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RENEWABLE ENERGY APPLICATION FOR SELF-SUSTAINABLE OFFSHORE MARICULTURE: THE CONCEPTUAL DESIGN

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ABSTRACT

Fish farming has become a blooming industry in the past few decades, especially to countries surrounded by large bodies of water. Offshore mariculture is rapidly developing and dimensions are expected to increase and locations are being moved to areas exposed to more energetic waves and stronger currents. Most fish farms have a large impact on polluting the environment and the species living in oceans; therefore, the idea of sustainable offshore has been introduced. The following project proposal aims at designing a complete automated offshore fish farm with renewable energy source and a durable physical structure. The design is revolved around three self-maintaining energies such as tidal, wind, and solar.

Keywords: Energy; Mariculture; Offshore; Renewable; Solar, Sustainable; Tidal, Wind

1. Introduction

Traditional fish farming takes place near the shore or on land. Offshore fish farming utilise the latest technologies and recycling systems and their designs improve the sustainability, efficiency and clean operations. Until this day, the fish farming industry is facing pressures to become even "greener" as scientists insist that the near-shore fish farming causes a lot of damage that ranges from fish poop pollution which results in outbreak of diseases to destructing mangroves with other wildlife [1].

The offshore fish farm can be a reason of providing a low impact, high sustaining alternative because with farming fish location is in open ocean where the circulation of water and local ecosystems are known to be more robust which will be minimizing the impact on environment, as shown in Fig. 1. The operations of offshore fish farming will be extending the benefits even more, a potential to lower the costs associated with fish farming generally also can make farming further at sea a more economical choice. The world's population by 2050 will reach around 9 billion people which is a 34 percent increase over today as predicted by the UN food and agriculture thus our food supply has to grow even more increasing around 70 percent by 2050. Increased fish farming is able in supplying the protein towards the growth of population at little environmental cost. Fish farms supply half the fish consumed globally as stated by the World Bank. It is known that the world's ocean are now under increasing pressures because of the oil and gas industries being near the coastal cities, a lot of plastics thrown are made of micro pieces which are easy to inject by the marine species in the ecosystem [2].

The offshore fish farming has a multi-use concept which combines the energy and aquaculture production of seafood within the ocean. The interest towards the aquaculture in the oceans has been explored as a standalone activity. Talking about the stability, the production of energy in offshores (i.e. wind turbines and oil platforms) is an attractive feature for many requirement such as mooring cage's attaching points and long lines, mounting feeding, nursery systems and hatchery. Though wanted attributes for the energy and seafood productions requires maximising the pieces of land's benefits is a solution for the adoption of the multi-use concept regarding renewable energy systems, but also from types of installations for example other installations of renewable energy (such as tidal energy) or oil and gas [3].

Figure 1: Offshore fish farming with cages [2]

The characteristics of offshore fish farm sites have greater depths with greater exposure in comparison with the coastal sites. Meaning while dispersing waste products as the start point is high, because of the strong currents also wind effects and a part affected because of greater water depths. Stressing that the hydrodynamic and bottom configuration will play a major role in more exposed areas. Adding to that, the water column with a possibility to be stratified because of temperature or salinity are affecting the sedimentation regime of waste products. There is a difficulty in obtaining information because of high costs of ship, expensive equipment and the planning of aquaculture activities operations thus this information is limited as shown in the figure below [4].

The quality of water at offshore fish farm sites is different from the coastal sites, the display of lower nutrients concentrations and lower biological productions. Because of quick dilutions of nutrients from marine aquaculture, it is not easy in detecting the elevations of nutrients concentrations surrounding fish farms by direct measures. Although some of the coastal sites with the offshore sites can be very productive such as the North Sea and has limitations like the seasonal variations in light rather than nutrients. Which is affecting the fate of the dissolved nutrients by farms. Water quality's other parameters are the toxin's concentration, chemicals and pollutants expected to be at a lower rate at offshore sites and thus very good for farm productions, the release of compounds from farm will have greater effect because of higher sensitivity of these pristine environments [5].

