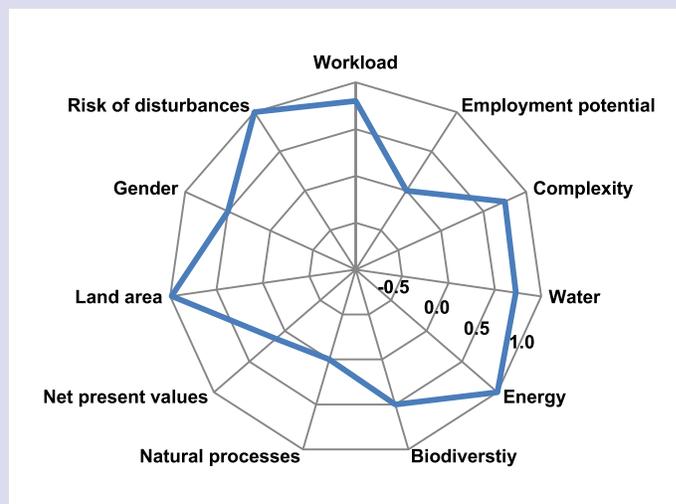


Key facts

- Water hyacinth (*Eichhornia crassipes*), an invasive aquatic species, is used to build rafts for floating vegetable cultivation in flooded areas during the monsoon season.
- Farmers produce seedlings and vegetables on the rafts.
- The decomposing raft is used to increase the soil fertility of arable land during the winter season.
- Water hyacinth contains elements needed for plant nutrition (N, P, K) at concentrations comparable to cow dung¹.
- Crops mature faster on the rafts, making multiple crop cycles possible in one season.
- Creates additional cropping area.

This graph summarizes the results of a sustainability assessment conducted for this technology. The closer the line is to the outer edge of the diagram, the better the technology performs in terms of the particular criterion.



What is a floating vegetable garden?

- Growing vegetables on floating beds is a traditional practice in the floodplains of coastal Bangladesh.
- A floating bed, constructed of water hyacinth and other aquatic plants, is used for production of high-value vegetables during the monsoon season, when much arable land is flooded.
- When the water recedes after the monsoon, the rafts are left to decompose on arable land, thereby adding to soil fertility for production during the winter season.
- The technology has many purposes: farmers gain 'land' for vegetable production during the monsoon flooding, the fertilizing qualities of water hyacinth are exploited in both the monsoon and winter season, and waterways are rid of water hyacinth.
- Floating beds can be used to produce vegetables (for family consumption, with the surplus being marketed) or seedlings (for sale or transplanting to homestead gardens).
- The vegetables produced include eggplant, bitter and wax gourds, pumpkin, cucumber, onions, taro, okra, amaranth and water spinach².
- Because of the fertilizing properties of water hyacinth, crops mature faster on the floating garden beds. Thus, multiple crop cycles are possible in one season on one raft.
- No land is required. Bangladesh floating gardens offer a sustainable farming method in flooded and waterlogged areas, with economic, environmental and social benefits.

Where it works

- The technology is suitable for seasonal or perennial water bodies where climatic conditions allow vegetable production and where construction material for the rafts, like water hyacinth, is available free of cost.
- The water should be still or slow-moving (depth is unimportant).
- In perennial wetlands and permanently waterlogged areas, floating garden cultivation is possible all year long.

Technological aspects

- Farmers in different areas use different materials³ and techniques to construct the rafts, depending on availability of the material, stagnancy of water, onset of monsoon, wetland area possessed by the farmers and the household financial situation.
- Materials needed to construct the raft are bamboo poles, organic matter such as aquatic and other plants and a tool (stick hook) to cut the plants.
- Rafts are usually constructed in the May–July period, depending on local conditions.
- The preparation of rafts depends on the availability and maturity of the hyacinth. Water hyacinth must be fully mature and this takes about 60 days. Rafts made from immature plants are not durable.
- Farmers usually gather the hyacinth and other plant material by themselves. However, due to increased demand, aquatic plants are sometimes purchased from local markets.
- The size of the raft varies, depending on the size of the water

¹ Irfanullah 2005, p. 6.

