Technical Note

Supporting and promoting flood-based farming systems

Spate Irrigation Network Foundation

PRACTICA FOUNDATION

META META

Rainwater for food security

Contents

Abbreviations

FBFS	Flood-Based Farming Systems
SSA	Sub-Saharan Africa
FCDS	Flood Control and Drainage Systems
HP	Horse Power
RPM	Revolutions per Minute

Introduction

Agriculture is often classified as 'rain fed' or 'irrigated'. This however leaves a large gap in the middle. There are several agricultural water systems that fall into this classification: the so-called Flood Based Farming Systems (FBFS). One example are the spate irrigation system that use the short terms floods in ephemeral rivers (wadis). Another example is the cultivation in flood plains on receding or rising floods (or on both ((Harlan and Pasquereau, 1969)), The FBFS lack the perennial water sources, common to irrigated schemes, and do not exclusively depend on rainfall, common to rain fed systems. They are an important third category.

FBFS are extensive throughout Africa, the Middle East and South and South-East Asia. It is estimated that FBFS cover 30 million hectares in sub-Saharan Africa alone. By this measure alone they constitute on of the largest agricultural potentials. This is underlined by the many large-scale agricultural investments that are now located in floodplain areas in sub-Saharan Africa (SSA) – such as in Gambela in Ethiopia or the Tana Delta in Kenya. Several of these projects are controversial as they interfere with the livelihoods of the local population and the ecosystems that sustain them.

The topic of the technical note is the potential for smallholders to better utilize the flood plain systems[1] – in farming, rangeland or aquaculture. Floodplains in SSA sometimes host extensive populations, see box 1. They are often remote areas with little infrastructure or basic services – isolated for part of the year. Yet the fact that floods are a source of nutrients and water constitutes an environment with a high potential for a number of productive systems, which can contribute significantly to local and regional economies.

Box 1: Floodplains and livelihoods

Floodplains have been inhabited since long ago, e.g. 1600 years in the Mekong delta (Fox and Ledger Wood, 1999). Inundation canals formed the cradle of Egypt's civilization. Floodplains are often very extensive: large part of Bangladesh falls in this category. The fertile soils, availability of water and flat terrain offer optimal conditions for different productive uses sustaining large populations.

In sub-Saharan Africa there are a number of large floodplains which host big populations, including the Hadejia-Nguru wetland in Nigeria with 1.5 million inhabitants (Hollis et al., 1993); the Sudd wetland in South Sudan with more than one million; Lake Chilwa in Malawi one million people; and the Inner Niger Delta in Mali with a population of 1 million (Zwarts et al., 2005). These populations are basically sustained by agriculture, fisheries and grazing activities. The population sustained by flood plain in sub-Saharan Africa are however nowhere near similar populations in the Asian systems. The production systems in SSA are less intricate - in terms of water management or multifunctional use. This however signifies the large potential.

Floodplains serve as an ecological base for diverse flora and fauna species. The interaction between vegetation, flooding pattern, water table, local climate needs to be understood and taken into account. F are used as agro-ecological systems. It is therefore necessary to develop sustainable production techniques ranging from agriculture and pastoralism to fishing, aquaculture and forestry, if there use is intensified for small holders.

FBFS have often been overlooked, if not misunderstood, by decision makers, agricultural experts and professionals. A good example is the construction of large-scale surface water storage that more often than not does not taken into account the presence of downstream flood based livelihood. Literature related to the topic is relatively sparse. This technical note intends to bring forward the concept of floodplains as valuable areas of ecological, agricultural and economic importance. Moreover it may serve as guideline for practitioners on a range of techniques and technologies to be applied in floodplains.

[1] Spate irrigation systems another important FBFS are extensively described in the material that is found at www.spate-irrigation.org

Key issues/questions

FBFS are multi-functional systems by nature. FBFS have a wide scope of productive systems, practices and techniques. Given that floodplains bear a great potential for agricultural production, the key issue lies on **how to make better use of floodplains and which techniques and technologies are more suitable**.

Another underlying question is **how to implement these techniques and technologies in different settings and floodplain types**. Floodplains vary in nature.: they may be lacustrine, riverine or coastal. What are the key implementers? What is the role of regional and national institutions? How can research contribute? How FBFS can be combined with wetlands protection? How can dam construction benefit, lest not undermine, downstream floodplain areas?

