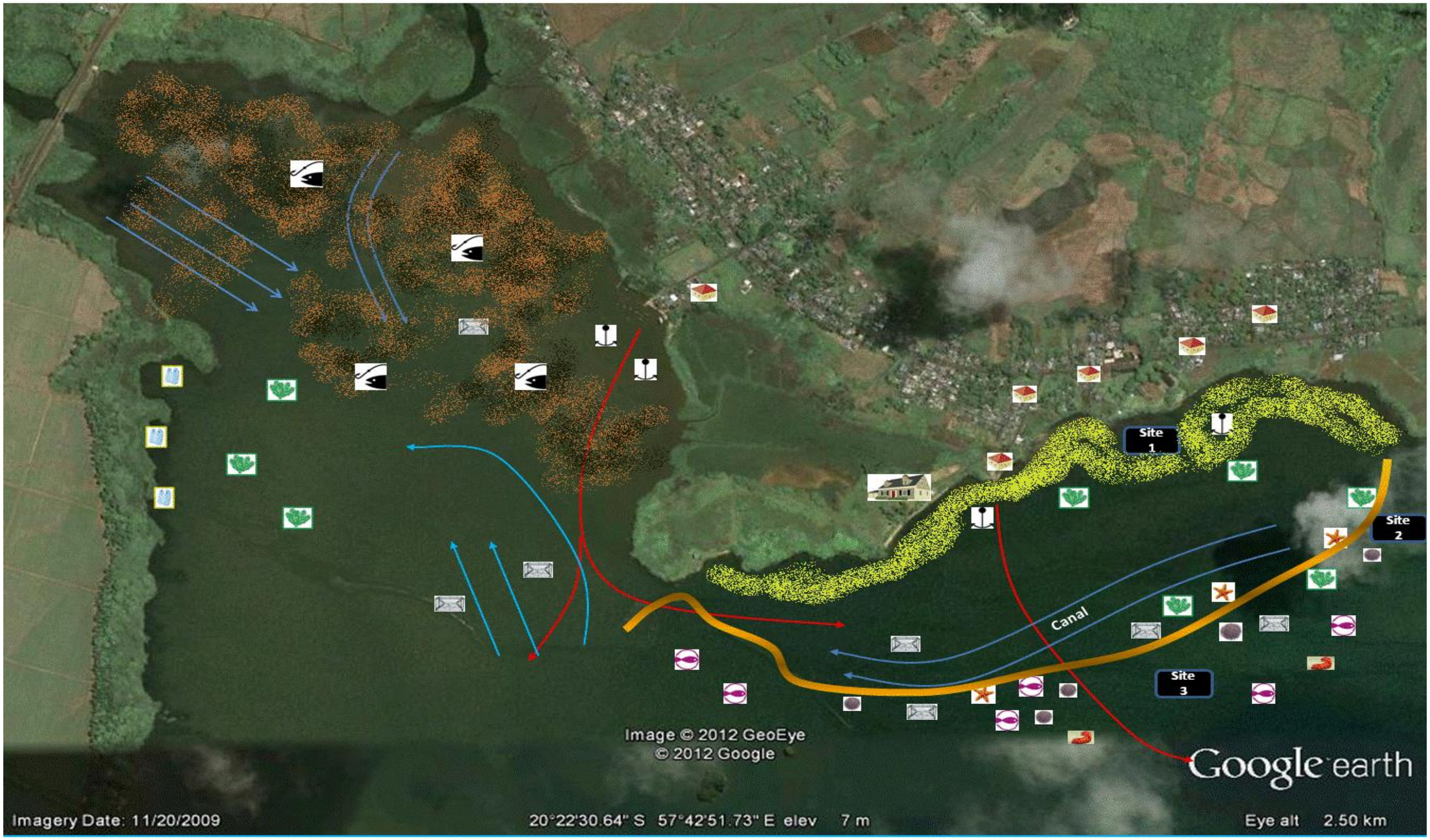

Figure 6: Community Map of Vieux Grand Port

5.0 Bio Assessment

An in-depth bio-assessment was then carried out on 5th and 6th April 2012 in an area surrounding Site 1.

The purpose of bio-assessment is to survey the biological features and organisms present. This would act as a benchmark to assess the impact of the experimental seaweed farms on its immediate environment. Future bio-assessment would hence allow inferring on the beneficial or detrimental impact of the farms.

Furthermore this type of study allows gathering of information on the predators that can affect seaweed growth and also on the possible hazards that might occur on the farm and working personnel.

5.1 Site Access

The access road to the site is 500 metres from the red concrete shop on View Grand Port main road leading towards Bois des Amourettes. It is found on the right. The GPS point for the access road is

Latitude: 20°22'29.98"S Longitude: 57°43'14.37"E

Alternatively, there is an access road in front of the Police station leading to an earth road. But this access is not good for vehicles and requires walking a considerable distance.

Moreover embarkation for sea access can be done at the Vieux Grand Port jetty.

5.2 Site Description

The site for bio-assessment is enclosed in 4 reference landmarks. The first delimitation is from the headland locally known as "terrace" up till between Islet Chat and Islet Jacot. The second delimitation is from the Vieux Grand Port Pointe locally known as "Grande Pointe" up to a distance of 400 metres in the sea. This area forms a secluded bay with moderate water currents and provides some shelter from waves and strong wind. This bay has a small strip of beach of approximately 100 metres and to a width varying between 2 metres at high tide to 8 metres during high tides. Alongside the beach are few inhabitations belonging mostly to fisherman. Agricultural activity is limited although 2 cultivation plots were observed. The area covered also contains two rock formations as major physical feature.

5.3 Methodology for Bio-Assessment

Data for bio-assessment were collected using the Line Intercept Transect (LIT) method. The LIT method is used to estimate the cover of an object or group of objects within a specified area by calculating the fraction of the length of the line that is intercepted by the object. In the present study, the LIT method was used to assess the presence of seaweeds and other marine organisms in site1.

5.4 Study Design for Bio-Assessment

Prior to Assessment (In Office)

The steps were as follows:

- Reference mark was used as starting point
- Landmarks were plotted based on GPS points which were located from the Google Earth
- Google Earth Virtual ruler measurement was used to measure and to determine transects which were 330m long and have around 150m inter-transects distance
- The number of transects which was used is six
- Total area which was covered is as follow:
  $330\times(6\times150) = 297000\ m^2$

Prior to Assessment (In-situ)

A hired boat was placed at the initial point of the transect line by the use of a GPS apparatus and with the help of collaborators. Divers/Surveyors were then dropped at the initial point.

The boat was placed at the end of the transect line point. This was used as a reference mark for the divers to follow. As such, they had an indication of a more or less straight line they had to survey.

During Assessment:

During the bio-assessment, virtual quadrates were used to determine the approximate proportion of biological features and organisms present.

Presence of biological features or organisms was used as stop mark.

The method used for assessment:

Skin diving techniques were used as the water at Vieux Grand Port is turbid and no precise observations could be done on board of the boat.

(It is to be noted that three divers were present for skin diving).

At the end of line: Divers/surveyors emerged from the water and they reported the observations made to the data logger who was on the boat.

The divers were then towed to the next starting point based on fixed GPS points.

After Assessment:

A post survey discussion was held among the surveyors and data logger to confirm the information noted and to iron out any possible discrepancies in the information gathered.

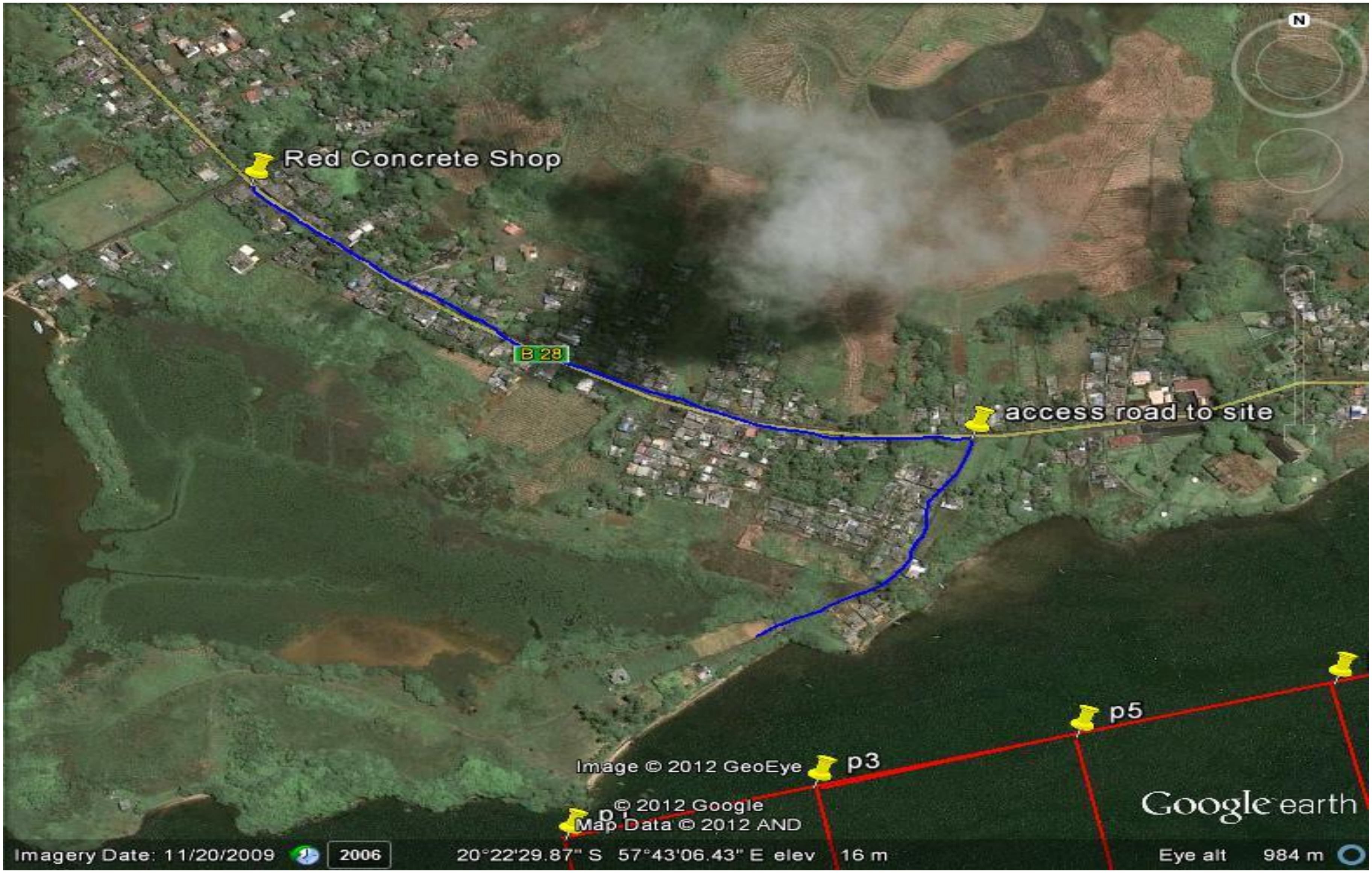

Figure 7: Site Plan for Access to Site

Figure 8: Transects for Rapid Bio-Assessment

Figure 9: Embarkation Sites

Figure 10: Landmark (la Terrace)

Figure 11: Landmark 2 (Ilots)

Figure 12: Accompanying MRC personel and datalogger

Figure 14: Surveyors at sea with diving arrangements

Figure 13: surveyors at work

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Figure 15: End of line reporting

5.5 Results for Bio-Assessment

Table 1: Showing observations recorded for the different transects:

