Multiple Use of Water- Design and Implementation Strategies

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Abstract

The multiple use system of the water has now become a necessity to make the cost of water affordable for irrigation in view of rising cost of water resource creation. Although is being done at research farm and small farmers' level, developing technologies and strategies that accommodate different user groups without hampering the rights of downstream users remains a major challenge for improving the overall productivity, as well as equity of water use. This paper presents available technologies, constraints in upscaling of these technologies and strategies for refining design and implementation to harness the huge socio economic potential of multiple use system.

Keywords: Canal system, Lowland system, Multiple use, Runoff recycling system, Water productivity, Water use efficiency,

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Sustainable management of natural resources requires optimal management of land and water resources in conjunction with human and livestock resources. However, among all these resources, the water is the critical enabling resource as the efficient utilization of other resources is dependent upon temporal and spatial availability of this resource. Thus efficient and economic use of water becomes an important factor in improving the livelihood of the people. Till now the water systems have been evaluated in terms of their ability to provide water for crop production and valued in terms of the 'crop per drop' produced. However, low prices of wheat, rice and other major crops produced on irrigation systems usually do not lead to substantial increase in overall economic and livelihood scenario of the people involved. With increasing emphasis on sustainable development of natural resources, it is logical to integrate appropriate farming practices to enhance water productivity through multiple use of water leading to a shift from 'crop per drop' to a more holistic concept of 'food per drop'. This has also become important in view of increasing cost of water resource development and growing demand from different sectors, viz., industry and municipalities. Thus the usage of water only for a single purpose can no longer sustain the high cost of creation and management as well as meet the demand of different sectors.

Unfortunately irrigation systems including large water infrastructres and water harvesting systems are recognized as common pool resources supplying water for agricultural production, but potential of utilizing water for other uses is often overlooked. This process starts from designing and continues upto its management by the end users. The design of existing systems as well as those in the process do not account for any additional use of water. Similarly the participatory management policies mainly emphasize user's involvement in only irrigation and domestic water supply. While farmers' organizations are being promoted for water allocation among themselves, their membership and structure which is mainly limited to agricultural land holders do not take into account the multiple uses or users of water, which provide challenging opportunities for increasing water productivity at various scales, both under irrigated as well as rainfed areas (supplementary irrigated) by integrating crops, horticulture, fishery, livestock, small scale industries, domestic needs etc. The importance of non-agricultural uses of irrigation water in livelihood strategies has implications for water management and water rights, especially as increasing scarcity challenges existing water allocation mechanisms. There are important gender, and class differences among the water users. In rural and peri-urban areas, water is used or could be used for productive purposes such as growing vegetable and fruits, livestock, poultry, fishery besides domestic needs. However intensification of multiple use has implications for downstream flow both in terms of quality and quantity. These implications will vary from basin to basin depending upon the water availability and other charcterstics. Developing technologies and strategies that accommodate different user groups without hampering the rights of downstream users remains a major challenge for improving the overall productivity, as well as equity of water use. This presentation takes a look on available technologies, different constraints in upscaling of these technologies and strategies for refining design and implementation to harness the huge socio economic potential of multiple use system.

ASSESSMENT OF TECHNOLOGIES AND POTENTIAL OF MULTIPLE USE

The assessment of the potential of multiple uses has to be done with first constraint that the multiple uses has to be non consumptive or low consumptive and non polluting. The work done on multiple uses in India is limited. However an overview of it will give an idea of the potential of this system.

Srivastava and Satpathy (2004) and Sikka and Bhatnagar (2004) have given a summary of multiple use of water in India. This included the multiple use in almost all domains of water, i.e., harvested rain water, canal water after outlet and in the network itself, pumped water from tubewell before it is delivered to the fields, seasonally or perennially waterlogged areas in vast inland tracts and saline coastal belt of eastern India. Srivastava et al. (2004) for Orissa and Samra et al (2002) for Haryana conditions have reported that multiple use of aquaculture, horticulture etc. in runoff recycling based irrigation system increases the returns very significantly. Based on studies of feasibility of multiple use in field conditions, Srivastava et al (2003) have reported that the tanks constructed primarily for irrigation on community as well as private lands could be used for multiple use. However due to poaching, aquaculture and papaya failed in community ponds but in private ponds, the farmers were able to generate a sizable additional income by growing fish, vegetables and pigeon pea on embankment.