In addition to recent developments in aquaculture, the energy sections have been undergoing significant changes. Establishing offshore fish farms as a sustainable and economically trusted source of energy production has attracted a lot of interest for its potential in optimizing the use of offshore farms alongside other activities. Saying that, considering uses of the renewable energy systems such as wind, tidal and solar during the design phase for the benefits to be

maximised in a sustained way towards the economy from sea. The offshore site has to be modified or adapted in way that it can accommodate other uses without the compromise of functionality and safety. Moving into high energy ocean environment is creating a need for new vessels such as installations, operations, maintenances and decommissions. This will overlap multiple services such as the transport of technicians. Now it is possible for securing the farm with various remote alarms for weather conditions and wave activities. And by confining the farm the farm to specific zones of production activities, it is then possible in avoiding conflicts with maritime traffics [6].

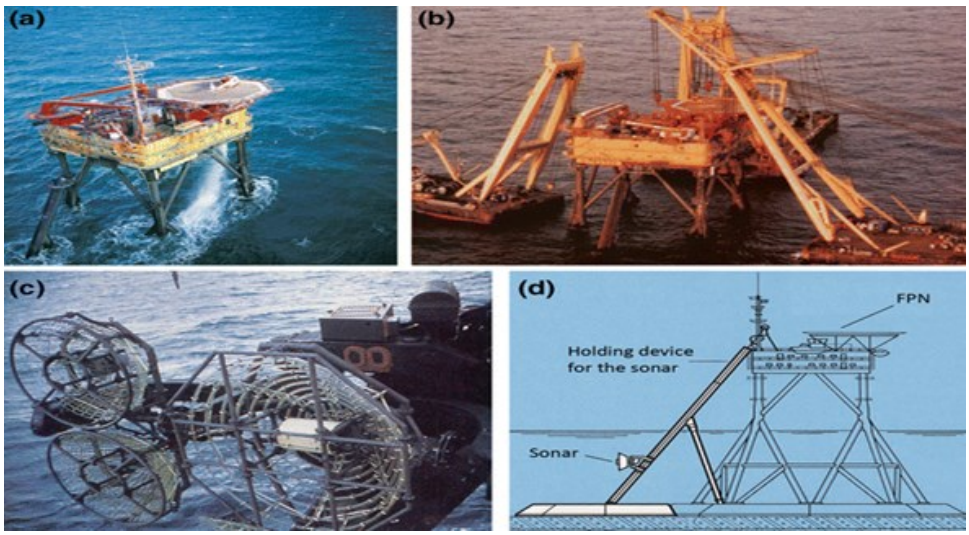

Figure 2: Fish farming applications on platforms [6]

Wind energy has been known as the major renewable source and the fastest in developments for renewable energies, its importance compared with other types of renewable technologies can be for two factors: the resources availability and the maturity of the technologies in terms of cost. These wind farms have experienced growth in the last decade and they consist of wind turbines that are fixed to the sea bottom in water below 50 m by the gravity structure, tripods, etc. Wave energies exist with high energy density a property of important interest in electricity generation, for that reason the wave energy conversions have been proposed such as tidal energy. Tidal energy is another well-known marine renewable energy which can be gathered by tidal stream turbines. In addition, another viable source of renewable energy is the solar energy, nevertheless solar energy highly depends on the weather like wind energy. Until now offshore platform to be developed for the accommodations of solar panels in the harsh ocean environment have one issue which is costly investments on this substructure (fixed or floating) although the light can supply electricity day and night. These types of energies can be essential in the function of the offshore fish farm in terms of the farm's activities whether it is for fisheries or any other activity [7].

2. Design of offshore self-sustainable farm

In general, the offshore farms operating in the open oceans are far enough from the coast that they have an ability in avoiding or minimizing many of the use difficulties that will arise in coastal waters. The waters at offshore are known to be deep and are flushing continuously by ocean currents. Without landforms acting as buffers, renewable energy will be significant. The fish farms have been located in sheltered near shore sites but with increase demand for fish over the recent years the platform can be converted into an offshore fish farm depending on many factors such as waves, winds, storms, sea level rises, biological data and chemical data.

In offshore Deepwater open oceans farms there will be more space, fewer conflicts and strong current in flushing waters from the nets so appropriate fish cages can apply to the design with the ability to be large rather than small, as shown in Fig. 3 [8].