Transect	Points	Coordinates		Observation
		Latitude	Longitude	
1st	P1	20°22'44.45"S	57°43'2.88"E	1 Coral Colony porites
	P2	20°22'56.12"S	57°43'5.29"E	10% *Sargassum spp*. and *Sargassum aquifolium*
				30% *Halimeda opuntia*
				30% Seagrass: *Symdosia spp*.
				2% Others: 1 Sea cucumber, Prickly Penshell: *Pinna muricata* (Larzdam), Sponges, Cyanobacteria
				28% Sand
2nd	P3	20°22'42.56"S	57°43'9.98"E	Goat Fish - *Paruperus spp*.
	P4	20°22'54.77"S	57°43'12.50"E	40% Dominant: *Halimeda opuntia*
				10% *sargassum spp*. and *Sargassum aquifolium*
				4% *Boodlea spp*.
				46% Sand
3rd	P5	20°22'40.75"S	57°43'17.48"E	8% Sea cucumber
	P6	20°22'53.33"S	57°43'20.35"E	8% *Halimeda opuntia*

				7% *Symdosia spp.*
				6% *Sargassum spp.* and *Sargassum aquifolium*
				2% *Dictyota spp.*
				1% Others: Seaworm, *Actinotrichia fragilis*, *Rosenvingea orientalis*, 1 Colony Pocillopora Damicornis (coral), *Gracilaria*
				2% *Padina spp.*
				66% Sand
4th	P7	20°22'38.82"S	57°43'24.86"E	30% *Symdosia spp.*
	P8	20°22'51.87"S	57°43'27.89"E	10% Prickly Penshell: *Pinna muricata* (Larzdam)
				1% Sponges
				2% *sargassum spp.* and S*argassum aquifolium*
				2% others :*Rosenvingea orientalis*, *Padina spp.*
				2 Small colonies of coral
				55% Sand
5th	P9	20°22'37.04"S	57°43'32.05"E	50% *Symdosia spp.*
	P10	20°22'50.00"S	57°43'35.39"E	30% *Halimeda opuntia*
				2% Prickly Penshell: *Pinna muricata* (Larzdam)

				2% Others: *Sargassum spp.* and *Sargassum aquifolium*, *Boodlea spp.*, Sea cucumber
				16% Sand
6th	P11	20°22'35.11"S	57°43'39.27"E	40% *Symdosia spp.*
	P12	20°22'47.89"S	57°43'42.59"E	40% *Halimeda opuntia*
				5% *Sargassum spp*. and S*argassum aquifolium*
				1% Others: Prickly Penshell: *Pinna muricata* (Larzdam), *Boodlea spp.*, Sea cucumber, Sponges, Seaworm
				14% Sand

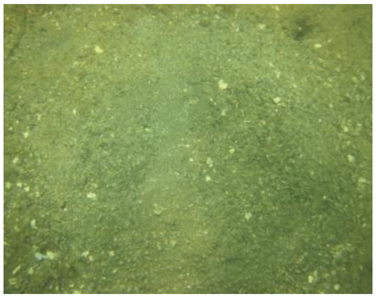


Figure 18: Substratum

Figure 16: Sargassum aquifolium

Figure 17: Sargassum Binderi

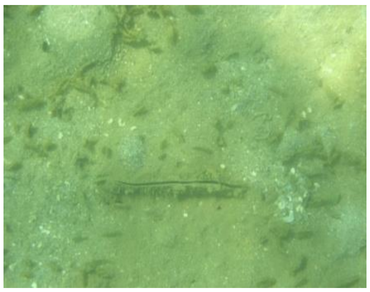


Figure 21: Prickly Penshell

Figure 19: Rosenvingea sp.

Figure 20: Rosenvingea sp.

Figure 22: Coral Colony

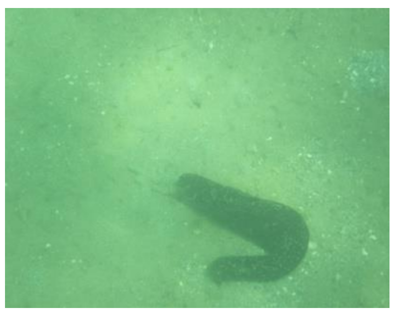


Figure 23: Sea cucumber

Figure 24: Substratum

Figure 25: Rosenvingea sp.

Figure 26: Potiera Tripinnata

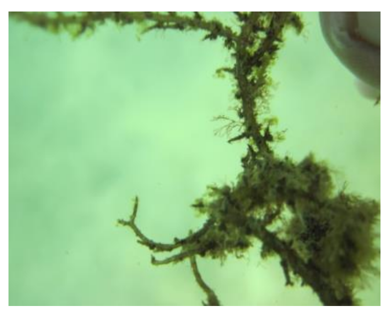


Figure 27: Rosenvingea sp.

5.6 Findings for Bio-Assessment

The surveyed area did not have a rich biodiversity. Apart from some patches of Sargassum sp. and Halimeda sp. there was no other dominant variety found. The presence of corals is very low and hence there is little risk for the seaweed farm to cause any impact on corals. However turbid conditions may hinder the growth of seaweeds. Moreover, Sargassum binderi seems to be a good candidate for seaweed culture as the conditions appears to be optimal for its growth. Bio-assessment post-farming would present a clear indication of the impact of seaweed farming at Vieux Grand Port.

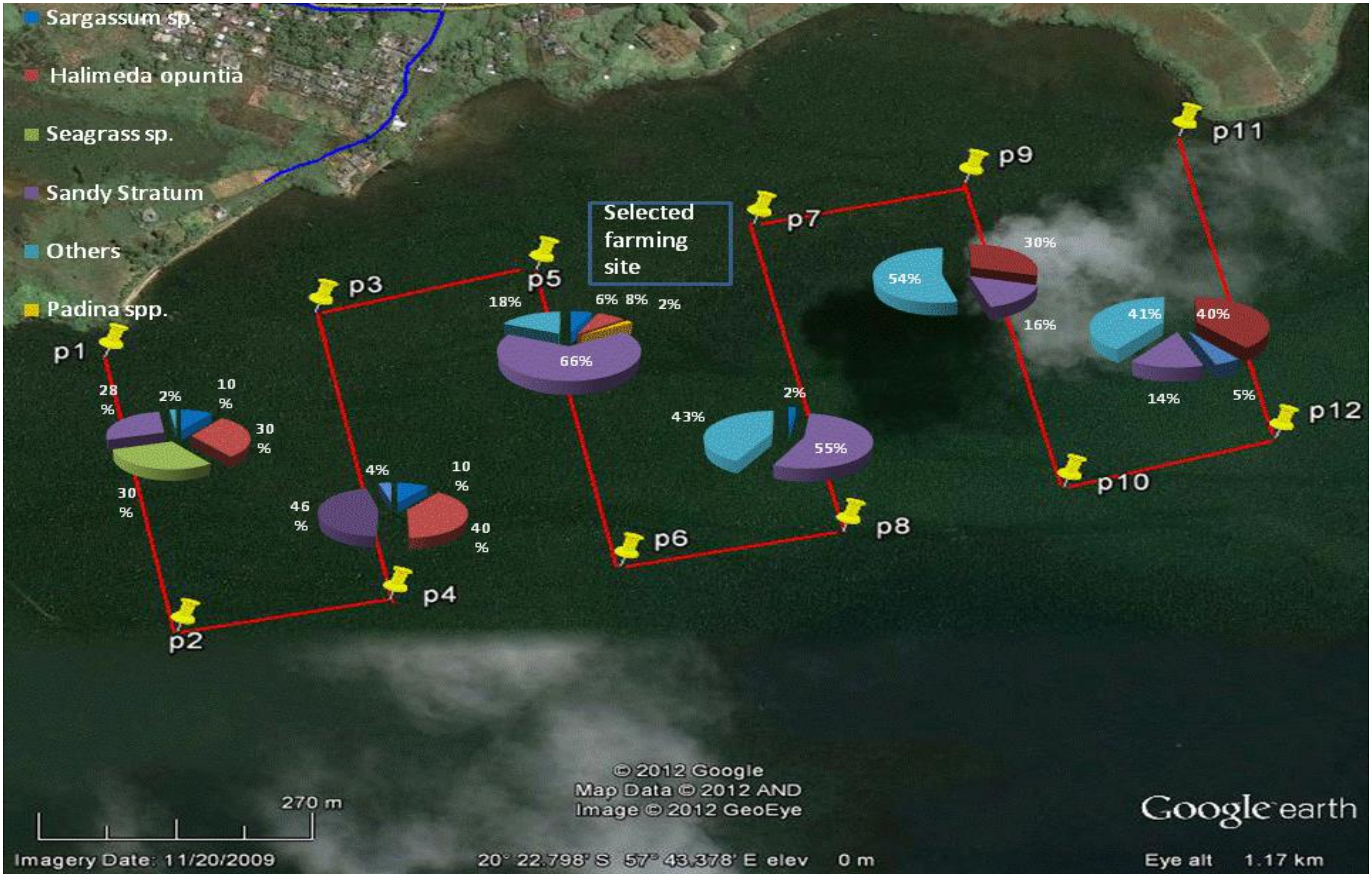


Figure 28: Bio assessment result

6.0 Workshop for setting-up of the seaweed farm

In September 2011, the “Seaweed Farming in Mauritius and Rodrigues” project was initiated by the Mauritius Research Council with the collaboration of Dr. F. Msuya of Institute of Marine Science (IMS), Zanzibar. Initially four sites were identified to implement the seaweed farms; Albion, Petit Sable/ Grand Sable, Pointe aux Feuilles and Poste La Fayette. After the implementation of the first experimental farm in Albion and subsequent media coverage, interest was aroused amongst fishermen of the region of Vieux Grand Port. A representative from this fishermen community, Mr. Christian Ho-Kam, contacted the Council to implement such a farm with close collaboration and voluntary participation from the fisher-group. Several meetings were conducted with the fishermen of Vieux Grand Port who displayed a keen interest and motivation into the project.

The Hands-on Seaweed Workshop was held on the 20th and 21st of April 2012 for two half days. The venue was Vieux Grand Port Community Centre, where about 20 fishermen actively participated. Trained resource persons from the first workshop from MOI, MSIRI, AFRC and AREU also helped in the workshop. The training was hosted by Mrs. P.V. Ramjeawon, MRC and conducted by Mr. K. Narrain and Dr. M. Madhou.

6.1 Pictures of presentation during workshop (20th April 2012)

Figure 29: Pictures of the presentation during the workshop of 20th April 2012

6.2 Setting-up of an Experimental Seaweed Farm at Vieux Grand Port

After discussion and deliberation with the fishermen and other stakeholders involved in the project, it was decided that Polyvinyl Chloride pipes (PVC) rafts would be ideal for the Vieux Grand Port Site. The advantages of the PVC Raft for this region are described as follows:

1. <u>Availability of Material</u>

Compare to other types of raft material required for building PVC frame are common construction and plumbing material readily available in any hardware shop.

2. <u>Speed and Ease of Assembly</u>

Assembling the frame of the PVC raft would require a maximum of 30 minutes and is assembled through simple gluing. Thus this technique requires no specific skills.. The mounting of this type of raft is easy as it requires four pipes which are glued together through elbow fittings (90^o) to form a square shape structure.

3. <u>Resistance of Raft</u>

The PVC raft would be the most convenient for this region as it has shown the best resistance against bad sea condition. Furthermore repairing a broken PVC Raft is relatively easier compared to other types of raft. The previous PVC raft used in Albion Seaweed farming has shown very good floatability, resistance and resilience in the lagoon conditions.