Box 2: Dam construction in African floodplains - African nations have been and are currently investing in major hydropower projects in order to meet growing energy demands. As a consequence floodplains close to dams are affected. Flooded areas, changing flood periods, fish migration, increase in water borne diseases and malaria are some of the side effects affecting floodplain areas. However, those threats can be turned into an opportunity if different uses are coordinated. Dams can regulate base flows, release floods when suitable (e.g. when rainfalls are late or insufficient), stagnate flooding periods (when flooding and drainage is too fast) and increase water flows over extended drought periods. Some of examples of integration of flood releases in floodplains are in Senegal (IUCN 2002) , South Africa (Mwaka et al. .2003), Cameroon (Loth 2004) and Nigeria (Acreman et al. 2000). There is much to learn and document practice and experience in this regard. Proper integration of infrastructure projects with agro-ecosystems is necessary if the above opportunities are to be met.

The last issue to stress is how FBFS, as productive systems, can help stimulate local economies through value chain creation related to early food processing and marketing of goods. This is a step beyond agricultural systems yet equally important for food security and safety purposes.

Suggestions for improvements

Floodplains have both a great ecological value and a high potential for productive use. In many African floodplains the productivity can be increased drastically by improving the following aspects:

1. Groundwater use
2. Field water management
3. Adapted crop agronomy
4. Multiple use.

A balanced approach in those fields can both increase productivity and diversify the production systems, which is beneficial to both food security and ecological sustainability.

(1) Groundwater use

While in the dry season floodplains may appear to be dry areas, the groundwater is often found at shallow depth. Using this shallow groundwater for irrigation in between flooding periods can extend the production system by one or two cropping cycles a year. Moreover, it allows for the cultivation of vegetables and other high value crops that cannot be grown on residual moisture only.

The fact that floodplains consist of alluvial soils (e.g. clay, sand, gravel) that are relatively easy to penetrate increases the accessibility of shallow groundwater even further. There is a number of ways to access shallow groundwater; i.e. by hand-dug wells, dug-out ponds or shallow tube wells. Particular where there are layers of sand or gravel reliable and productive shallow tubewells can be developed (see next).

Box 2: Manual drilling – a promising low cost technology

Conventionally boreholes are drilled using large machine rigs, which cannot access remote areas and are far too expensive for smallholder farmers. Manual drilling is an innovative technique to drill wells with human labour only. Depending on the soil formation and groundwater level, shallow wells drilled in this way are between 10 and 30 metres deep. This makes it possible to seal and protect the wells from flooding pollutions. The technology can be fabricated and operated by local enterprises using affordable and widely available materials, which decreases the cost significantly. The water lifting technologies depend on the required water flow , depth of the groundwater table and finances.

There are a range of manual drilling techniques. Hand Augering: uses a rotating auger that is lifted and emptied once filled with soil Sludging (Figure 2): uses a manual vacuum to circulate water and bring the soil up to the surface; Jetting: uses an engine pump to create downwards water pressure; and Percussion uses a heavy object to crush hard formations and a bailer to bring up the cuttings

Figure 2 Hand dug-well in equipped with lifting mechanism, Yemen (source Oxfam UK).

Standard hand dug wells

This is a common technique whereby circular or rectangular wells are dug manually. Its diameter is normally about one meter, but can be much larger in some cases. Hand-dug wells are a good option for clay soils, since its large diameter allows water to seep into the well while pumping. Advantages: easy to construct, cheap, under normal conditions water is sufficiently recharged

Disadvantages: collapses after flooding, siltation problems, require relatively large areas, risk for children and animals to fall into

Lined hand dug wells:

Hand dug wells can be lined with stones, wood or other materials to prevent them from collapsing.

- Advantages - modification to prevent collapsing of wells. In principle, more resilient to floods.
- Disadvantages - expensive, recharge by seepage is diminished and stones for lining can be difficult to obtain in floodplains.

Figure 1 Manual drilling using simple sludging method - Fogera floodplain Ethiopia (source MetaMeta)

Shallow tube wells

Shallow tube wells consist of a 2 – 5 "borehole lined with a PVC casing and filter screen. Boreholes are generally deeper than hand-dug wells as they tap water from an aquifer, i.e. a sandy or gravel layer below the static groundwater level. Water can be extracted by a variety of manual and mechanised pumps. Shallow tube wells can be completed by a concrete apron and capping to protect it from the flood.

- Advantages - resistant to collapse after flood events, reduced surface is required, potentially high water yields, low maintenance required, no siltation issues
- Disadvantages – a shallow aquifer is required, manual drilling is complicated in compacted and or rocky layers, cost is higher than standard hand-dug wells, specific skills and equipment required for its construction

Joint hand dug-well and borehole

There is an option to combine hand-dug wells with shallow tube wells. The first 4-5 metres are dug manually as a conventional hand dug well. Thereafter a borehole is drilled at the bottom of the hand dug well. In this way there is an increase of 4-5 metres head as the pump can be place at the bottom of the hand dug well. Siltation and collapsing of hand dug well are disadvantages to this method.

