Raised fields for lowland farming

Traditional systems of farming on raised fields have been very successful but do they provide promising models for agriculture development too?

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In several places in the tropics e.g. in Indonesia, Mexico and Bolivia, farmers who deal with regularly inundated lowland, salinity affected areas or tidal swamps developed sophisticated integrated farming systems. Balanced water management by systems of ridges and furrows are the basis of these systems. Soil of the furrows is used to create well-drained raised fields for cultivation of a wide diversity of crops and trees. The furrows function as drainage canals and on some places they are used for cultivation of wetland rice and/or for aquaculture. Sediments from floods, organic matter from aquatic plants, soil moisture-nutrient dynamics between ridges and furrows, favourable microclimates induced by water and trees and reduced risk of complete crop failure all contribute to the sustainable success of these relatively high productive systems.

Chinampas in Mexico

Maybe the most famous of these systems are the Chinampas along the border of Lake Texcoco in Mexico which were developed by the Aztec some 2000 years ago. They covered several hundred square kilometres of terrain, part of which is still used for intensive cultivation of vegetables and flowers for the market of Mexico City. New Chinampa beds were -and still are today- built of alternating layers of aquatic weeds, bottom muck and earth packed inside rectangular cane frames. The artificial "islands" thus formed varied in size ranging from 30 to 100 meters in length and 3 to 8 meters in width. Ahuejote trees (Salix bonplandiana) were planted along the banks to provide shade while their roots formed living fences that anchored the beds more securely to the lake bottom. Soil fertility was maintained through regular applications of swamp muck, aquatic plants and manure. A wide variety of crops, ranging from staples such as corn and beans to vegetables and flowers for the market, were mixed with an array of fruit from small trees and bushes. Abundant aquatic life such as fish, salamanders, frogs, turtles, and all kinds of fowl provided valuable sources of protein for the local diet. This self-sustaining system has operated for centuries as one of the most intensive and productive ever devised by man (Chapin1988).

Pre-Inca farming in Bolivia

Recently, archaeologists have discovered near Lake Titicaca (about 3800 m above sea level) the remnants of an extensive complex of ancient raised fields (Waru-Waru) dating back to the very successful Tiahuanaca culture which abruptly ended around 1000 AD. The design of the fields is both obviously simple and surprisingly complex. The ditches provided water in times of drought and the elevated fields protected crops in times of flooding. Among the more complex features is the impermeable layer of clay at the base of the fields. Its purpose seems to have been to keep the salty water of Lake Titicaca from seeping up into the topsoil. By efficiently exposing the ditches to the sun, the water contained gets enough heat during the day to protect the fields from frost damage during the altiplano's bitterly cold nights. Research is now conducted to see whether the ancient farming system could be successful again. Early results have been more than encouraging. On the raised fields, yield of potatoes was 10 metric tons compared to 1- 4 metric tons on the unimproved fields where chemical fertilisers were
used. Yields of grains and vegetables were about 30% higher. And of not less importance, in the extreme dry years of 1982 and 1983 and the extremely wet year of 1985 production on the raised fields was not much effected. This contrary to other places in Bolivia where crop losses were severe (Mullen, 1988).

**Raised fields in Tlaxcala, Mexico**

The raised field system of Tlaxcala which date back to as early as 300 BC are still in use. The fields of Tlaxcala vary in size from 15 to 30 m in width and from 150 to 200 m in length. These long narrow strips are surrounded on all four sides by "zanjas" or drainage canals. The canals’ banks are planted with various tree species, particularly alder (Alnus firmifolia). The canal network serves not only hydrological management, but it also functions as a nutrient catchment system. In Tlaxcala farm nutrient outputs are be compensated for by nutrients from weathering of parent rock and soil, sediments from floods, nutrients from atmospheric deposition, biological nitrogen fixation a.o. by alfalfa (Medicago sativa) and alder. The typical raised field plot has a strip of alfalfa, approximately three meters wide, running between half to full length of the field, depending on how many animals the farmer needs to feed. The secret of the sustained fertility however, seems to be connected to a great extent with the robust aquatic vegetation which takes up nutrients from the water and sediments. Much of this vegetation dies back in the fall and sinks to the bottom of the canal. Farmers undertake the arduous task of cleaning up to one meter in depth of muck, sediments and aquatic vegetation out of the canals every one to four years. It has been calculated that in this way approximately 1080 kg/ha N, as well as 120 kg/ha K and 9.7 kg/ha P are spread on the raised fields (Creus and Gliessman 1991).

**Surjan in Indonesia**

The Surjan farming system is a traditional farming system developed in Central Java, Indonesia in the beginning of this century which is widely used in submerged, salinity affected areas and tidal swamps. It consists of parallel ridges and furrows. The size of the ridges and furrows vary greatly from place to place and may be from two to fifteen meters wide. The size of the furrow is much more important. It determines the hydrological function of the Surjan. In places where water inundation can be expected to last long the size of the furrow is increased. Farmers usually construct the Surjan gradually which has a technical reason. Continuous digging and piling expose relatively less weathered subsoil materials which is a poor substrate for growing plants. By allowing the soil enough time to weather fertility is built up. In areas with cat clay or pyrite layers or where organic matter may shrink irreversibly special problems may occur. During the rainy seasons excessive water on the ridges will be drained to the furrow. Crops which do not stand water logging such as maize, soybean, groundnut, cassava and different vegetables are grown on the ridges whereas the furrows are used for growing wetland rice. If the farmer predicts a low risk of water shortage for rice in the following dry season, a second rice crop will be grown. Otherwise upland annuals such as soybeans will be planted. Crops on the ridges can be provided with supplementary watering which makes year round production possible. Farmers usually make field wells along the border of the ridges. In certain places ridges are used for tree crops like coconut, citrus, papaya, and also jack fruit, clove, coffee, etc. In this case, the ridges are frequently made individually for each tree. The Surjan system increases the cropping index by an average of 227.5% as compared to non-Surjan. Surjan proves to be an advantage to improve soil fertility too. Nutrients enter the ridges from the furrow by capillary rise of soil
water or from the irrigation water. High salinity and acidity of the soil of the ridges is washed away.