4. <u>Adjustability of Raft</u>

The PVC raft can be easily adjusted to any type of culture, that is both line and net bags can be cultivated. As such this raft can support a much higher load of seaweed growing and can accommodate large size seaweed such as *Sargassum sp.*

5. <u>Price and Transport</u>

The light weight of the PVC material makes transport easier and thus doesn't require a lot of persons/ labour for implementation. This material is also moderately cheap.

6.3 Material Required for Implementation

The following materials are required to implement a PVC Raft:

1. 4 full length (9m) PVC Pipes of 110mm in diameter
2. 4 Elbow (90^o) fittings (110mm)
3. High pressure PVC Glue/ Cement (Tangit High pressure)
4. Silicone High pressure sealant
5. 12mm diameter Nylon rope
6. 8mm diameter Nylon rope
7. Concrete Blocks for anchorage
8. Net bags
9. Floating Buoys

Figure 30: Fishermen mobilizing for the setting up of the PVC raft

6.4 Process for Mounting a PVC Raft

During the workshop the participants were taught about how to mount a PVC raft. They then on Friday 20th April participated actively in building a PVC Raft.

The process used for Building the PVC Rafts during the workshop is as follows:

1. The full length of the PVC Pipes were aligned in a square arrangement
2. Glue was then applied to the extremities of the pipes
3. The inside of the elbows were smeared with glue
4. The two extremities of the pipes were adjusted to the PVC elbow fittings. This process was repeated for all four corners of the square arrangement

5. To ensure that the arrangement is fully waterproof additional glue/ PVC cement was applied to the borders of the pipe and fittings.
6. The arrangement was allowed to set for one hour in the sun
7. After the glue in the pipe has set, high pressure silicone sealant was applied to ensure

ws.

llowed to set for a further 8 hour as per guidelines and icone to harden

m nylon rope was tied at the centre of one PVC pipe and ated to the other two sides. This particular arrangement is on the structure due to surface tension and wave interaction

Figure 31: Mounting of the raft

6.5 Seaweed Collection

The seaweed used during this workshop are *Gracilaria salicornia* and *Sargassum aquifolium.* The *Gracilaria salicornia* was collected in the Albion lagoon and transferred to Vieux Grand Port on the eve of the workshop (Thursday 19th April 2012). This seaweed was inserted into a resistant plastic net bag and with the help of a block anchor immersed in a marked location in the lagoon of Vieux Grand Port. This can also be considered as an acclimatisation exercise for this particular seaweed. As for *Sargassum aquifolium*, it is abundantly present in the vicinity of the selected site. Hence it was collected on the day of farm implementation (Saturday 21st April 2012)

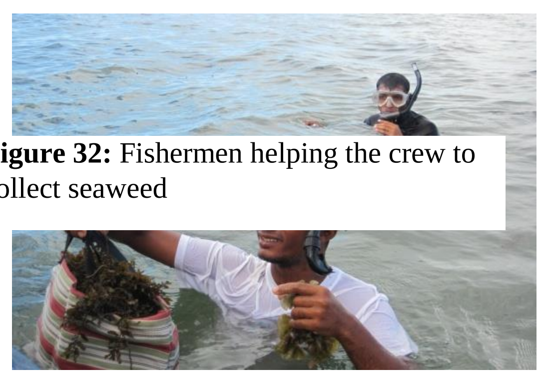


Figure 32: Fishermen helping the crew to collect seaweed

Figure 33: The crew at work

Figure 34: Seaweed on the boat

Figure 35: The diver analyzing the seaweed collected

6.6 Process for tying and attachment of seaweed

<u>For Net Bags Technique</u>

1. Six 8mm nylon rope of 10.5 meters in length were cut
2. These were tied on the raft using the 8-lock knot at an interval of 1.5 metres

Figure 36: Tying of ropes

3. The collected *Gracilaria salicornia* was distributed in 20 net bags with each having an initial wet weight of 100gms

Figure 37: Gracilaria salicornia being put in net bags

4. 8mm nylon rope consists of 3 intertwined ropes. These intertwined ropes were separated and the net bag inserted in them. This arrangement restricts the net bags from detaching away from the culture lines in case of loose tying or bad sea conditions.

Figure 38: Attaching the net bags with nylon rope

Figure 39: Attaching the net bags with nylon rope

5. All the net bags were tied to the culture lines

Figure 40: Net bags tied to culture lines

<u>For the tie-tie technique</u>

4 Twenty 4mm nylon rope of 10.5metres in length were cut

5 A number Rafia rope (tie-tie) were cut to 30cm in length

6 4mm nylon rope consists of 3 intertwined ropes. These intertwined ropes were separated and the tie-tie inserted in them. This arrangement restricts the tie-tie from detaching away from the culture lines in case of loose tying or bad sea conditions and causing an environmental problem.

7 The tie-tie are inserted at a 30 cm distance in the culture line

8 The *Sargassum aquifolium* was then tightly secured by the tie-tie on the culture lines

Figure 41: Sargassum aquifolium tightly secured by tie-tie on culture lines

9 The culture lines were then tied to the raft by using an 8-lock knot

Figure 42: Culture lines tied to raft

10 The seaweeds were allowed to hang freely

6.7 Raft Implementation

Once the rafts have been loaded with seaweeds they have to be set in the sea in their earmarked location. The following outlines the process that is used.

1. Three metre 12 mm nylon ropes are cut. 8 length of such rope is required for one raft

Figure 43: Ropes are being cut to make the raft

2. Two concrete blocks are used for one anchor. These concrete blocks are holed in their centre so as to allow for a 12mm nylon rope to pass through.
3. The 3 metre nylon rope are used to tie the 2 blocks together and allow 2 metre to length to tie the raft

Figure 44: The crew tying the ropes to the concrete blocks

4. Eight such anchor arrangements are used for one raft
5. The raft are taken to the prescribed location and are held in place by two divers

Figure 45: Setting the raft into the water

6. The anchors are taken on board a boat and lowered in at approximately one metre from the raft.

Figure 46: The fishermen helping for the anchoring process

7. The divers then tie the raft to the anchors by using a slip knot

Figure 47: Setting the raft into water and helping for the anchoring process

8. Finally floating buoys are tied to the raft the signal the presence of the structure to any boats.

Figure 48: The floating raft

6.8 Post Implementation Debriefing

After the implementation of the PVC Raft, a debriefing session was held with the fishermen. In this session, they were briefed on the way to clean and maintain the farm. All fishermen present agreed to contribute voluntarily in this endeavour. After the debriefing session lunch was offered to all the participants.

6.9 Workshop Observation and Finding

The workshop has achieved its aims and can thus be considered as successful. The participants who were mainly fishermen learnt about different cultivation techniques and were able to apply this knowledge in building and successfully implementing a seaweed farm. Following this workshop a smaller core group of fishermen has been created to monitor and maintain on a regular basis the rafts and the seaweeds. The core group also agreed to keep the other fishermen in the fishing community updated on the progress of the farm.

7.0 Experimental Seaweed Farm at Vieux Grand Port

The site plan

The site for the experimental farm at Vieux Grand Port is located at 20°22'29.98"S 57°43'14.37"E. The site is approximately located around 250 meters from the shore line.

Figure 49: Satellite Imagery of Experimental Farm in Vieux Grand Port.

Gracilaria salicornia

The seaweed *Gracilaria salicornia* is classified as a red alga in the *Gracilaria* genus. This genus is known to be one of the largest genera of seaweeds with over 150 established species (Tseng and Xia, 1999). Increasing focus is being placed on this species due its importance in the agar industry as the main source of gelling phycocolloid "agar" in the world (Oliviera *et al.*, 2000). It is largely used as a thickening agent and has applications in a vast number of industries such as in foods, cosmetics, textiles, brewing, paper and biotechnology.

Introduced in the 1970's in Hawaii for an experimental aquaculture, the *Gracilaria salicornia* is now widely spread; with 65 species of *Gracilaria* in the Indian Ocean (Silva *et al.*, 1996; Tseng and Xia, 1999). The *Gracilaria* species are characterized as remarkably resilient due to its resistance to extreme conditions; temperature, salinity and chemical treatments. Recent studies have showed good adaptability and responses in the photosynthetic mechanisms and respiratory systems of the algae to oceanic salinity as well as to subtropical to tropical temperatures (Phooprong *et al.*, 2007). The robustness and elasticity of this species enables them to adapt to both tropical and temperate climates. Its high physical resistance promotes *Gracilaria's* global distribution which spans from the warm India Ocean water to the Pacific and Atlantic Oceans (FAO, 2003).

Taxaonomy of *G.salicornia*

Division: *Rhodophyta*

Class: *Rhodophyceae*

Order: *Gracilariales*

Family: *Gracilariaceae*

Genus: *Gracilaria*

Figure 50: Seaweed Gracilaria Salicornia

G.salicornia is characterized by its cartilaginous, brittle cylindrical club-shaped segments which split into two or more branches. Dark red, brown or green to yellowish in colour, the thallus can be up to 10cm long and 1-2mm in diameter, with irregularly placed constrictions (Oliveira *et al.*, 2005). It arises from creeping axes with discoid holdfasts and is found to propagate both sexually and asexually. It usually forms extensive mats in the intertidal zones on rocks and sand-covered rocks and in the subtidal fringe (Branch *et al.*, 2010) and in areas of moderate water motion. Moreover it has high growth rates and multiplies through fragmentation which consequently leads it to be so widespread and even known as an invasive species in certain areas such as Hawaii for instance (Botany, University of Hawaii, 2001). It responds quickly to pulses of nutrients and has been shown to have the potential to increase in biomass by up to 24% per day (Cordover, 2007)

As reported by Cordover (2007) China, Indonesia, Vietnam and Thailand together produce about 60,000 wet tonnes of G*racilaria*, in most cases a mixture of wild and cultivated harvests. About one-third of this production is used fresh as a food vegetable or to locally process with sugar and colouring as sweets. The value of dried and baled *Gracilaria* seaweed could range from US$250 to US$900 per tonne, depending on the impurities, gel content and gel strength (Cordover, 2007). Moreover it is also a popular food consumed fresh in South East Asian communities of Philippines, Malaysia and Thailand. Together with Laminaria, Porphyra and Undaria, *Gracilaria* make up 93% of the total seaweed cultured currently.

The future of the *Gracilaria* species production relies on the selection of species with faster growth rates and high agar content and quality. According to the FAO (2003), the most dynamic sector of the seaweed industry is the extraction of seaweed colloids with applications in almost every aspect of the modern society. The protection on natural stocks of *Gracilaria* is crucial to prevent over-exploitation and the development of improved cultivation techniques is vital for further development of the agarophyte industry (FAO, 2002). This consequently makes agarophytic *Gracilaria salicornia* species as crops with very high commercial potential and a promising future (FAO 2003).

7.1 Farming Method for *Gracilaria salicornia*

Several types of farming methods were experimented in the Albion Lagoon for *Gracilaria salicornia*. These are as follows;

1. Off-bottom farm
2. Floating Rafts (Bamboo)
3. Floating Rafts (PVC)
4. Floating Rafts (Line)

For Vieux Grand Port, the PVC raft was considered to be the most appropriate method for cultivation of *Gracilaria salicornia*.

7.2 Floating Raft (PVC)

The PVC floating raft system is a novel system which has been developed in Mauritius during the workshop. PVC pipes used in conventional plumbing system are joined together with 90° elbow fitting so as to make a square shape arrangement. This arrangement hence acts as floats and the seaweed lines are tied 50 cm below these floats on the anchor lines. Hence the seaweeds are always submerged and are at optimum depth at all times. This system is anchored by using 4 25kg anchor blocks. The arrangement is illustrated in Figure 10.