Dug-out ponds

This technique is popular in West Africa, Ghana in particular. Dug-out ponds are large shallow ponds dug (normally by excavator) in river banks and depressed areas of floodplains. They require large areas as they are recharged by seepage. Channels dug from river streams are another recharge mechanism, basically conducting run-off to ponds. If topography allows it, water is distributed to irrigated fields by gravity. In case plots are above the dug-out pond, water is pumped using motor pumps.

During the dry season water from dug-out ponds is also used for animal watering, aquaculture and/or domestic water demands. Government authorities and/or agencies are normally involved in their construction. Management of dug-out is done either by irrigation users (which can be individuals or communities) or in the absence of irrigation, fishermen take over management roles. Maintenance activities involve embankment conservation in order to prevent collapsing.

Mapping groundwater potential zones in floodplains

Shallow ground water is a resource that can be easily accessed and exploited in floodplains. Rainfall and flood flows recharge shallow ground water tables by surface runoff, percolation and seepage. The ground water table (phreatic level) can be found in the first 25 meters. However groundwater development across much of sub-Saharan Africa is constrained by a lack of knowledge on the suitability of aquifers for borehole construction.

Mapping groundwater potential zones is essential for planning the location of new abstraction wells to meet the increasing demand for water. The occurrence, distribution, and movement of groundwater mainly depend upon the geological and hydro-geomorphological features of the area. Mapping shallow groundwater resources is different from mapping deep groundwater. A detailed study of groundwater occurrences can be made by surface and subsurface investigation methods. The use of remotely sensed data along with Geographic Information System (GIS) is well suited, and it can be combined with the data generated from conventional and ground measurement systems (Gumma & Pavelic 2012).

In Ethiopia, there are encouraging figures coming from groundwater mapping considering shallow ground water. A total of 38 million hectares is the estimated potential area for Ethiopia. This figure can be divided in different potential areas:

- 15 million hectares of extensive regoliths ideal for mechanically drilled wells and hand dug wells.
- 17 million hectares of alluvial and lacustrine deposits appropriate for manual drilling and hand dug well development.
- 3 million hectares of riverine and lacustrine floodplains suitable for shallow tube wells and lined hand dug wells.
- 3 million hectares compromising the periphery of seasonal wadis, best accessed by a combination of sand dams and subsurface dams or flood water spreading and tube wells or dug wells.

The prospect for shallow groundwater development in Ethiopia is illustrated in the map below.

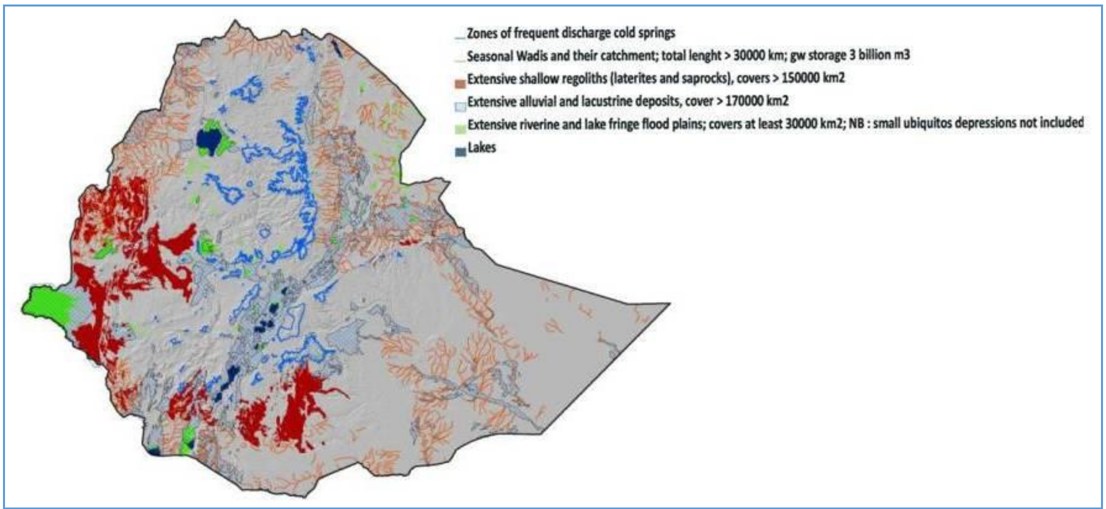

Figure 3: Mapping shallow groundwater for Multiple Use Systems

Mozambique is a country with vast floodplains and its population is predominantly engaged in smallholder agriculture. A study based on literature research, mapping and a field assessment has shown a large potential for tube wells and low-cost pumps to increase the productivity in floodplains. Table 1 provides an overview of the technical, socio-economic and overall potential for flood wells.