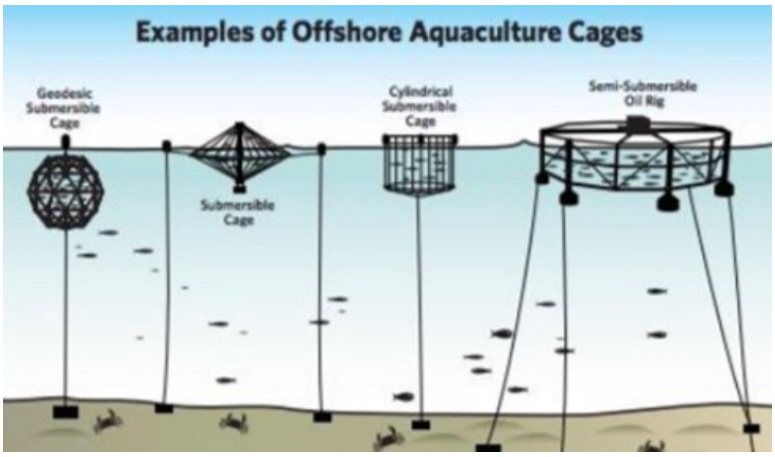

Figure 3: Examples of offshore aquaculture cages [8]

The preliminary design of offshore self-sustainable farm was formulated using the Functional Decomposition Analysis FDA, as shown in Fig. 4 [9].

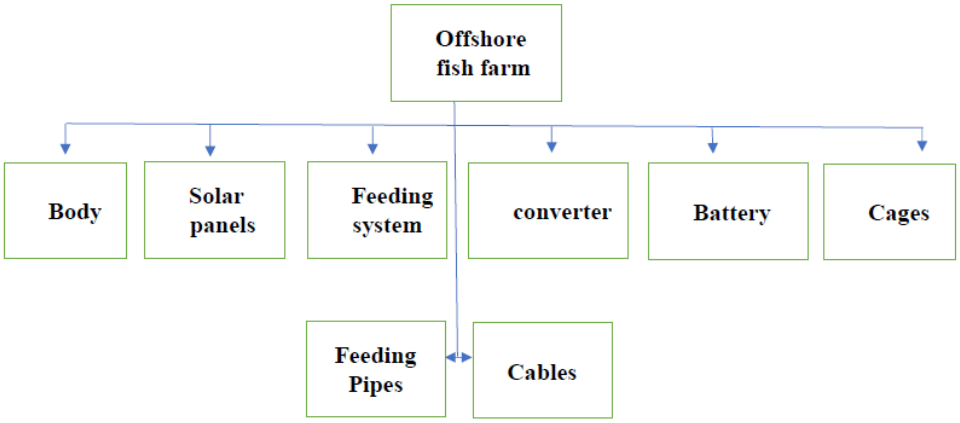

Figure 4: FDA of design of offshore self-sustainable farm

2.1 Design 1

In this alternative (Fig. 5), the two sources of power are the solar cells and the wind turbines. The platform is relatively small in size with poles stretching to the seabed in order for it to stay stationary. There are 4 spherical cages, made from a combination of truss components, which would allow for a high capacity of fish. This design also aims to have plants on the surface (shown in the deeper areas on the platform), which would be used to feed the fish. A power of approximately 14,000 kW is produced through a single turbine and power of 350 Watts per hour for every single solar panel; and 4 of each is present on the platform. The number of cells and turbines is kept low in order to also keep the price low. Here circular cages are used with supports of plastic but no walkway. For that the cages will depend on the boats for maintenance. In feeding the fish the automatic cage does all the work with machine having a capacity up to 100 square meters. Farm's visit are unusual thus decrease the labour costs.