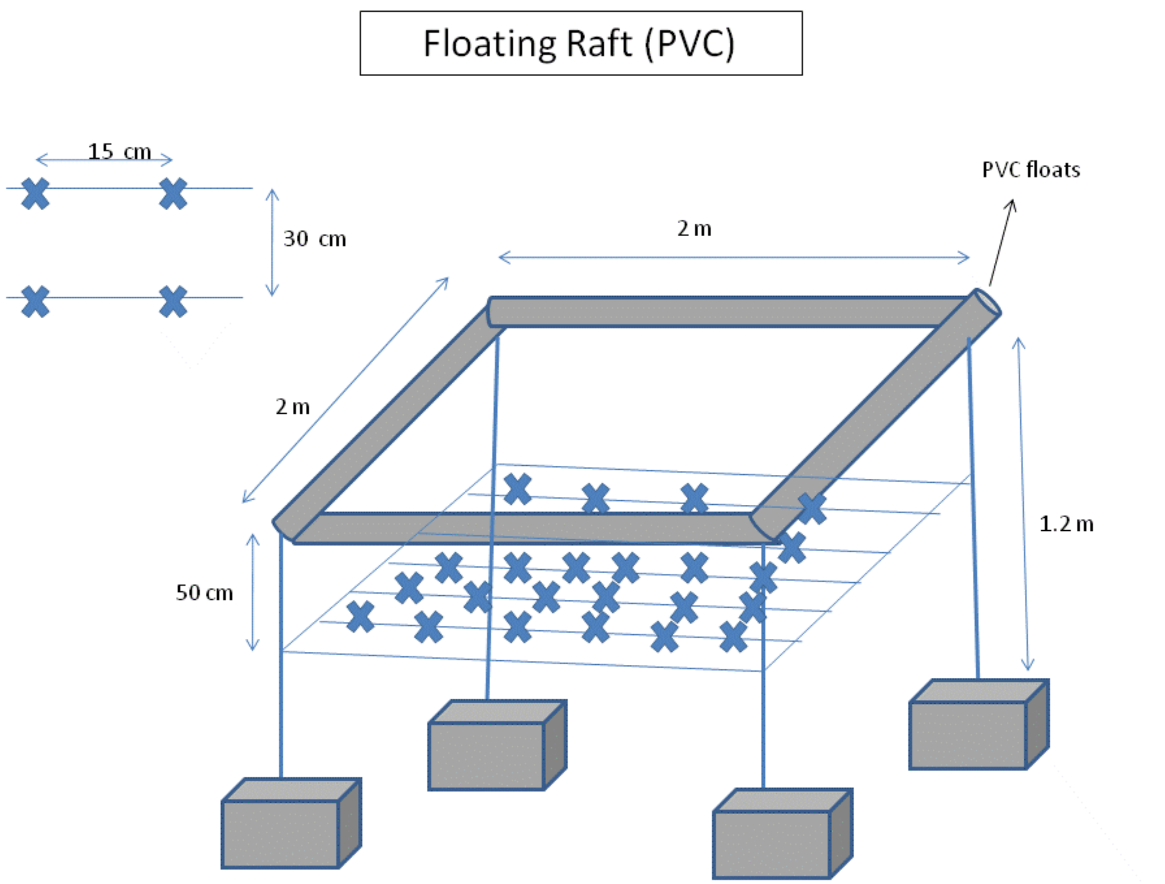


Figure 51: The schematic representation of the PVC Floating Rafts.

Advantages

- PVC is a material which is readily available in Mauritius and more specifically near the sites of cultivation.
- Mounting a PVC raft is a very easy process where only fitting and gluing is involved. Hence no special skills are required. As such it is less time consuming than other methods of cultivation
- PVC is a very durable and resistant material in seawater. It showed no sign of disintegration during its exposure to seawater and sun.
- PVC raft can be modulated to any size up to a maximum of 9m X 9m which is the common maximum available length of PVC piping.
- The overall weight of the structure is very low as compared to other techniques. This confers the structure a very good floatability and implementation at sea does not require a large number of staff.
- Due to the colour of the PVC it is a very visible structure at sea and hence requires no extra buoys for signalization.
- Even in case the water infiltration the integrity of the structure remains and hence no further cost is required when repairing the rafts
- A pipe being smooth on the surface limits the amount of fouling as compared to other farming techniques

Disadvantages

- Due to the light weight of the structure it experiences the effect of surface tension which may bring about deformation and breakage of the raft.
- It requires very careful gluing as if the fitting are not airtight, water infiltration occur. Furthermore with time it has been observed that there is gradual deterioration of the glue with seawater. Hence regular maintenance is required. In addition, silicone cement has to be applied to maintain air tightness.
- Fouling and subsequent shell accumulation on the PVC pipes in the long run can cause puncture of the pipes.

- It requires a certain amount of investment due to the price of the PVC pipes, fittings and glue.

7.3 Net bags

Following problem of fish grazing of *Gracilaria salicornia*, the method of net bag farming was adopted. This technique is very easy to adapt upon the current farming techniques. It consists of placing the seaweed inside the net-bags and tying the net bag to the culture lines on the PVC raft. Initially net bags of hydroponic grade were used but it had a high price. Then an alternate solution was found by using onion bags as net bags as shown in figure 12 below.

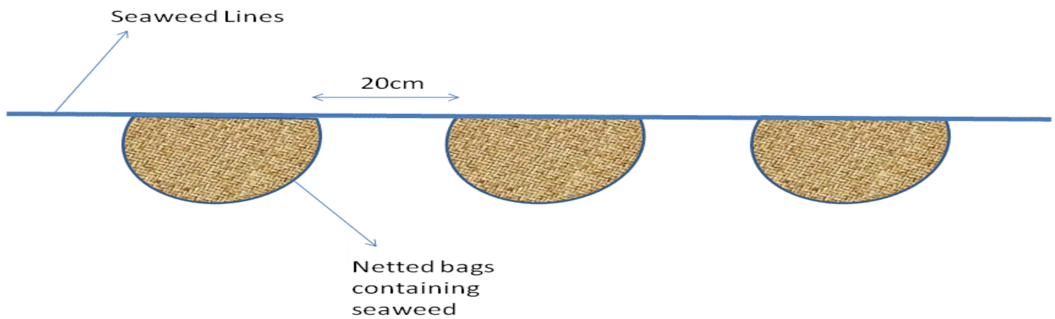


Figure 52: Schematic representation of floating Onion Net bags.

<u>Advantages</u>

- The onion bags are very cheap to obtain. Also used onion bags of good quality can be obtained freely from onion growers or sellers.

- This technique reduces the amount of labour hour required to implement a seaweed farm and also in maintenance.
- The net bag provides a protected environment for the seaweed to grow. Apart from protection from predation it offers a structure which can resist rough sea condition and reduces seaweed breakage.
- In the case of *Gracilaria salicornia*, it has been observed that the net bags tend to replicate the natural environment for the optimal growth of the seaweed.
-

<u>Disadvantage</u>

- The net bags tend to favour more fouling as compare to the culture line method.

8.0 Monitoring of the Experimental Farm

The methodology for monitoring the water parameters was as followed:

Readings for salinity, temperature, pH and dissolved oxygen were taken at three selected sites in the proximity of the seaweed farm. Two measurements were taken in the raft and two upstream and downstream respectively as shown in Figure 46 below.

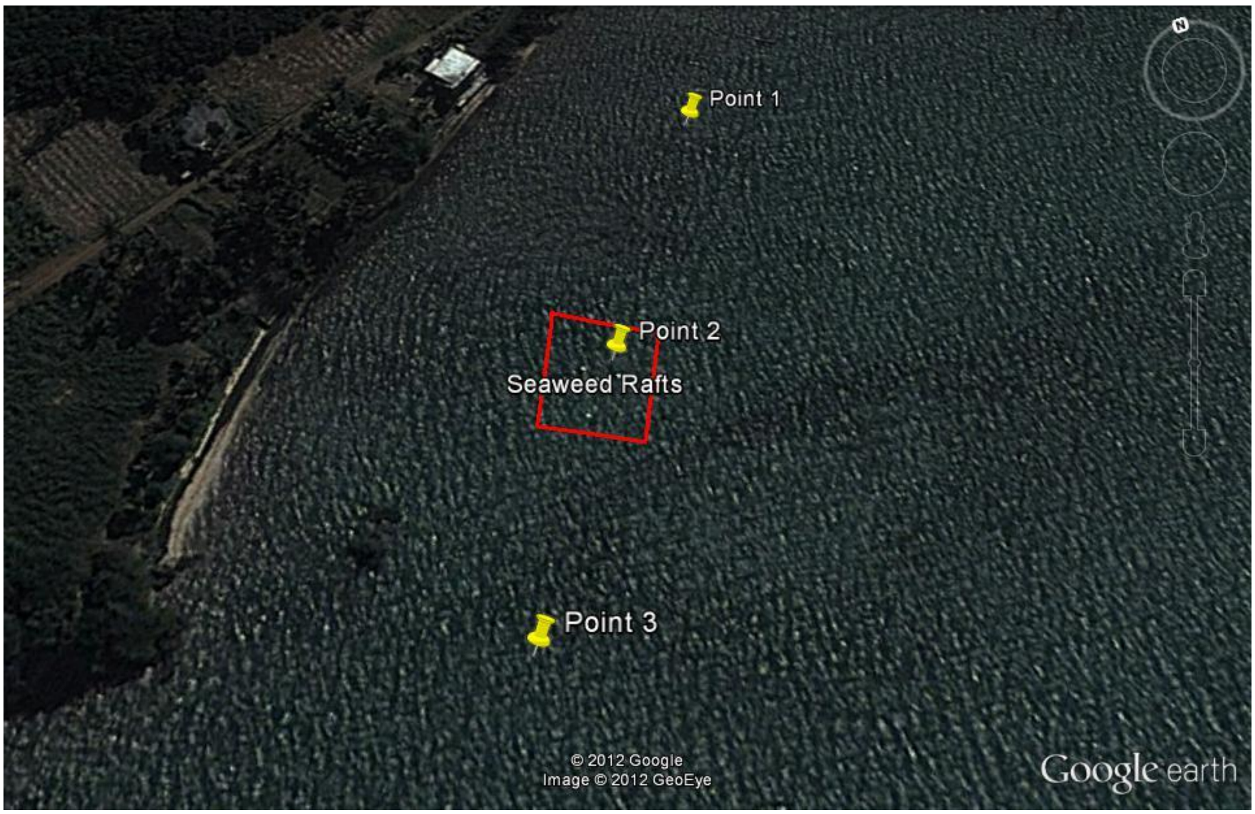


Figure 53: GPS map for the three selected point for water parameters monitoring.

Table 2: GPS coordinates of selected points for water parameters monitoring.