	Technical suitability	Socio-economic suitability	Potential for flood wells
Lower Zambezi			
Riverine zone	High	High	High
Sofala plains	High	Low	Low
Zambezia plains	High	High	High
Coastal zone	Medium	Low	Low
Lower limpopo			
Chokwe	High	Low	Low
Guija	High	High	High
XaiXai	Medium	Medium	Medium
Inharrime			
Inharrime plains	High	Low	Low
Pungwe	High	Low	Low
Save	High	Medium	Medium
Incomati	High	High	High

Table 1: Potential for tube wells in flood plains of Mozambique

Pumping technologies

As floodplains are vast and sometimes remotely located, electricity is seldom available. Furthermore it is desirable to use pumps that can be installed and moved easily, to prevent the pumps from being flooded or stolen (in general farmers do not live in the floodplains) Therefore treadle pumps and a range of motor pumps are recommended.

Figure 4 Treadle pump Source: PRACTICA

Rope pumps

Rope pumps can lift water up to 35 metres depth. Its construction and maintenance cost is low. The main disadvantage is that the flow is relatively low for irrigation purposes: water delivery ranges between 0.17 L/s at 35 metres depth and 0.67 L/s at 10 metres depth (Olley, 2008). Furthermore it takes time to install the pump, making it unsuitable to take home daily.

Treadle pumps

Introduced as a low cost technology for irrigated agriculture, its use has been handicapped by the arrival of motor pumps. It uses treadles serving as levers to pump the water up. Like all suction pumps, its suction depth is maximum seven meters. Treadle pumps require little maintenance. The total dynamic head is of 8 or 14m, depending on the type. Water delivery is 1.4 L/s at 4 metres depth (Olley, 2008). The maximum irrigated area by one treadle pump is on average 0.26 ha (Abric et al., 2011).

Motor pumps

Motorised suction pumps are the most popular pumping technology for small scale irrigation in floodplains, since they are physically less demanding, widely available and easy to install

The African market knows a large range of diesel pumps between 2.5 and 5 hp. The suction depth is 8 m maximum, the total dynamic head is around 20 – 30m. To reach groundwater that is situated deeper, the pumps can be installed inside a large dug hole.

The models from 3.5 – 5 hp can be used to irrigate 1-2 ha, which largely exceeds the average irrigated plot size cultivated by smallholder farmers. These pumps are also difficult to transport and know an excessive fuel consumption if used for small fields only. Models from 2.5 – 3.5 hp are notably lighter, though still exceeding 50 kg. These pumps can be used to irrigate fields of 0.5 – 1 ha (Abric et al., 2011). Since most smallholder farmers have smaller fields, they tend to run the pumps on a low rate that is not fuel efficient.

A recommended alternative is the use of Chinese micro pump-sets of 1.5 – 2.5 hp. Its flow of about 3 L/s can be handled by smallholder farmers to irrigate fields of around 0.5 ha. Fuel consumption is more efficient and with a weight of 10 kg farmers can carry them home daily.

Figure 5 Chinese Micro pump-set Source: PRACTICA

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(2) Field water management

Field Water management in floodplains is crucial to maximize productivity.

Rainfall is the main factor affecting flooding patterns. Yet, land cover is another factor that may cause alteration of flood rising and drainage. The lack of vegetation cover in floodplains is believed to increase the speed of flood rising and drainage (Hollis et al., 1993). At river basin level, interventions as dam construction, made to regulate flooding patterns shall take into account land use and other anthropogenic factors in order to preserve flooding dynamics.

Flood delaying measures, dikes and soil bunds – In order to protect fields from early unpredicted floods, bunds and small dykes can be constructed. This is especially relevant where farmers have sown flood rising rice varieties. Dykes can be equipped with wooden sluice gates so as to regulate flood inflow. Alike, bunds may be laid to conduct flood flows to desired areas where first floods are welcomed.