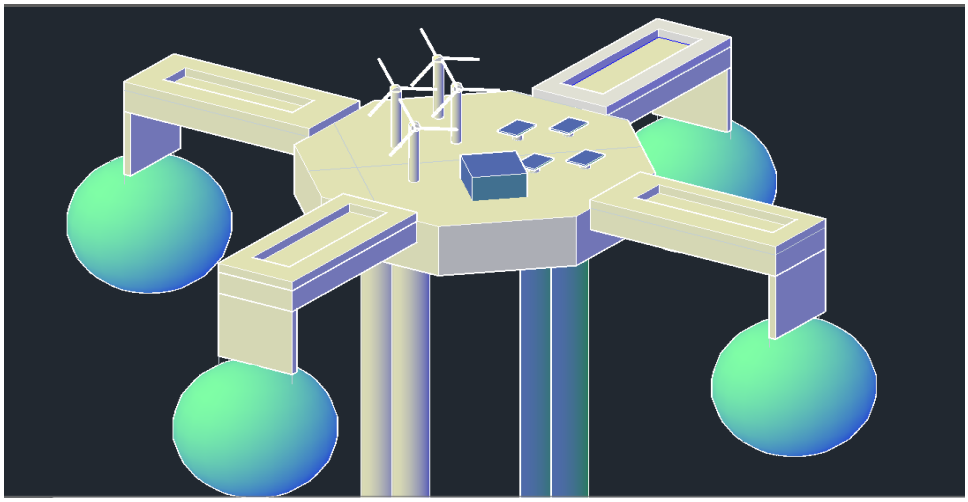

Figure 5: Design 1

2.2 Design 2

The platform consists of three levels at the top (Fig. 6). There are solar panels and turbines to generate enough power for the platform. A power of approximately 14,000 kW is produced through a single turbine, equivalent to 504,000 kW for all turbines on the platform. And power of 350 Watts per hour for every single solar panel, which is approximately 22,344 kW for the total number of panels in the platform. There are 12 fish cages (60 * 60 * 60) that can accommodate for about 9,000 fish, approximately 110,000 fish in the platform. There is a small plantation plant on the second level that produces a sufficient amount of feed to feed the fish (Aquaponics). The platform consists of three levels which can be used to store batteries and generators. The platform is covered with nets of iron instead of stones to reduce the weight of the platform.

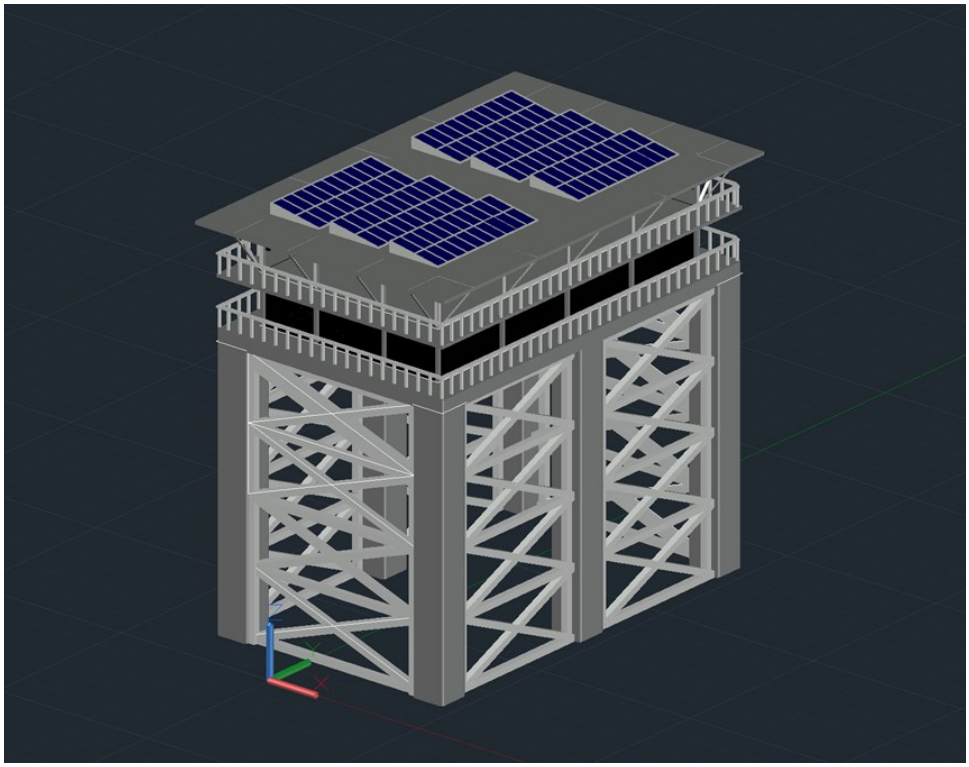

Figure 6: Design 2

2.3 Design 3

This farm is considered different of its kind as it depends on alternative energy and It can analyze water that is used to irrigate crops (Fig. 7). Also, this farm has the ability to store its energy produced from turbines and solar panels and use it to operate the water pump and the feed production machine and this The farm has a zero pollution rate and depends on itself at 85% without human intervention.