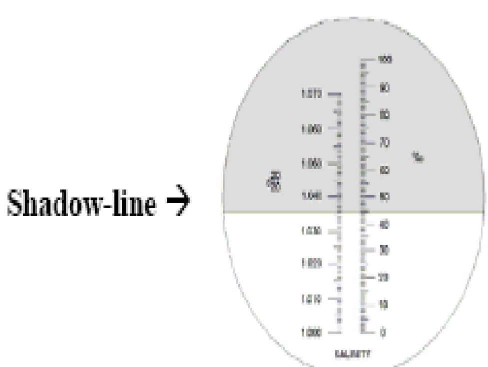
Selected points for water parameters	Latitude	Longitude
Raft	S 20º22’41.97”	E 57º43’07.27”
Measure Pt1	S 20º22’40.04”	E 57º43’68.80”
Measure Pt2	S 20º22’441.98”	E 57º43’07.18”
Measure Pt3	S 20º22’42.87”	E 57º43’06.39”

8.1 Material used for water parameters:

1. Refractometer was used for salinity determination
2. HACH portable probe meter was used for pH, temperature, dissolved oxygen and electrical conductivity (EC) measurements.
3. HACH portable probe DO6

Procedures:

1. Salinity measurements



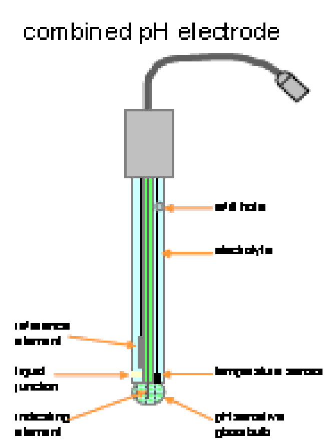
The salinity refractometer measures the refractive index of the samples and displays the results in parts per thousand (ppt).

- Calibration of apparatus:
    - Few drops of distilled water are placed on the entire prism.
    - The cover plate is closed and the adjusting screw is rotated so that the shadow line (light/dark boundary line) evens up with zero line.
    - The prism is cleaned with a piece of tissue paper after the zero adjustment.

- Sample preparation and reading:
    - Few drops of sample liquid (seawater) are placed on the measurement prism and enough liquids were added in order to cover the entire prism (liquids were spread on the entire prism and no air bubbles were allowed)
    - Sample was allowed to remain on the prism for approximately 30 seconds and the salinity concentration was read under a light source through the eyepiece.

      The salinity concentration is determined by the intersection of the boundary of the light and dark fields (known as the shadow-line) on the printed scale.
    - Once a reading has been taken, the prism is wiped dry with a clean cloth and is placed in a safe and dry environment.

2. **Measuring temperature, dissolved oxygen (DO), pH and conductivity with multi-probe, portable meter.**



- The protective cover of the probe is removed first
- The probe is washed with distilled water and blotted dry.
- The instrument is turned on (the power key '**Φ**' is pressed).
- The '√' key is pressed to begin measuring
- The probe is placed in the sample liquid with sensors submerged.
- Probe is swirled and reading is allowed to stabilise
- The readings are recorded (temperature: **°C**, DO**:** **%**, Electrical conductivity: **mS/cm**)
- The instrument is switched off and is cleaned with distilled water and dried with soft tissue only by contact (without rubbing) before storage.

Note: All measurements were taken in-situ that is directly in the seawater. Apparatus were calibrated before taking the first reading.

9.0 Results and Discussions

9.1 Physico-chemical parameters

The physical parameters (Salinity, Temperature, pH, and Dissolved oxygen) of Vieux Grand Port were measured at a weekly basis from May 2012 to September 2012 for the first growth cycle and from October 2012 to February 2013 for the second growth cycle. The Parameters ranges are summarized below in Table 2 and the trends are shown in Figure 10.

Table 2: Parameters range of Vieux Grand Port from May to September 2012. Data represents Mean ± SD.

Vieux Grand Port	
Parameters	**Range**
Salinity (ppt) **(May to September 2012)**	10.8 ± 0.5 – 37.8 ± 0.5
Salinity (ppt) **(October to February 2013)**	22.0 ± 0.0 – 35.0 ± 0.0
Temperature (°C) **(May to September 2012)**	21.6 ± 0.4 – 26.3 ± 0.5
Temperature (°C) **(October to February 2013)**	25.5 ± 0.0 – 31.6 ± 0.1
pH **(May to September 2012)**	8.4 ± 0.6 – 9.4 ± 0.1
pH **(October to February 2013)**	8.4 ± 0.6 – 9.2 ± 0.0
Dissolved Oxygen (%) (**May to July 2012**)	90.1 ± 0.8 – 147.5 ± 12.5

The ranges of the Physical Parameters for Vieux Grand Port met more or less the range for the optimum growth of seaweed as prescribed by FAO (2010).

9.2 Salinity trend

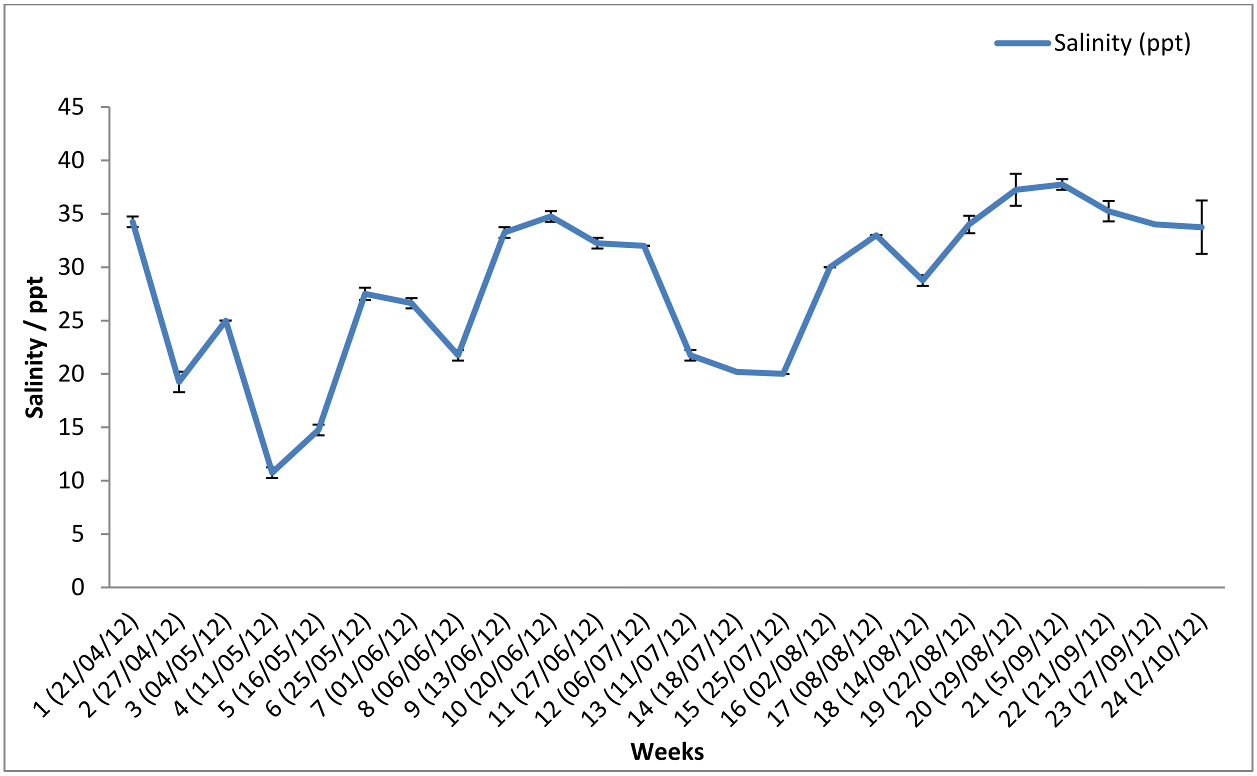


Figure 54: Salinity record for Vieux Grand Port during the months of May to September 2012. Data represents Mean ± SD.

The wide range in salinity observed at Vieux Grand Port is attributed to the specificity of the site. The proximity of the farm with the river mouth of Riviere des Creoles and its accompanying input of fresh river water coupled with heavy rainfall during the month of May explains the decreases in salinity. The whole farming period also encountered salinity fluctuation due to the input of fresh water near our farming zone.

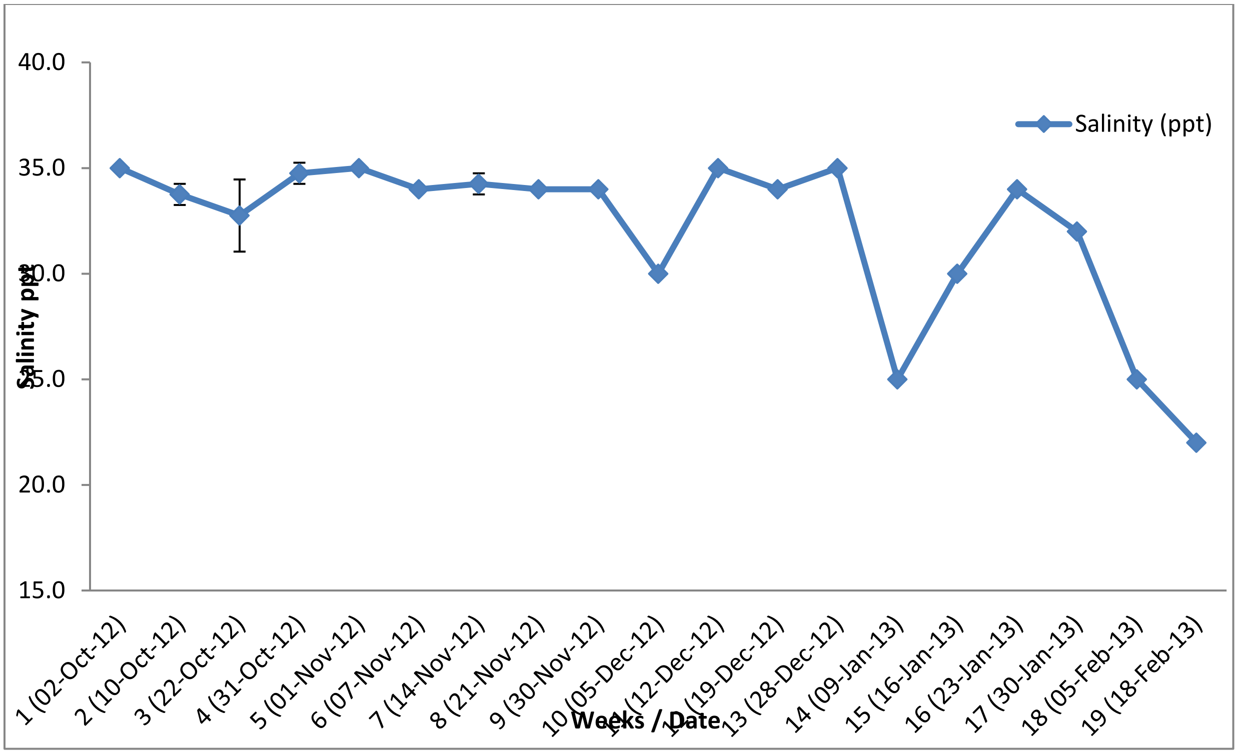


Figure 55: Salinity record for Vieux Grand Port during the months of October 2012 to February 2013. Data represents Mean ± SD.

The above graph shows a constant level of salinity from October 2012 to November 2012. However there was a quite significant decrease in salinity in February 2013 due to torrential rain and thus input of fresh water.