Flood staggering and retention measures - At plot level, farmers are advised to build soil bunds to help retain receding floods. This should be done before floods. When the water level drops, soil bunds retain water. Farmers can drain water using small incisions in bunds. At floodplain level, large soils barriers are sometimes used to retain water or block livestock to enter the floodplain (e.g. Okavango delta). Similarly, dikes have been used in countries like Cambodia, Bangladesh or the Netherlands (both in delta regions) for centuries. In the case of Bangladesh, a sophisticated system of drains, dikes and gates help stagger and control flood recession, also known as flood control and drainage systems (FCDS, Wester & Bron 1998). Examples of alternative flood retention methods can be found in Thailand – known as “monkey ponds”. These structures are ponds which get filled by rising floods. After floods recede ponds are used to supply water to surrounding fields, either by gravity when these are lower, or higher using pumping systems.

Controlled drainage – Drainage systems are equally important when it comes to controlling floods. As floods are difficult to predict in time and intensity, it is advisable to optimize its benefits through adequate drainage systems. When floods are too intense, water shall be drained efficiently, to prevent for damage to farmlands and flood control structures. When floods are insufficient, flood water must be retained as long as possible. Drainage ditches are commonly used to channel away floods. They also help to evacuate water in saturated soils.

Reuse of flood water - field to field water delivery. Field to field water delivery is a common practice in irrigation systems – especially in South and South-East Asia. Water used by land holders upstream is released when water demands are met to downstream users. In this way downstream users can use the same water. However this system needs careful land levelling and common agreement on irrigation turns among water users. It is possible to combine shallow ponds with this type of irrigation delivery. Ponds can be located either at upper higher fields or at the bottom ones.

Figure 6 Field to field water delivery in Laos - Note lower fields are used as ponds (source MetaMeta)

Adapted crop agronomy

Crop agronomy of FBFS differs from flood rising, flood recession and dry season conditions.

Flood rising varieties – Rice varieties such as *Oryza glaberrima* (African rice), *Oryza longstaminata* (endemic to most of SSA), *Oryza rufipogon* and *Oryza Barthii* (or African wild rice) are suitable to cultivate under rising flood conditions (also known as deepwater rice). Floating rice varieties can grow up to 6 metres long, with a growing and maturation period between 150 and 270 days. Rice seeds are broadcasted in fields and require a germination and emergence of at least a month prior to flood arrival. One of the measures used by farmers is found in the Nguru flooplain build soil bunds to protect fields and let rice grow up to 12 cm (critical height). Yield ranges between 0.5 and 1 ton per ha (DeDatta, 1981).

Figure 7 Local villager poling through a flooded field of flood-rising rice with a load of fodder (Oryza rufipogon) to feed livestock, Tonle Sap Floodplain, Cambodia

Alternatively some grassland varieties are tolerant to flooding conditions. *Echinochloa stagnina* also known as Bourgou or hippo grass is grown over extended areas in SSA, in the Niger Inner Delta floodplain for instance. It seeds are used for food and beverage production. *Vossia cuspidata,* is a grass with great potential for pasture during flooding periods as well as the dry season with spontaneous shoot emergence. Other flood resistant varieties common in floodpalins are *Phragmites australis and Phragmites comunis* (used for food)*; Cyperus papyrus* (food and paper production)*, Typha domingensis* (healing properties).

Flood recession varieties – Flood recession is agriculture is based on using residual moisture and fertile sediment left after floods. Therefore crop varieties suitable for flood-recession agriculture must tolerate semi-saturated soils at early stages and high ground water tables. Crop selection may vary according to soil properties and flood conditions, medium textures are suitable for Maize (*Zea mays*), Sorghum (*Sorghum bicolor*, *Sorghum* spp.), Millet species (*e.g. Pennisetum glaucum*) and Wheat (*Triticum* spp.) while more impermeable soils are optimal for flood recession rice. As an example, maize is normally cropped on high parts of floodplains as it does not support water logging conditions. In addition, it is preferable that flood recession crops tolerate high temperatures and drought conditions. Pulses such as chickpea (*Cicer arietinum*), cowpea (*Vigna unguiculata*) and lentil (*Lens culinari* or *Lens esculenta*) are also grown under flood recession conditions.

Pulses require little crop maintenance, they fix rich nutrients in soils and render grains with high protein and calorie content.

The average time span for wheat, maize and sorghum is between 120 and 150 days. The rainy season in northern hemisphere floodplains normally ends toward September. Therefore flood recession crops are likely to be harvested towards February or March. Thus there is chance to sow a third crop (with a time span of about three months) before the floods or otherwise leave the land fallow.

Inter-flooding varieties – Crop varieties under this group are dry season crops. Thus inter-flooding varities can be sown right after floods recede or after flood recession crops are harvested. In some floodplains varieties of *Cucubita pepo* (Pumpkin *Curcubita pepo* var. *pepo*; Zucchini *Curcubita pepo* var. *cylindrica*) are sown after floods. The cropping period for these varieties relatively long ranging between 5 and 7 months, thus will only allow to have two cropping seasons per year. Nevertheless these species tolerate well saturated soils and heavy rains and can be combined in the same plot with maize, beans or vegetables for instance.