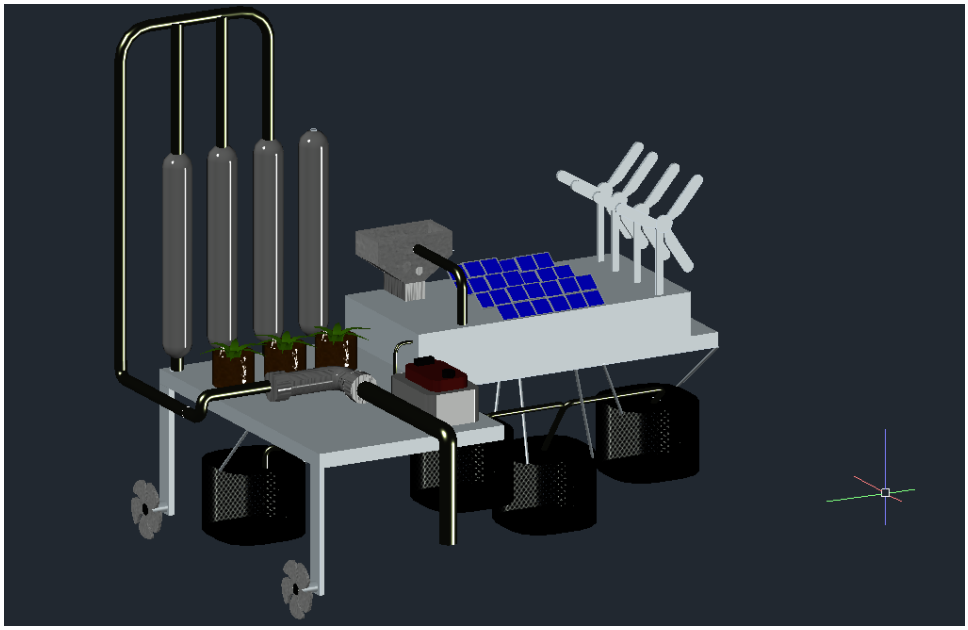

Figure 7: Design 3

2.4 Design 4

The figure below (Fig. 8) shows an offshore fish farm that is supported by three means of renewable energy systems which are wind, solar and tidal energy for the power generations with cables that must be safely secured as shown without compromising them as the power generators depend on them for functioning and protect them from exposure to rocks or sand waves and scour. While the focus on fish will be from the submerged fish cage near the fish farm that is able to capture and hold the fish. The platform will be managed without the need of labours transportation and minimal maintenance while being eco-friendly that is appropriate for mariculture. Being supported by three power generators ensures the long run and lifetime of this fish farm also with the big fish cage that can hold enough fish until a boat is required to land on this fish farm for maintaining as this platform includes boat landing area. No human interaction is required at this location thus this design is cost and time efficient. The mariculture platform will require a stable power supply for remote sensing, communication, and actuation of automated systems, on-board refrigeration. The following are the possible alternatives for power production

- Use of tidal waves to produce energy, this is more reliable compared to wind and solar energy
- Solar panels and maximum power point tracking control devices to ensure efficient conversion of solar to electrical energy
- Wind power generation will use helical wind turbines for the conversion of wind energy to electrical power since the helical turbines are more reliable.