9.3 Temperature trend

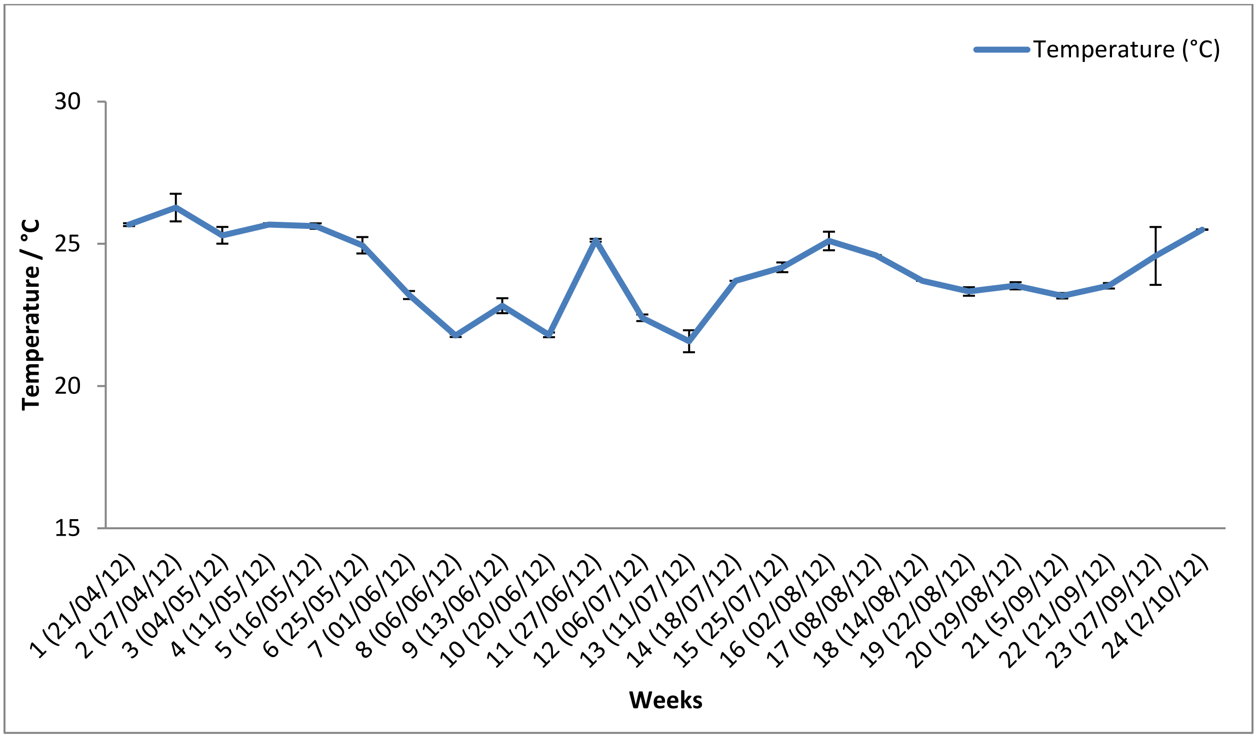


Figure 56: Temperature record for Vieux Grand Port during the months of May to September 2012. Data represents Mean ± SD.

The temperature remained mostly constant throughout the study period. The temperature range was within the optimum one prescribed in the FAO technical report (2010).

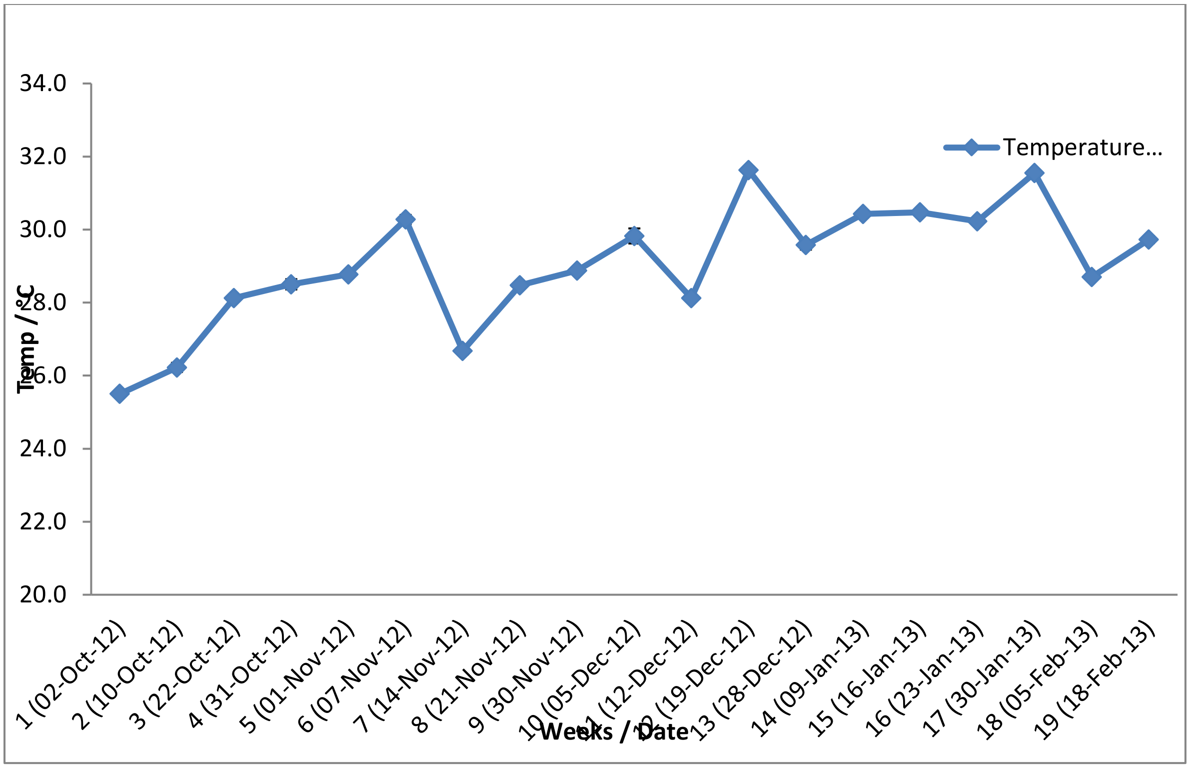


Figure 57: Temperature record for Vieux Grand Port during the months of October 2012 to February 2013. Data represents Mean ± SD.

The graph shows an increase in temperature from October 2012 to February 2013 as it is known that February in the hottest month in the Summer period in Mauritius.

9.4 pH trend

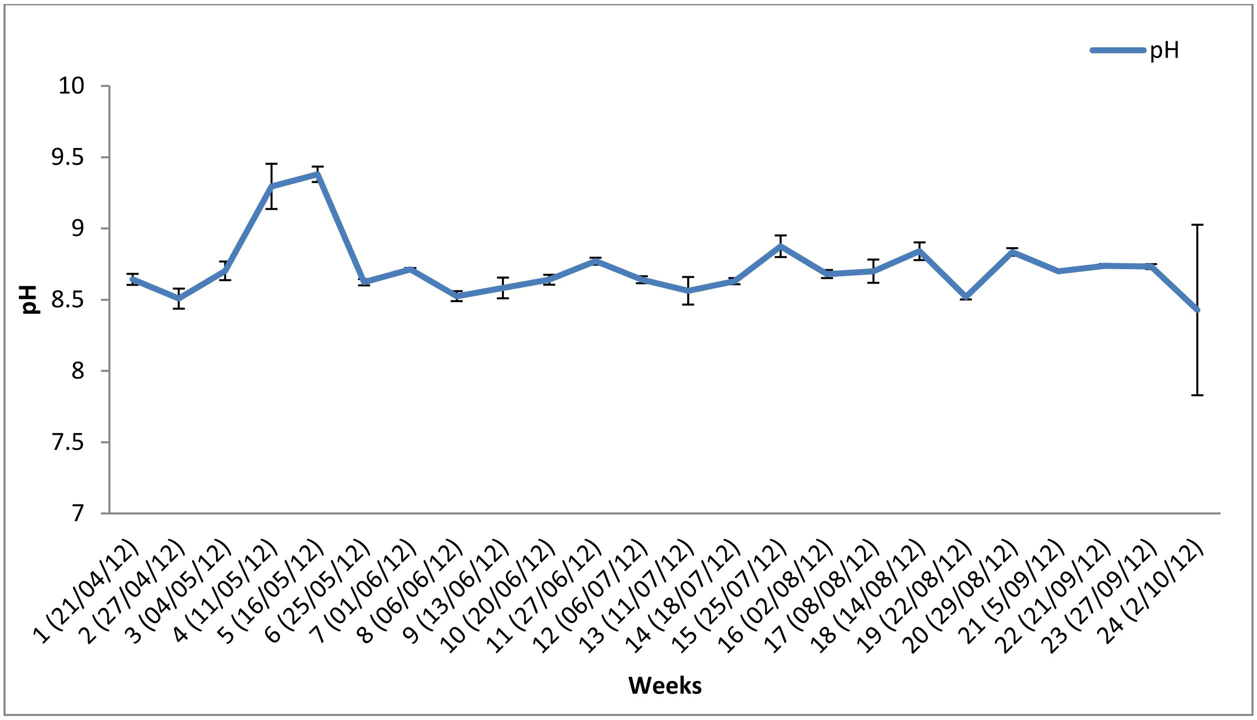


Figure 58: pH record for Vieux Grand Port during the months of May to September 2012. Data represents Mean ± SD.

The pH was also constant throughout the study months. The water of Vieux Grand Port became slightly alkaline in the month of May. This abnormality can be related to the salinity decrease during the same period.

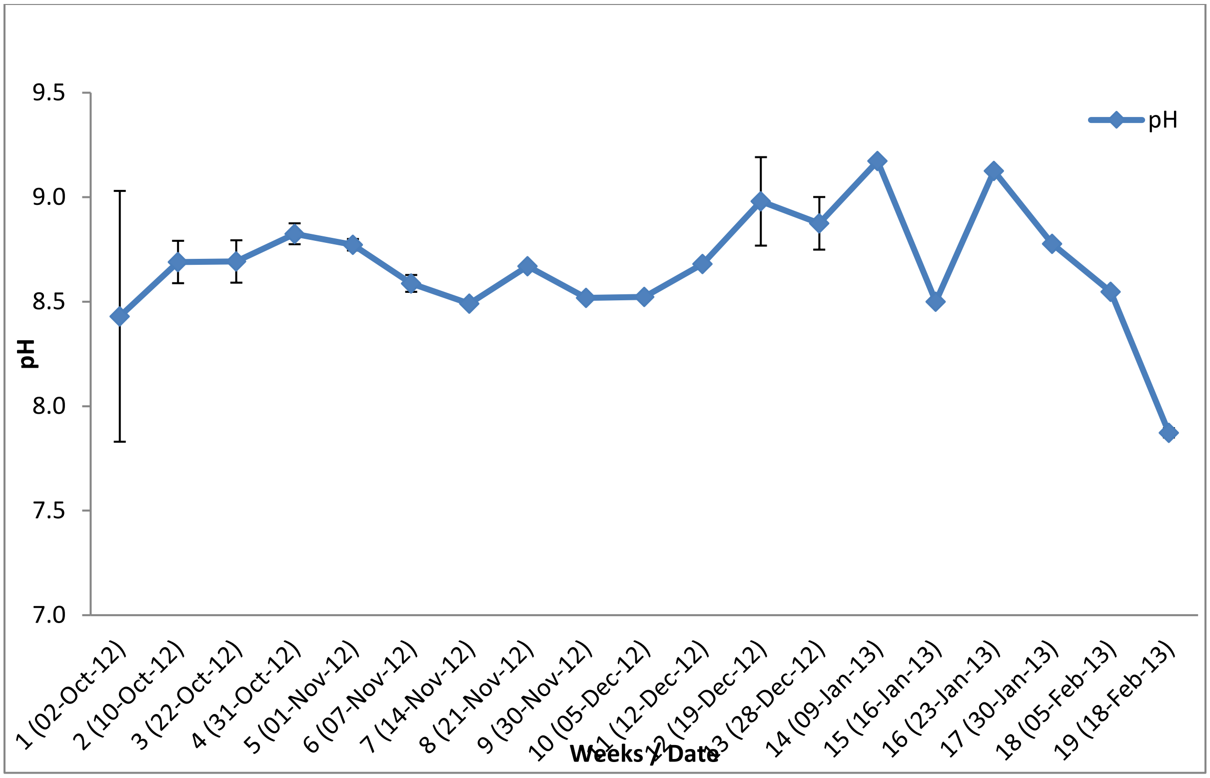


Figure 59: pH record for Vieux Grand Port during the months of October 2012 to February 2013. Data represents Mean ± SD.