Sweet potato (*Ipomea batatas)* is known to be grown in SSA floodplains (e.g. Nguru flooplain) after flood recession crops in low lying fields during the dry season (4 to 5 months crop duration). As a general rule tuberous species do not tolerate well saturated soils. Therefore sandy and well drained soils within floodplains are the most suitable locations. Potato (*Solanum tuberosum*) and sweet potato are crops with high yield return, provided high production costs and adequate pest and disease control (120 – 150 days crop duration). Both crops can be grown either as rain-fed or as irrigated crops.

Pulses such as Lentil and chickpea or staple crops like Sorghum can be considered as inter-flooding varieties. Flooding intensity and duration may drive farmers to grow these crops in the dry season. An example of this can be found in the Fogera floodplain in Amhara region, Ethiopia. After cropping flood recession rice, farmers sow chickpeas as dry season, rain-fed crop.

Vegetables such as Onion (*Allium cepa*), Garlic (*Allium sativum*), Tomato (*Lycopersicum esculentum*), Pepper (*Capsicum annum*) or Cabagge (*Brassica oleracea* var. *capitata*) are common cash crops. Floodplain agriculture has been widely used for staple crop production. However the potential for commercial agriculture through cash crop production is large. Wherever water availability for irrigation is assured (by use of shallow ground water resources for instance) and farming skills are well developed, there is great potential to use floodplain areas for vegetable production. Given that floodplains are often vast and with a range of topographic and soil conditions, vegetable production can be developed provided the necessary conditions and inputs.

Figure 8 Fishermen at Mongu floodplain, Zambia (source IWMI)

4. Multiple use

The potential of floodplains is optimised most if measures are not only directed to agriculture, but rather build on the multiple usages that have always characterised these areas. Especially fish species provide a rich source of nutrients including proteins and high value vitamins. Interventions to maintain a sustainable fish production system also strengthen the protection of the valuable ecology in floodplain. Fishing culture in floodplains can be geared applying several techniques.

Aquaculture in floodplains
Aquaculture is common to floodplains. Fish is part of the diet of floodplain communities and contributes to household income. A popular practice is to build ponds in floodplains. These ponds are used to raise fish which are brought by floods or selected to be raised as fish species.

Inland ponds
Inland ponds are ponds laid within floodplains, not necessarily near river or lakes but where flood fronts or water flows reach. Contour ponds are ponds laid in dambos or valley sides along gentle slopes and are fed by streams or conservation dams. Barrage ponds are ponds commonly set in dambos, and are set as series of ponds where each ponds overflows and feeds the following one (Maar et al., 1966). All barrage ponds can be fed by a single furrow.

Riverine and lacustrine ponds
Ponds can be laid in the vicinity of lakes and rivers. These are known as fingerponds (also known as “trap ponds”). Fingerponds are meant to trap fish under flood rising conditions. Once floods retreat, fish get trapped and are raised until they reach optimal weight and size for market. These practices have been reported in Lake Victoria, East Africa (van Daam et al., 2006)

Paddy ponds
A third type of pond is the paddy pond. These are laid over flat surfaces of dambos or floodplains. Four walls are set to construct these ponds (as opposed to three walls of contour ponds or one wall of barrage ponds). Water is distributed in furrows on top of the ponds. Water usually comes from a spring or seepage area.