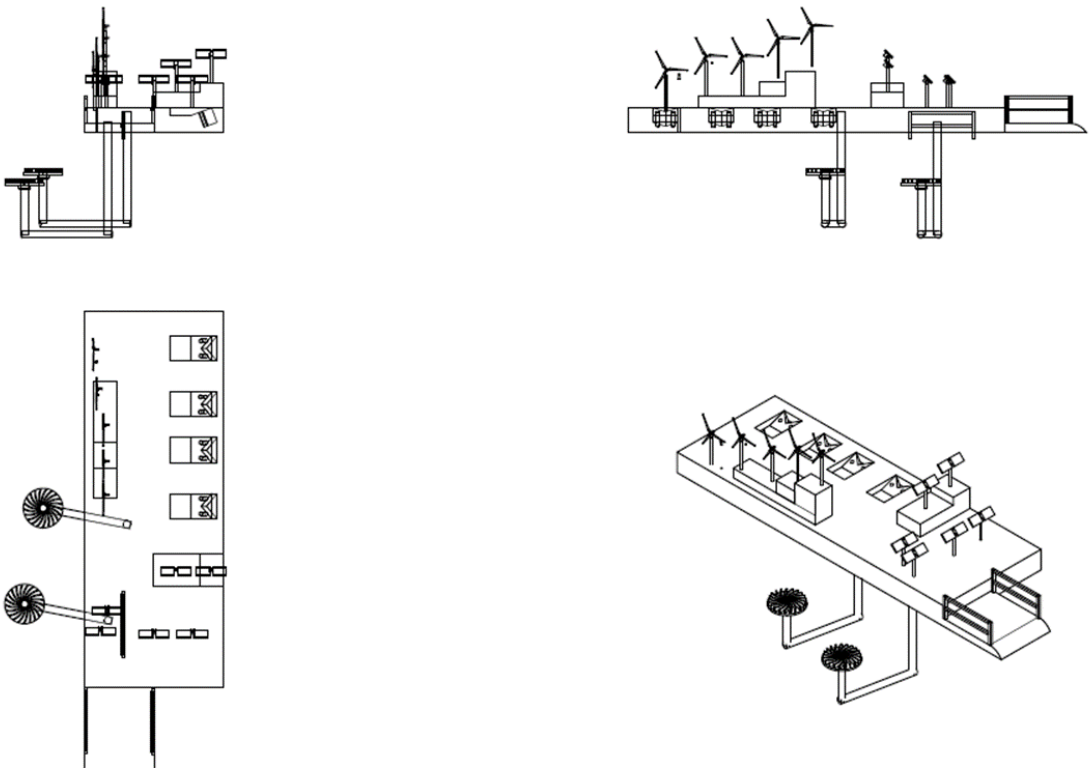

Figure 8: Design 4

2.4 Final Design

The decision matrix showed that alternative Design 4 is the best alternative. Since the design has large spaces, aquaponics could be applied on the platform itself. Aquaponics, whereby plants could be grown on the fish farm (hydroponics) and then be used to feed the fish, and then finally the fish's waste could be used as fertilizer for the plants, and hence the cycle repeats [10]. It has many benefits and could be a very useful way to feed the fish without any human intervention. The final design is shown in Fig. 9.

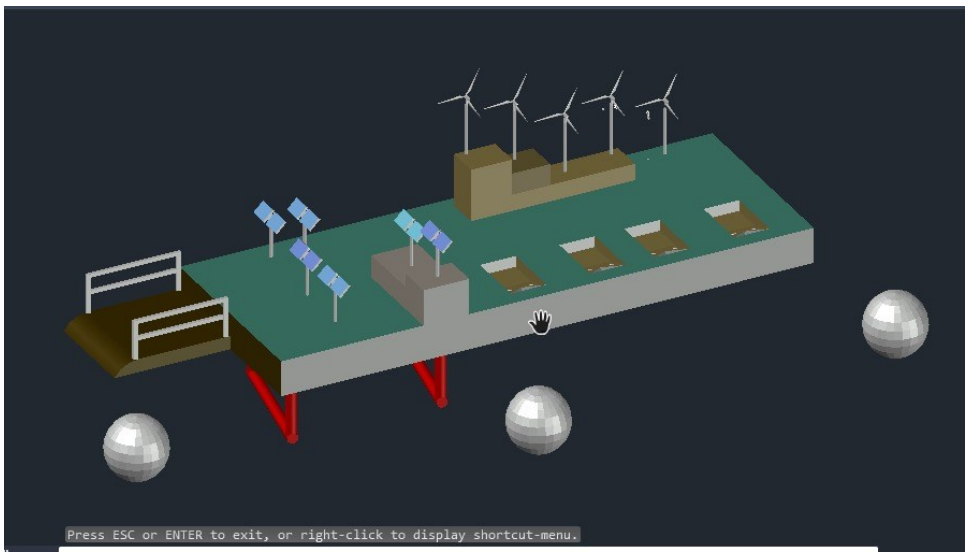

Figure 9: Final Design

3. Conclusion

The design is revolved around three self-maintaining energies such as tidal, wind, and solar. The aim is to reduce costs and increase efficiency thus an assessment of alternatives to assess the best possible design is conducted. In conclusion, the present study would contribute to the success of greener fish farming in the future. In the coming years, multiple mode of aquaculture activities will be available and feasible to be conducted on the platform and better technology will be offered.

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