The pH remains quite constant across the months of October 2012 to December 2012. Moreover during the period of January a dip was observed on the graph. One of the possible reasons may be the erosion of silt from the Ferney river which may have caused the seawater to become slightly acidic. This can also be due to accumulation of nutrients in the seawater triggered by percolation/runoff of rain water on the surrounding plantations.

9.5 Dissolved Oxygen trend

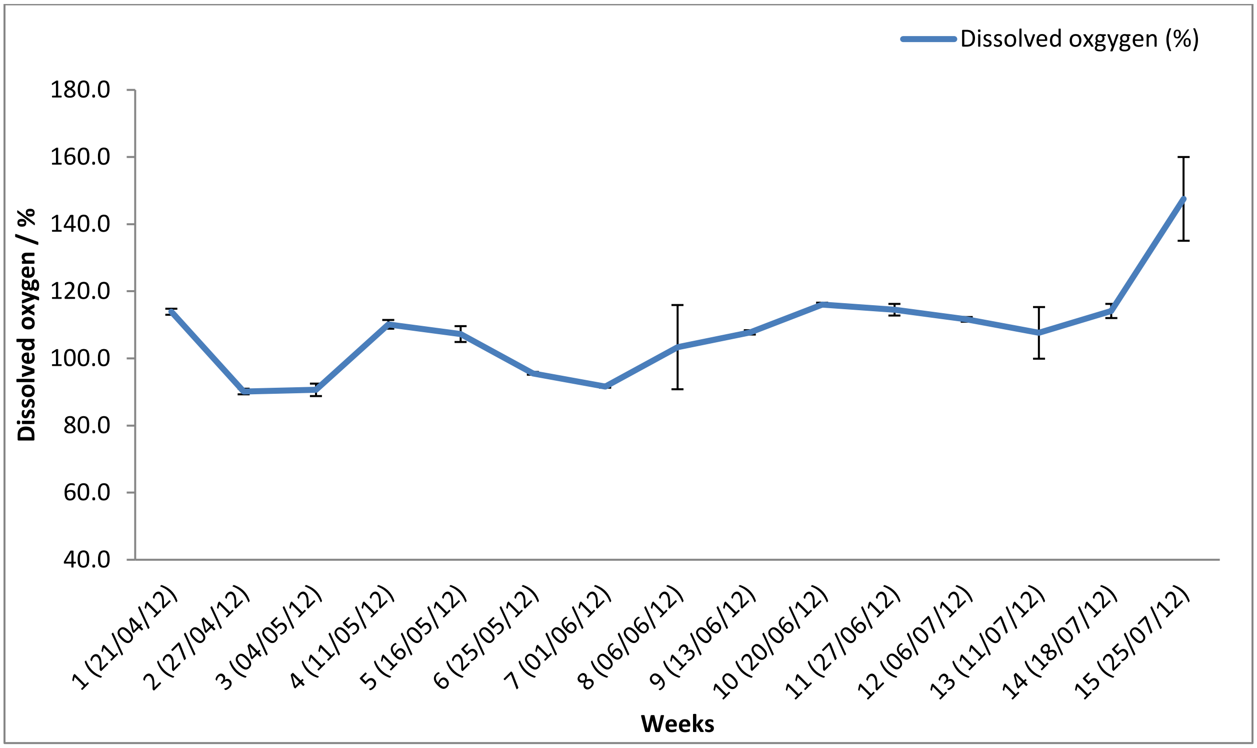


Figure 60: Dissolve Oxygen record for Vieux Grand Port during the months of May to July 2012. Data represents Mean ± SD.

The Dissolved oxygen was recorded in percentage. The recording months were from May to July 2012 due to unavailability the probe. During the study period, the percentage dissolved oxygen was more or less on the constant line.

9.6 Percentage Relative Growth Rate Curve

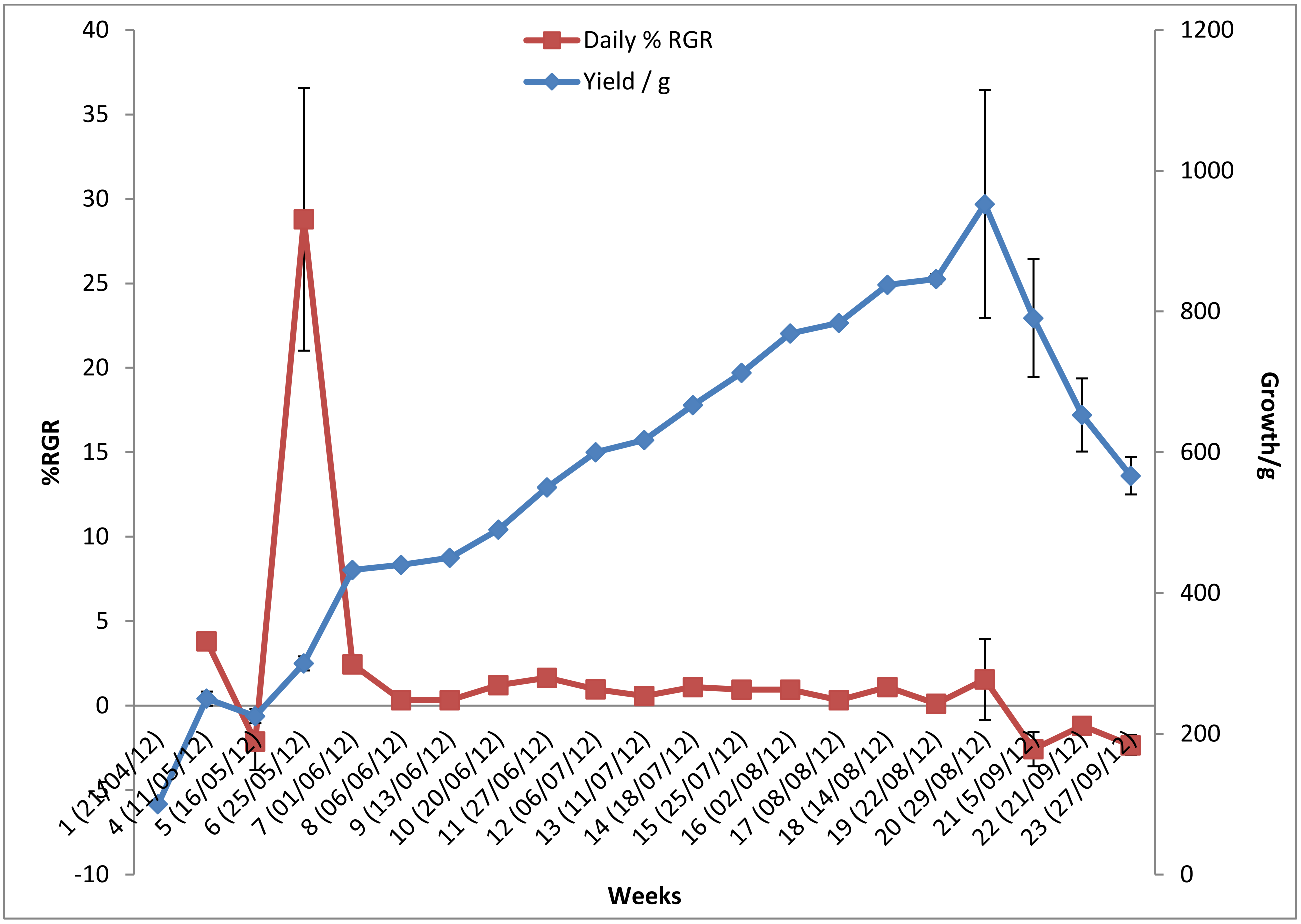


Figure 61: Percentage Relative Growth Rate Curve and the Yield Curve of Gracilaria salicornia in Vieux Grand Port during the months of May to September 2012. Data represents Mean ± SD.

Figure 51 above demonstrates the growth potential of *Gracilaria salicornia* in the lagoon of Vieux Grand Port. The greatest increase in biomass was observed during the initial stages of cultivation. The negative percentage RGR obtained at week 5 was due to adverse weather conditions which damaged the net bags consequently causing a loss in seaweed. As seen from the graph above, *G. salicornia* did not reached a stagnant phase but after reaching its peak period, it started to decrease in mass as the seaweed started to disintegrate. This explains the negative percentage RGR value during the last three weeks of the study period. The highest average mass of seaweed obtained per average net bag was 952g.

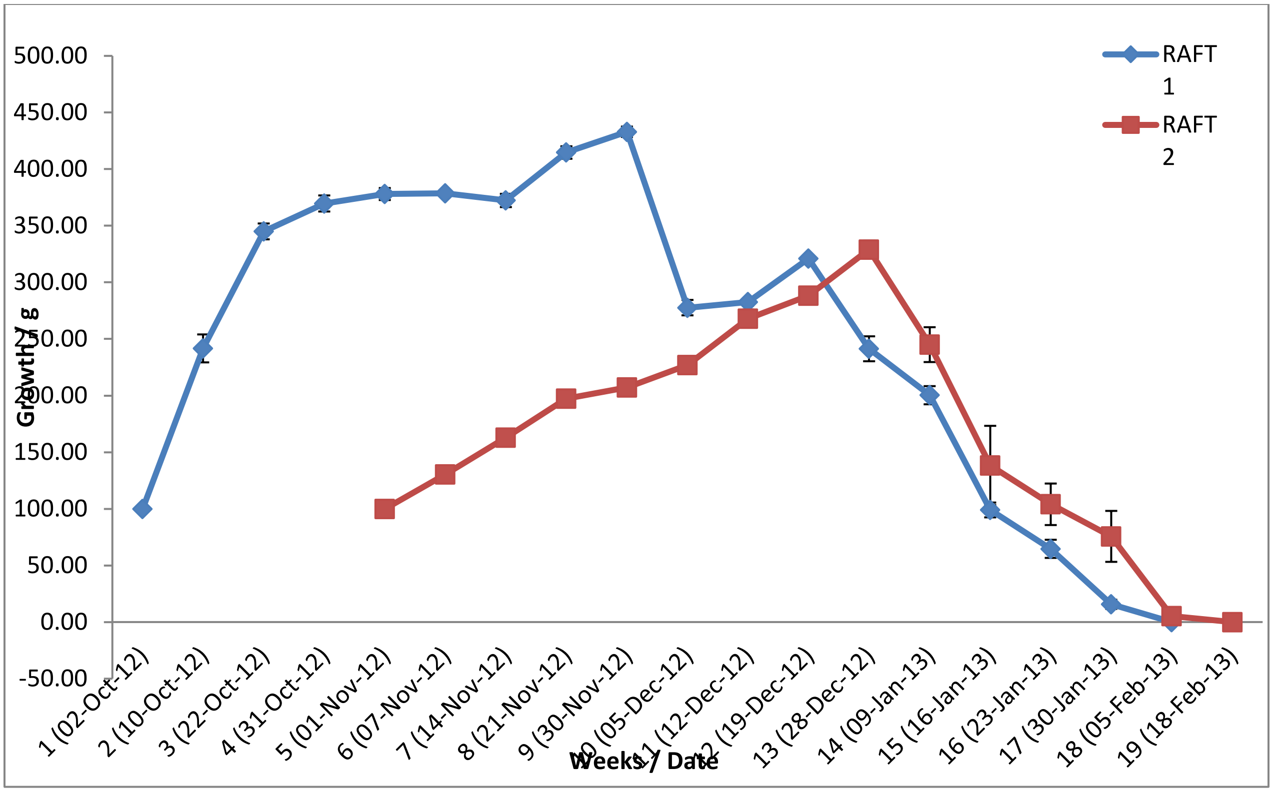


Figure 62: Percentage Relative Growth Rate Curve of Gracilaria salicornia in Vieux Grand Port during the months of October 2012 to February 2013. Data represents Mean ± SD.