² See Irfanullah 2005 p. 21, and Saha 2010 p. 146, for a list of summer and winter crops grown on rafts in Bangladesh.

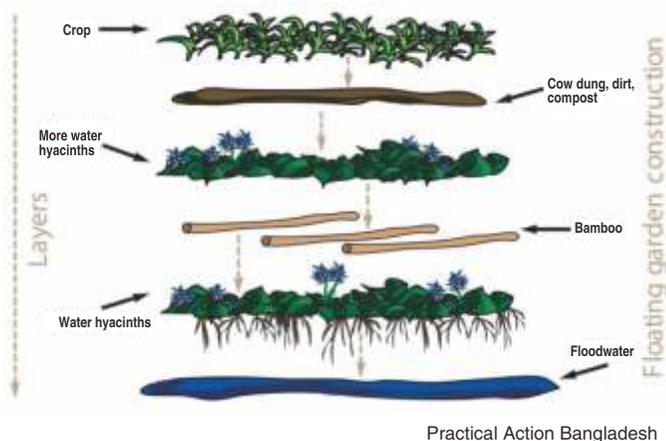
³ Other aquatic plants include Bengal wild rice (*Hygroryza aristata*; Bangla name: durali), water lettuce (*Pistia stratiotes*; Bangla name: topapana), duckweed (*Lemna*, *Spirodela*; Bangla name: khudipana), hydrilla (*Hydrilla verticillata*; Bangla name: kanta shaola), floating ferns (*Salvinia* sp.; Bangla name: idurkanipana) and pink morning glory (*Ipomoea fistulosa*; Bangla name: dholkolmi). Other plant materials include coconut husk and bamboo.

body, plant material and labour available. For the purpose of this document, a floating bed is assumed to be 15 x 2 x 1 m.

- The life cycle of a floating bed is six to eight months: three to six weeks of raft preparation, four months of floating and several months of decomposition.

Constructing the floating garden bed

Figure 1. Technical drawing of floating bed construction



- Place the bamboo poles to form a frame of the desired length and width on a mass of fully mature hyacinth. The plant mass and frame are then placed in shallow water for easier raft construction.
- Standing on the frame and using the stick hook, the farmer pulls the water hyacinth (or other aquatic plant used for the raft construction) from both sides of the frame, flattens it with the feet and weaves it into the raft⁴.
- This process is continued until the desired length and breadth is achieved and repeated until the right thickness of the raft is reached. This first layer acts as the base of the floating bed and maintains its stability, buoyancy and thickness. It is recommended that the height of the decomposed bed be at least 1 m above the water line. This requires several layers of water hyacinth.
- Once the raft's basic structure has been created, the bamboo poles can be pulled out.

Figure 2. Pulling water hyacinths onto the bamboo frame



- The raft is left to rest and decompose for one week.
- The newly constructed raft can be used for cultivation immediately if mulch, soil, compost or cow dung are spread thickly on it.
- If soil is not used (as described in the step above), more water hyacinth (or other aquatic plants) can be added to the top of the raft after seven days. The raft is left to decompose for another 15 to 30 days, depending on local conditions. When the top layer turns black, the raft is ready for vegetable production.
- The decomposing top layer of the raft should always be moist to facilitate the decomposition. Therefore, the raft should be watered if there is no rain during this period.
- If necessary, the raft is then hauled to the desired anchoring spot and can be tethered to bamboo poles.
- The raft should be placed in still water (water depth is unimportant). Water areas that are affected by tides or currents make the raft more vulnerable to erosion and disintegration.
- The vegetables on the floating bed should be protected from predators (especially rats and ducks) with a fence.

Figure 3. A fence protects the floating bed from predators



Two methods for seed germination on floating beds

First method: planting seeds in a ball of aquatic plants

- The ball is made of aquatic plants known to help in rapid seed germination⁵. The plants are collected by the farmer (in one day, one person can collect enough plants to make 2,000 balls), or purchased at the local aquatic plant market. The plants are left to dry in the sun for three to four days.
- To make the ball, the plants are softened with a little water (to prevent breakage when making the ball). This also adds moisture, necessary for seedling growth.
- Several seeds (depending on seed size) are inserted into each ball and covered with a small piece of rotting water hyacinth which acts as a fertilizer.
- The balls are spread out in a shady area to allow germination. No further irrigation is needed.