Srivastava et al (2004) has reported that it is feasible to change from surface irrigation system to hybrid pressurized system to increase the irrigation efficiency of the flow based minor irrigation system in plateau by adding a service reservoir as an adjunct. This service reservoir can be used for multiple use and it was found that the annual cost of the pond was recovered with returns from papaya on embankment and fish. The present B-C ratio of the system is 2.55 but if ducks and intensive vegetable on outward slopes could also be integrated, the total cost of the system inclusive of drip and sprinkler can be recovered from multiple use of reservoir itself.

The huge canal network in India can also be used for multiple use. WTC, TNAU, Coimbatore explored this possibility in the cages installed in the Lower Bhawani Project (LBP) irrigation canal. Although not very encouraging results were found for the cage fish culture (grow out fishes) in running water system from economical point of view, but raising upto 4-5cm fingerlings at the end of the canal supply period has potential in view of very good market demand. The net return from rearing of fish fry to fingerlings in a canal of 1 KM length (100 cages) worked out to Rs. 10,000/- (Mayilswami, 2004).

Exploring the feasibility of integration of secondary reservoir or small tank in the tubewell based irrigation system, ICAR-RCER, Patna found it as an effective mechanism for better regulation water as well as enhancing water productivity by raising fish in the reservoir which generates additional income and improves livelihood, Bhatnagar et al (2003) found fish yield of 11.0 t/ha with weekly water exchange. The integration of horticultural crops viz., tomato, banana, lemon and guava planted on the bunds has given good results. Duckery, animal husbandry, piggery, poultry can easily been integrated with the system using the secondary reservoir as a central unit.

The rainfed lowlands of eastern India are one of the least productive land mass. For enhancing productivity of such lands, Central Rice Research Institute, Cuttack has developed an adaptable production technology of rice-fish integrated farming system (Sinhababu and Venkateswarlu, 1996). The system involves construction of dikes and refuge/trench, with refuge/trench being used for growing rice and fish and dykes for growing vegetables and fruit crops. It has been found that the profit over investment is 132%. Similar work in rainfed plains of Bihar, where seasonal waterlogging is a serious problem have given . encouraging results at initial stage and efforts are being made to evaluate such interventions under different set of conditions (Sikka and Bhatnagar, 2004). In Mekong Delta in southern Vietnam, farmers implement such system of fish trenches connected to the adjacent rice fields (Prein, 2002).

The multiple use technology is not limited to the research farm alone. The enterprising farmers like S. Darshan Singh in Punjab and Shri Radhakant Sahoo in Orissa, have taken innovative initiatives for multiple use of water using tubewell water and seasonally waterlogged area respectively, which has increased the water productivity and their income manifold (Sahoo et al. 2003).

In coastal areas of eastern India, WTCER, Bhubaneswar found that properly designed and constructed subsurface water harvesting structures (SSWHS) will mitigate the early drought in monsoon season and provide irrigation during post monsoon and summer season for this chronically waterlogged area having saline ground water. Integration of aquaculture in the system improved the water productivity manifold. Water productivity varied from Rs. 15.84/m^3 to Rs. 80.43/m^3 with an average of Rs. 36.20/m^3 while taking total income from all the structure. If only the benefit is considered then water productivity ranges from Rs. 9.00/m^3 to Rs. 53.70/m^3 with an average of Rs. 23.26/m^3 (Sahoo etal., 2003, Sahoo and Verma, 2003, Sahoo et al., 2003).

CONSTRAINTS IN DESIGN AND IMPLEMENTATION

It is evident from above that there is immense potential of multiple water use system in all water domains. However, the challenge lies in up scaling these technologies for their adoption on a larger scale taking in account the socio-economic conditions. Based on our experience, farmers' perception and available literature, some of the constraints in adoption of these technologies on a large scale are as below:

1 Social impediments such as religious feelings, poaching especially at remotely located ponds, theft, local conflicts in case of community water bodies or open access water bodies and water rights.