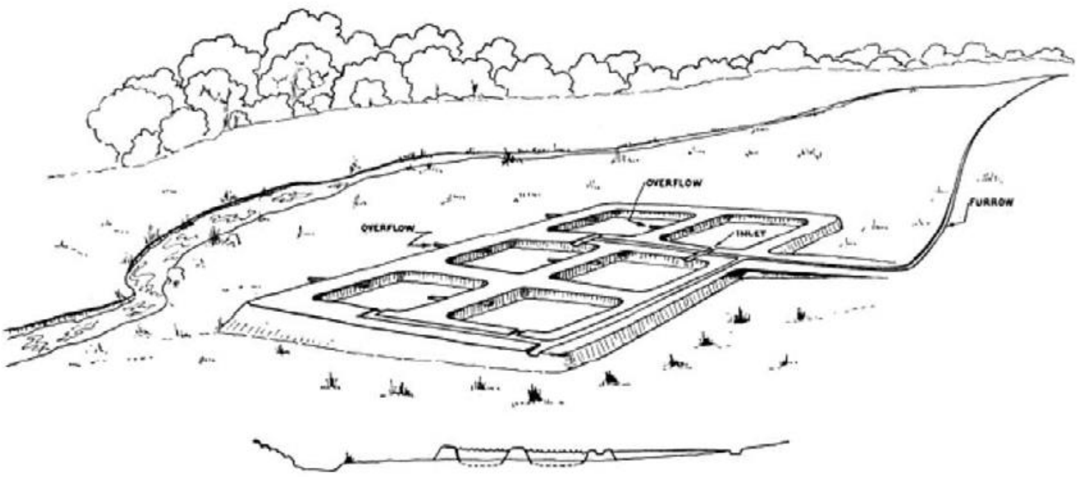

Figure 9 **Paddy ponds made in a flat dambo (Source: Maar et al. 1966)**

Box 3 Fisheries in South East Asia - South-East Asia has been known to the world for typical images of flooded paddy fields. Farmers in countries such as Cambodia have been managing floods for centuries. Yet alternative uses of floodplains have been developed. Fisheries in riverine and lacustrine floodplains are widespread. In the Mekong Delta of Vietnam, From ancient times the rhythm of the floods, providing fresh water and new nutrients, form the secure foundation generating income for its inhabitants, making use of the rich aquatic life, consisting of aquatic crops (e.g. Aquatic Caltrop, Lotus and Neptunia) and water animals (fish, snails and crabs). The aquatic crop production and catching of fish provides 75 % of the total income for the local households (Duy Tien & Van Ni 2014). There are several techniques related to floodplain fisheries. One is to trap fish species when floods rise and later recede using ponds. Another option is to develop aquaculture with fisheries within the floodplains, using high water tables and combining it with poultry farms. Another important source of income is the harvesting of aquatic weeds.

Fishing culture
Apart from fish ponds, fishing activities can be carried out in floodplains. Fish culture in floodplains is based on migration of fish to flood rising areas or fish retreating to lakes and riverine environments under flood recession. Species such as *Clarias spp* spawn on floodplains. Catfish are known to be the first species to spread through floodplains (and last to leave). Sardine species *Alestes spp* are more sensitive to changing water levels and are the first to go back to rivers and lakes. Therefore sardines are fished using shaped traps and dragnets when they retreat to rivers in mass numbers. Other techniques involve digging of channels next to rivers. Nets are place in channels trapping fish heading back to rivers, especially for *Clarias spp* and *Tilapias spp*.

Combination of techniques; flood rising and recession with fisheries – In areas of South and South-East Asia there has been developments on integration of different FBFS. This is the case for flood rising and/or recession rice and pond fisheries. There are three basic arrangements (Prein and Dey, 2006)***.***

- Flood rising rice varieties combined with stocked fish during the flooding season followed by dry flood recession rice.
- Flood rising rice varieties combined with stocked fish during the flooding season followed by non-rice crops.
- Rice cultivation during dry season alternating with stocked fish only in the flooding season.
- Stocked fish can be combined with wild fish in the above systems.

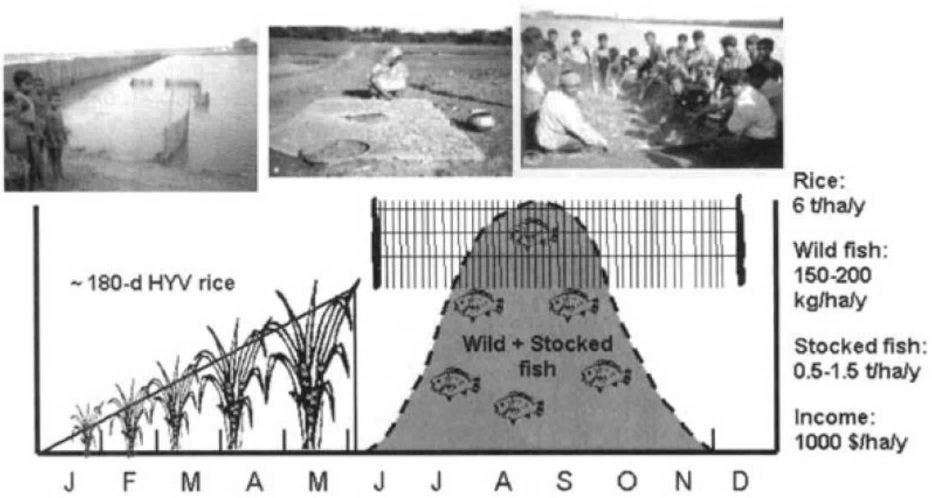

Figure 10 Integration of different FBFS in deep flooded land, source (Prein and Dey, 2006).