⁴ For a demonstration of raft construction, watch the video from Helevtas Swiss Intercooperation Bangladesh, https://www.youtube.com/watch?v=AK_qTm2pUsw

⁵ Such as Bengal wild rice (*Hygroryza aristata*; Bengal name: durali), water ferns (*Salvinia* sp; Bengal name: indurkani pana), and alpine pondweed (*Potamogeton alpinus*; Bengal name: dulali lata).

- After about nine days (depending on the species), when the seedlings are 10 cm tall, the balls are transplanted on the floating bed (20 cm of spacing between balls is recommended).

Figure 4. Seedlings, growing from the balls



Second method: Using coconut husks to germinate seeds directly on the floating bed

- In this method, coconut husks are spread on the top layer of the bed with a thickness of about 15-20 cm.
- Seeds are sown within the husk layer (density depends on type of vegetable) and covered with the husk. The husk layer retains moisture and acts as a heat insulator, creating optimum seed germination conditions. Seedlings need irrigation for the first few days. The crop remains on the bed until harvest.

Crop management on the floating garden bed

- Because several crop cycles are possible on one floating bed in one season, crop rotation is practised⁶.
- Weeding is usually not necessary.
- Chemical fertilizer use is discouraged and, usually, not necessary due to the highly fertilizing properties of water hyacinth.
- Some farmers spread ash to protect against insect pests. Chemical insecticides may also be used.
- An integrated pest management strategy has not yet been developed.
- Rats are a major threat, especially if the raft is anchored close to shore. Traps, electric shock, netting and poison are used to deal with the menace.
- Ducks are also a major threat. To guard against both ducks and rats, a fence can be erected around the raft.
- Ants can remove seeds out of the balls before germination. To avoid this, seeds can be pre-soaked in a mixture of either Neem (*Azadirachta indica*) leaf extract and water or mahogany (*Swietenia mahogany*) seed powder and water.
- As the floods recede at the end of the monsoon, the rafts are moved to arable land, broken down and mixed into the soil as an organic fertilizer.

Economic aspects

- Fixed costs are that of the cutting tool and, if necessary, a boat. Most inhabitants of rural flood-prone areas in Bangladesh own these.
- Variable costs are BDT 560 (\$7.05) for buying seeds and bamboo poles, and the time needed for collecting raw material, constructing the bed, crop maintenance and harvesting.
- Farmers do not need to buy chemical fertilizers.
- A floating platform shortens the time needed for crops to mature due to the fertilizing quality of water hyacinth. Thus, two or three crop cycles per bed are common in one season.
- In a recent study, farmers produced leafy vegetables with a seasonal total market value of BDT 1,500 (\$18.89)⁷ from one bed.
- With seedling production, farmers can earn BDT 400-800 (\$5.04 - \$10.08) per seedling cycle, depending on the vegetables they choose⁸.
- Because seedlings grow faster on floating beds, only 20-25 days are needed from seeding to marketing. Thus, farmers can have three to five seedling cycles in one season.
- If market access is easy, seedling production is more lucrative than vegetable production⁹. However, farmers living in areas with limited access to fresh farm produce, prefer to grow vegetables for family food needs.
- Surplus vegetables can either be sold directly in the local market or to a wholesaler. However, without local storage facilities to keep produce fresh, farmers cannot access larger markets.
- Landless farmers can sell the decomposed raft as organic compost.
- Some farmers integrate seedling and vegetable production. The seedlings produced are first transplanted to the home garden. The farmers then begin producing vegetables at home and on the floating bed.