2 Pereniality of water availability in the streams and water bodies.

3 Mortality of fish fry due to change in environment, intrusion of snakes and carnivorous fishes.

4 Loss of natural fish feed (planktons) due to excessive water flow through fish pond

5 Lack of capital investment and resources in developing the system, provision of aeration & mixing specially for resource poor and socially disadvantaged section of rural population.

6 Lack of awareness, technical know-how and technical and institutional support

7 Lack of multiple use systems and technologies for different bio-physical, agro-ecological and socio-economic conditions and crop – livestock – fish – enterprise combinations

INNOVATIONS REQUIRED TO OVERCOME THESE CONSTRAINTS

To overcome above-mentioned constraints, few innovations in design of multiple use systems and their implementation are required. Based on experience of authors in the field, few of them for each water domain, i.e., water harvesting system, canal water, ground water, and areas having waterlogging due to water congestion have been identified and listed below:

Water harvesting Systems:

The WHS can be divided in three categories depending upon their location and present use : (i) Near the homestead which can get good management practices; (ii) far off from homestead, which will have to be under poor management practices and will suffer from poaching; and (iii) WHSs located in highly permeable soils where water don't last beyond monsoon season. Different design parameters and utilization strategies are required for optimal utilization of these water bodies.

(i) For WHS, which are near to homestead and can be managed properly, a combination of aquaculture + horticulture (both fruits and vegetables) on embankment+ duck raising + rudimentary livestock raising + irrigation can be adopted. A major constraint in these tanks is the drying up of water by Feb-March. This reduces the growth period of fish and therefore overall productivity. For enhancing the growth period following options can be studied for their efficiency:

a) Enhance the capacity of tank by increasing the depth so that sufficient water remains during summer season even after accounting the seepage loss. This can be done only in high rainfall areas and the economics of creating additional capacity for aquaculture has to be worked out. Its implication in overall design of multitank-based irrigation system will also have to be worked out.
b) A lined small adjunct reservoir can be constructed alongwith the main tank. The frylings will be stocked in main tank and will be allowed to grow upto December. By December, the frylings will reach to 10-15 cm., i.e., fingerlings stage. These fingerlings can be shifted to small tank for high density stocking where they will remain as stunted fingerlings till next July. In next July these fingerlings will be restocked in main tank alongwith fresh stock of frylings. In December, the grown up fish can be harvested for table purpose and fingerling can be harvested for stocking in small adjunct tank, and the cycle will continue (Fig. 1).
c) In multitank multiwell based irrigation system (srivastava et al. 2004), , the part yield of the open dugwell can be used for maintaining the water level in pond for aquaculture by taking care of seepage and percolation loss. However, this can be possible only when electricity is available for pumping. The overall economics of use of water from well for continued aquaculture and duck rearing should be compared with summer crop cultivation.

(ii) WHS, which are located away from homestead and are prone to poaching , can be putup to multiple use system by exploring the aquatic crops which will spread over the water surface. The product of these crops should not be prone to poaching. Makhana (*Euryle ferox*) and Water Chestnut *(Trapa bispinosa)* are two such crops suitable for Eastern India. Few other crops can also be explored for other agro-ecological conditions. Aquaculture with specific type of fishes can be integrated with these crops. A suitable system both in terms of design as well as cultivation practices need to be developed.

(ii) In plateau as well as hilly areas , the land near the homestead have soils of coarse texture and thus have high seepage rates. Due to this, the unlined tanks are not feasible. WTCER, Bhubaneswar has developed design of LDPE film lined tanks. A multiple use system comprising aquaculture+ duck rearing + rudimentary livestock+ horticulture +domestic water use + vegetable activation on a limited scale can provide a decent livelihood to a farm family. This aspect requires research on proper designing and its evaluation (Fig. 2).