The second raft was placed in water in November 2012 and both graph shows an increase in growth rate for the first month, that is from October 2012 to November 2012 for the first raft and from November 2012 to December 2012 for the second raft. The optimum weight of the seaweed is obtained after approximately one month and its mass varies from 300 to 400 g. Then, there is gradual decrease in growth rate as well as weight of the seaweed. This might be a natural phenomenon occurring in this particular seaweed variety in this region. It had been observed that Gracilaria species occurring in the wild experience a gradual decrease in their population mass or simply disappear from the substratum in this particular region.

9.7 Re-seedling

A total 4360g of *G. salicornia* was collected during harvest made on the 2nd of October 2012. All the harvested seaweed was used for re-seedling whereby 100g of seaweed was placed into 40 net bags into the same PVC raft of 9m X 9m.

9.8 Problems Encountered and Lessons Learnt

Numerous problems have been encountered during the course of the experiments. These are described below.

Presence of harmful organism

In November 2011, a dead whale drifted to the shores of Albion, at about 200 metres from the farming site. This dead carcass attracted a number of shark and other marine predators which triggered a restriction notice from the National Coast Guards. Hence it was not possible to monitor the farm during a period of 2 weeks.

Netbags Disintegration

Net bags were a cheaper alternative used against fish grazing as net bags of hydroponic grades were available off the shelves and were at a cost of about Rs.150. However, once implemented, these types of bags did not resist the seawater and constant abrasion from harsh weather conditions. These net bags disintegrated and let out all the Gracilaria salicornia.

From discussions with fisher group, it was found that onion bags were already used in fishing cages and boats and were very resistant to seawater and harsh weather conditions. Another benefit that was highlighted was that used onion bags (linen bags) were available free of cost or at a very cheap price. In some cases it was found that the lifecycle of onion bags in seawater exceeded one year.

Hence the onion bags were evaluated in farming conditions and found to be a very good material to use as net bags. In the course of this experiment 25kg onion bags were used.

Water Infiltration in PVC Raft

- Overcomed by gluing Fittings and pipes with high pressure PVC Glue then by PVC Concrete

- PU Foam is used to fill the tube to confer buoyancy and floatability.
- Finally Sealed with silicon
- This arrangement is allowed to dry for 8 hours

- Surface Tension and Resistance to rough sea conditions
  - Being a floating structure a PVC raft experiences surface tension. This is exacerbated during rough sea conditions and raft gets dismantled
  - Overcome by Cross sectional tying of raft so that overall pressure is balanced

Gracilaria salicornia bleaching

- Direct exposure to sunlight causes discoloration and die-off of Gracilaria spp.
- In the wild, best quality of growing Gracilaria is found under rock in shaded area
- Solution to replicate the natural conditions for growth was to use net-bags and lower the supporting lines

Conclusion

Following the one year experiment carried out, it was found that the best period for *Gracilaria salicornia* farming was during the period of April till September. Hence this activity can be carried out only during 6 month period over one year. Moreover this experiment has only been conducted in one particular site and inference can be made to farming for only this region. Furthermore, seasonal variations may also influence patterns in which seaweed growth happens. Hence this one year data may not give an accurate perennial indication for *Gracilaria salicornia* growth. Thus, further studies will be required on different sites and also on subsequent years for more clarity on the pattern of growth for this particular specie.

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ANNEX

70/8.

PRIME MINISTER'S OFFICE
REPUBLIC OF MAURITIUS

SEC/MRC/1 **13 December 2011**

Dear Sir,

<u>Experimental Seaweed Culture in Mauritius and Rodrigues</u>

Please refer to your letter dated 22 November 2011.

2. I am directed to inform you that there is no objection to the setting up of experimental seaweed culture plots in the lagoon areas mentioned in your above letter provided that:-

(i) the project is conducted in close association with the Ministry of Fisheries and Rodrigues along with the fishermen of these areas, so that appropriate information is provided to the local communities;

(ii) necessary action is taken to prevent the proliferation of seaweeds which may have a harmful effect on the marine flora and fauna.

Yours faithfully,

S. Rambeas (Mrs)
for Secretary to Cabinet
and Head of the Civil Service

Dr A. Suddhoo
Executive Director
Mauritius Research Council
Level 6
Ebène Heights
34, Cybercity
Ebène

MAURITIUS RESEARCH COUNCIL
Date RECEIVED
15.12.11

Figure 63: Permit from Prime Minister's Office

PRIME MINISTER'S OFFICE
REPUBLIC OF MAURITIUS

SEC/MRC/1 **22 March 2012**

Dear Sir,

Experimental Seaweed Farming in Mauritius

Please refer to your letter dated 20 March 2012.

2. Approval is hereby conveyed for the Mauritius Research Council to conduct experimental seaweed culture in the Vieux Grand Port Lagoon on the same terms and conditions laid down in this Office letter (Ref.: SEC/MRC/1) dated 13 December 2011.

Yours faithfully,

S. Rambeas (Mrs)
for Secretary to Cabinet
and Head of the Civil Service

Dr A. Suddhoo
Executive Director
Mauritius Research Council
Level 6, Ebène Heights
34, Cybercity
Ebène

MAURITIUS RESEARCH COUNCIL
Date RECEIVED
26-03-12

Figure 64: Permit from Prime Minister's Office

In reply please quote:

GEN/MHL/G63/00061

REPUBLIC OF MAURITIUS

Ministry of Housing and Lands
Ebène Tower, Plot 52
Ebène, Cybercity
Tel. No.: 401 6808 / 09
Fax No.: 454 6328
Email: mhl@mail.gov.mu

13 April 2012

Experimental Seaweed farming in Mauritius

Dear Sir,

Please refer to your letter dated 20.03.2012 on the above mentioned subject.

2. I am to inform you that this Ministry has no objection to the implementation of the experimental seaweed farm in the Vieux Grand Port Lagoon of the extent of 10374 m^2 shown edged red on annexed plan.

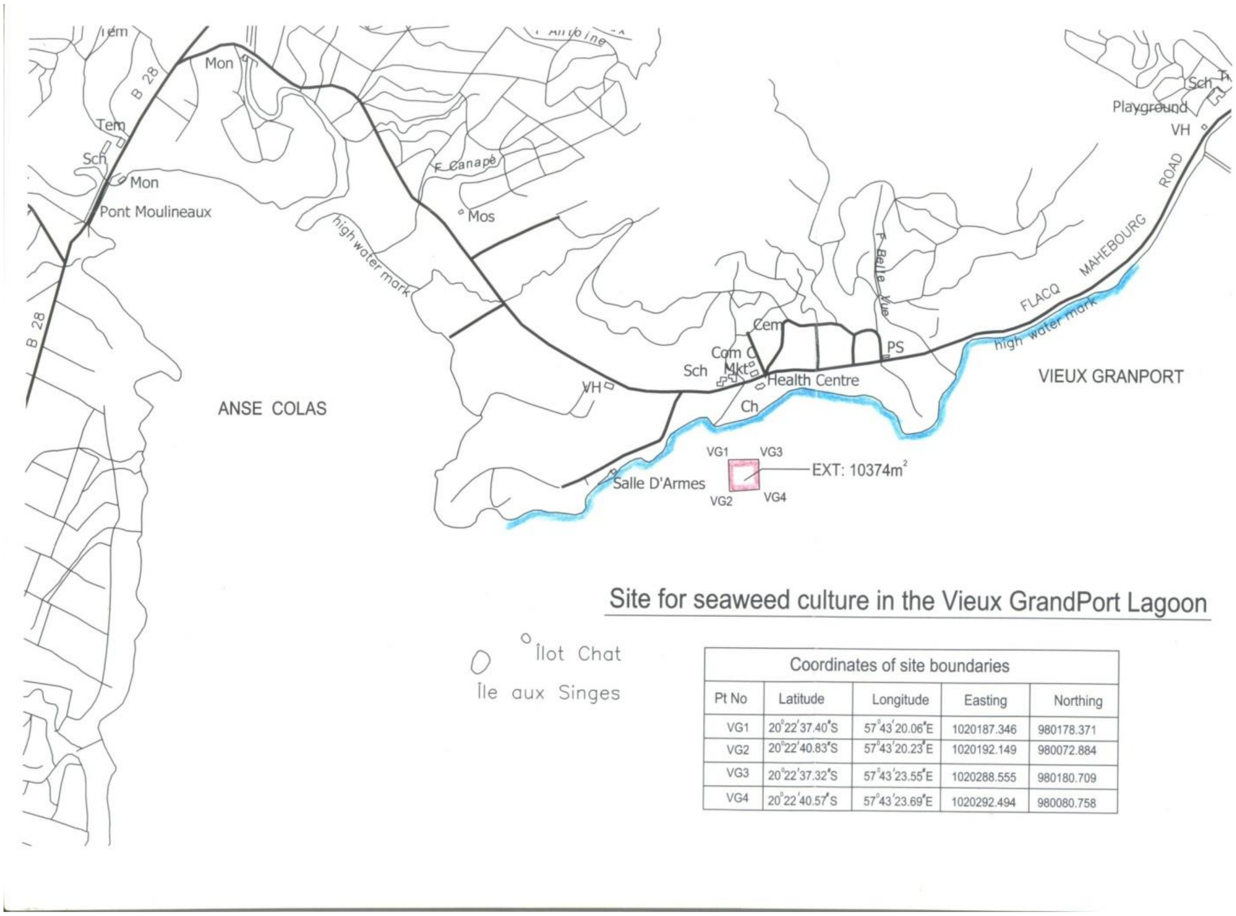
Yours faithfully

Y.Luchoomun
for Permanent Secretary

Dr A.Sudhoo
Executive Director
Mauritius Research Council
Level 6
Ebene Heights
34, Cybercity
Ebene

RECEIVED 17/04/12

Figure 65: Permit from Ministry of Housing and Land



Coordinates of site boundaries				
Pt No	Latitude	Longitude	Easting	Northing
VG1	20°22'37.40"S	57°43'20.06"E	1020187.346	980178.371
VG2	20°22'40.83"S	57°43'20.23"E	1020192.149	980072.884
VG3	20°22'37.32"S	57°43'23.55"E	1020288.555	980180.709
VG4	20°22'40.57"S	57°43'23.69"E	1020292.494	980080.758

Figure 66: Site for seaweed culture in Vieux Grand Port Lagoon

KEYS FOR COMMUNITY MAPPING

1.  Seaweeds

2.  Fishing Site

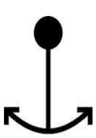
3.  Line Fishing

4.  Fish Trap

5.  Star Fish

6.  Sea urchin

7.  Sea cucumber

8.  Where boats are kept

9.  House

10.  Hotel

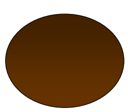
11.  Sea current

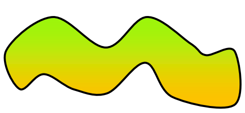
12.  Boats pass

13.  Corals

14.  Site located

15.  Accumulation of wastes

16.  Muds

17.  Sand