Floodplains as grazing land – Floodplains provide extensive grassland areas ideal for grazing activity. A number of plant species are well adapted to flood rising and flood recession conditions. Pastoralists are therefore encouraged to take their herds to floodplains. Normally this is done after floods retreat, when grasses have the best nutritious conditions for livestock feed. Plant species such as wild rice (*Oryza glaberrima*), Borgou (*Echinichloa stagnina*), *Sporobolus robustus* grass and *Vossia cuspidata* form the basis for producitive pasture land, as in the Niger Inner Delta in Mali.

House thatching, basket and mat manufacturing – Some tree and palm species can used to manufacture baskets, mats, ropes, hammocks and other utensils. Species such as *Acacia nilotica* and Doum palm *Hyphaene thebaica* are valuable for their wood and leaves and *Phragmites spp* reeds are used for house thatching.

Scaling up

FBFS are agro-ecological systems which have great potential for up-scaling. Given that FBFS are worldwide present, and floodplains and wetlands are increasingly given attention by its ecological relevance; the potential of floodplains as areas of agro-ecological importance is huge. There are a number of strengths in FBFS

- FBFS stimulate local economies and early value chain creation.
- FBFS can provide diverse sources of food and nutrition.
- FBFS reach remote and often neglected areas.
- FBFS host a wide range of communities and lifestyles (farmers, fishermen, pastoralists, gatherers, etc).
- Floodplain conservation provides water buffer areas in arid and semi-arid regions.

Capacity building at different levels may be one of the drivers for up-scaling FBFS. Policy makers, decision makers, and governmental authorities must be familiar to FBFS. Thus awareness campaigns and trainings must capacitate officials to understand and apply new techniques and technologies linked to FBFS. Likewise, there is great need to include FBFS in Universities curricula, as these systems are still unknown to many agronomists and engineers. New engineering principles which consider FBFS as alternative and unique systems are required. Engineers and water professionals must acknowledge the intrinsic characteristics of FBFS and therefore elaborate design standards accordingly. At field level, practitioners, entrepreneurs and model farmers shall be approached and involved in bringing knowledge and expertise to FBFS.

Another strategic field which can help upscale FBFS is the research sector. A core of national and regional experts and academics specialized in FBFS for every country and socio-economic context must be formed. In this way dissemination amongst the research sector would be possible favouring technical and policy discussions throughout different countries. Engagement with organizations working in wetland protection and floodplain agriculture would be favoured as well.

The role of governments in development of FBFS must be strengthened. Regulatory policy regarding land and water access in dry and flooding season can accommodate different needs amongst different floodplain users. Possible gaps in early value chain, such as food early processing and storage are sectors institutions and agencies must develop. Apart from supporting farmers and other floodplain users, extension officers can monitor and evaluate performance of FBFS at a medium scale. This information can help decision makers formulate strategies adapted to flooding patterns, changing rainfall events or migration fluxes.

Conclusions and strategic recommendations

Floodplains have a potential for many different uses; and to improve its productivity planning and interventions should focus on combinations of usages

Local differences in soil type; (ground) water levels and ownership allow for a patchwork of different usages within a floodplain. For example; in the clay areas improved hand-dug wells can be promoted; whereas the areas with sandy aquifers can be used for borehole construction.

These multiple uses have both a spatial and temporal character: a field can be used for fisheries or rice cultivation in the rainy season; and for vegetable cultivation in the dry season. Such an approach requires flexibility from farmers but also from technologies used. Therefore one should opt for wells that can be capped during the rain and pumps that can be taken home.

As indicated in the paper the issues which require further development are the optimization of shallow ground water use through manual drilling, shallow wells, affordable pumping technologies and groundwater development maps that indicate the availability of groundwater resources and the techniques required to find and develop groundwater in flood plains. However, such measures should be embedded in a wider water management plan at floodplain level including improved flood management and drainage systems, agronomy of flood tolerant and flood recession varieties; floodplain fishing culture and alternative uses of floodplain resources.

The authors are exploring ways to develop a toolkit that could guide the selection of appropriate measures and technologies for particular floodplain settings. Considering the large variety in socio-economic, geo-hydrologic and environmental features of flood-based farming systems, this could be a valuable tool for policy makers, NGOs and other stakeholders planning to intervene in the promising but complex floodplain systems.

Additional resources/tools

- http://www.spate-irrigation.org
- www.practica.org

Frequently asked questions

When applicable, a list of frequently encountered problems with guidance on how to overcome them.

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