Comparative economic studies are few. According to one study for the year 1976/77 Surjan farmers obtained an income 2.2 times higher than non-Surjan farmers. The level of investment had increased with 134%. Due to higher total production per year per unit of land and to diversification, more inputs were purchased. Although return to capital decreased by 6.7 to 4.4 (-52%) it remained a sufficient high level. Benefit/cost ratio remained more or less equal, hired labour increased by about 30% and return to labour increased by 64% indicating that farmers managed to use their family labour more efficiently throughout the year. In Kalimantan, in tidal areas, early settlers of Java (from the 1930s onwards) started spontaneous establishment of the Surjan systems. Sometimes variations of the Java Surjan were made by making a second higher raised bed on the ridge, giving them a stupa-like shape. Here, the farming system developed from wet rice monoculture into a diversified system of wet rice, dryland crops and fish culture, in which the proportion of rice is gradually reduced. The relative price ratio of rice and coconuts influences the rate in which succession takes place. The optimal mix of raised and sunken beds depends on technical factors as well as on farmers' resources and market conditions (Sudaryono and Meindertsma 1990).

Development of raised fields in India

The production of wet season rice in the coastal region of West Bengal has to cope with many problems such as high risk due to erratic rainfall, salinity of soil and groundwater, lack of irrigation and drainage facilities and with occasional flooding. Based on farmers' local wisdom, technology for improved land-shaping, irrigation and drainage has been developed and refined through a participatory programme in which Ramakrishna Mission worked closely together with farmers. A tank for storage of rain and flood water with a depth of about 2.5 m is dug out in about 1/5th of the area of a plot of 0.5 to 1.0 acre. The adjoining area is elevated by 30-50 cm with the dug out soil. The well-drained elevated area is at an early time available for a second and third crop of vegetables. The stored water is used for irrigation during post monsoon and for fish culture. Some green manure/fodder can be grown and the peripheral embankment is used for growing tree crops. Though 0.10 acre is utilised for the tank, the remaining 0.40 acre is cultivated with HYV rice and the gross area under cultivation is more than 1 acre due to multiple cropping instead of monocropping as practised earlier. Farmers' income increased with 364% from Rs.695/= to Rs.3,915/= (Rs.300/= from fish farming included, US$ 1 = Rs.18 approx.). Employment increased 363% from 35 to 127 man days. Cropping intensity increased to 200% or more. Labour investment to dig the tank involves about 140 man days to be provided mainly from the farm family. The land-shaping model has created considerable impact through improvement of rice productivity creating opportunities for multiple cropping, vegetables and tree crops and fish culture, while involving farm women in vegetable production, improving family nutrition and employment potential. This model can be considered as a promising approach for sustainable development (Das and Mandal 1990).

The seduction of models

The above cases of raised field agriculture clearly show the potential of these systems. Many development workers and scientists get thrilled by their attractiveness, but what are their real prospects for adoption in other places? Several attempts have been made to transplant Chinampas to other places e.g. in Mexico. However, all these attempts failed. The main
reason for these failures was that a model was transplanted without considering the specific ecological, social, economic and political context in which the farmers lived. In pre-Hispanic times, the Chinampa system thrived in the Valley of Mexico because the environmental, social, economic and political circumstances were favourable. It developed naturally over a period of centuries as an adaptive response by the people of the Valley of Mexico to meet their particular needs. Although the Chinampa system has survived into the 20th century, conditions are becoming so overwhelmingly adverse that the model will soon exist only in history books. Perhaps the time of the Chinampa -like that of the steam engine- has passed. Yet the myth lives in the literature with remarkable vigour. The Chinampa model, after years of promotion in journals, has managed to break free to take a life of its own. But the Chinampa case is not an exception. Especially in the field of ecodevelopment, perhaps because of the desperate urgency accompanying the search for valid models, such apparently promising models occur regularly. Considerable amounts of time and money are wasted when we become blinded by the beauty of a conceptual model and lose our bearings, mistaking it for reality itself (Chapin 1988).

Feasibility of raised field agriculture

The case of the Chinampa makes clear that the social, economic and political conditions for complex, labour intensive and often subsistence oriented agriculture probably in many places are not at all favourable. This however does not mean that integrated agriculture is not feasible at all. The dynamics of the Surjan system in Indonesia, which is now also being promoted by IRRI and IITA (Saumon 1990) and the development of raised field systems in West Bengal indicate the possibility that integrated systems such as raised field agriculture can be developed from within the system. This, however, asks for an integrated approach in which farmers, scientists, bankers as well as policy makers are involved not only to develop new technologies in a participatory way but also to create a favourable social, economic and political context in which such systems can flourish.

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