Environmental aspects

- The crop is naturally watered from the water body below the raft through the root system. Some additional irrigation may be necessary early in the seedling stage. No wastewater is produced.
- Chemical pesticides are used to protect the crop from insect pests. This can be a risk for water fauna when the toxic run-off from the applied pesticide enters the water. An integrated pest management strategy is needed.
- Due to water hyacinth's fertilizing properties, no chemical fertilizer is needed.
- There is zero waste as the rafts are recycled back into the soil after use. The use of chemical fertilizer in winter is also reduced.
- No energy is required besides human labour.
- The use of water hyacinth to construct the beds is also an effective way to control this notorious weed which is a breeding ground for mosquitoes, harbours water-borne

⁶ See Irfanullah (2005), p. 46 and Islam (2007), p. 6 for examples of crop rotation in practice.

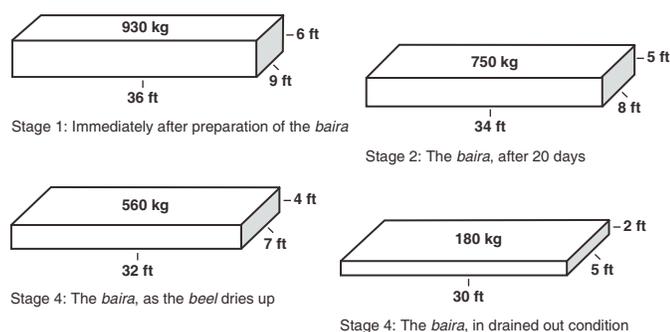
⁷ Hag *et al.* (2004).

⁸ See Irfanullah (2005), p. 39 for a comparison of income generated from different kinds of vegetable seedlings.

⁹ See Irfanullah (2011), p. 27 and Islam (2007), p. 9 for a discussion of problems with market access.

- pathogens and makes water unsuitable for other aquatic organisms. The weed's prolific growth impedes navigation and fishing.
- The construction of one floating bed requires five times the surface area of mature water hyacinth as the bed is large¹⁰. For a standard 15 x 2 x 1 m bed, 150 m² of water hyacinth is needed.
- If the upper layer of the bed is not fully decomposed after the monsoon, it may be used as cooking fuel or piled up around the edge of the homestead to prevent erosion and soil loss.

Figure 5. Changes in dimension and weight of the floating bed (*baira*) over time (beel is the body of water)¹¹



Social aspects

- Land-owning farmers are employed throughout the monsoon season when their arable land is under water. Usually, one or two people per household are employed in floating garden cultivation.
- Because no land is required, floating gardens provide an opportunity to the landless to crop during the monsoon.
- Women are also involved in floating garden cultivation, although more than 50 per cent of the farmers are men. The women often work in teams, cultivating their own rafts as well as providing casual labour to other farmers¹².
- Raw material collection and raft construction takes eight person-days. Crop management and harvesting takes 10 to 13 person-days per crop cycle.
- Other local employment opportunities are created by the increased demand for raft construction material and rafts: people gather aquatic plants or construct rafts for sale. A completed raft sells for BDT 300 (\$3.78).
- The technology helps conserve indigenous knowledge and techniques adapted to flood conditions.

- Local vegetable supply is increased during the monsoon, traditionally a time of vegetable shortage, thereby increasing local nutritional options.

Figure 6. Woman working in floating garden



Issues for replication

- Since floating gardening is highly weather dependent, excessive floods or long dry spells can lead to crop failure¹³.
- The beds may be blown away during big storms.
- Heavy rain can cause waterlogging on the beds, which rots the crop roots.
- Floods can damage the floating beds.
- Floating garden cultivation may attract infestation by insects and rodents.
- Anchoring the floating gardens in common areas can cause social tensions, including domination by socially powerful groups¹⁴.
- The size of the raft, materials used for its construction, type of crop planted and the timing of raft construction and crop production can be adjusted to local conditions.

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References and useful links

Available at: <http://www.satnetasia.org/database>.

¹⁰ Haq *et al.* (2004).

¹¹ Irfanullah (2005).

¹² Islam (2007).

¹³ See Irfanullah (2011a), p. 36f for a discussion of weather and climate issues.

¹⁴ See Islam (2007), p. 10.