Canal Water

The multiple use of water especially aquaculture in canals has tremendous potential given the vast area available. However given the limitation of water availability, flow rate, and the water velocity, the canal sections will have to be identified where aquaculture can be practiced. Central Institute of Freshwater Aquaculture, Bhubaneswar has developed design of floating cage for controlled aquaculture in large water bodies. There is need of refining this technology for its use in canal system, under varying conditions of flow and water availability. Some modification in canal sections may also be required to ensure water availability for longer period. The effect of these interventions on canal hydraulics requires detailed study to avoid any adverse effect on overall canal management. This technology has a very significant social impact as it can serve as a tool of increasing the number of stakeholders in canal system by involving landless people in the enterprise. A large-scale adoption of this system can alleviate the stigma on canal irrigation that it serves only landowners and increase the disparity between landowners and landless.

The canal water can also be put for multiple uses below the outlet especially in plateau areas, which have sufficient slope to ensure pipe flow through gravity. An adjunct service reservoir connected to the outlet and then a network of pipes for conveyance of water will ensure highly improved irrigation efficiency. Srivastava et al (2005) have shown that the conveyance efficiency below the outlet is 75% with unlined field channels and a pipe network will improve it to 95-100%. The cost of pipe network and service reservoir can easily be recovered through multiple use of reservoir by integrating aquaculture, duck rearing and horticultural crops. Thus multiple use planning can ensure not only additional returns but also improved irrigation efficiency.

Ground water

The pumped ground water can be used for multiple use before it is conveyed to the fields for irrigation . The technology developed at ICAR, RCER Patna needs to be further refined by developing design parameters for the service reservoir, automation in terms of erratic electricity supply and overall economics. Among all water domains, this domain has maximum potential due to its controlled condition, water quality and water exchange facilities. The design parameters will vary for alluvium aquifers and hard rock aquifers in view of difference in yield of well.

Waterlogged lowlands

Rainfed lowlands in India are one of the most poorly exploited land mass. They are monocropped and productivity is 1 to 1.5t/ha. To achieve higher productivity from this underutilized otherwise high potential area, the multiple use should be linked up with reclamation to make the reclamation economical. Most of the waterlogged lowlands can be divided in two parts. Saucer shaped areas having very high water congestion and ii) water congested area lying between two rivers. A possible option for reclamation of such lands has been given in Fig. 3&4. If suitable multiple use systems could be designed which are compatible to such systems, the reclamation will be economical and the productivity can be increased manifold.

The implementation of multiple use system in all domains will require integration of both consumptive and non-consumptive uses of water to achieve maximum water ruse efficiency in terms of production and money. In view of this, the strategy for managing this vital resource would be two fold: first to get maximum optimal returns from created water resource and secondly to use same water to meet the demand of different sectors in complimenting manner. The first part means integration of water uses for multiple purposes both consumptive and non-consumptive to achieve maximum water use efficiency in terms of production and money. The second part means designing a system where emission/outflow from one user serves the demand of another user with or without any minor treatment. The technologies of integration of water uses for multiple purposes will achieve following:

- Increasing farm productivity/production without any net increase in water consumption.

- Enabling diversification in higher value crops, including aquatic species.
- Enabling utilization of otherwise wasted on-farm resources.
- Reduction in net environmental impacts of semi-intensive farming practices.
- Ensuring diversification of risk, self-employment, flow of income throughout the year.
- Satisfying the needs of various sectors with limited water availability

The above goals will be achieved by integrating multiple use system in existing waterbodies by making suitable interventions without jeoparding the efficacy of the waterbody. Both in terms of quantity and quality. , and by modifying the design of future water resources to incorporate multiple use. This will require a very concerted effort of capacity building at different levels starting from farmers to the design engineers.

WATER RIGHTS, CONFLICTS AND SOLUTIONS

Water rights are at the heart of any water allocation system. Reallocation has to take care of not only efficiency but also fundamental issue of equity. The delineation of water rights is further complicated when we take into consideration multiple uses as well as multiple users. The demands of multiple users may be in conflict both in terms of quantity and time. Each case require a separate understanding of the problem and probably an innovative solution, because just as water is a fluid and dynamic resource the water rights are also fluid and dynamic, rarely a single consistent system.

CONCLUSION

The technology for multiple use systems are more or less standardized for research farm conditions for different water domains. However, those designs require fine tuning and large scale field testing under different agro-ecological socio-economic and management level conditions, before they are recommended for wide-spread adoption. Further water rights scenario need to be tackled to take care of conflicting interests both in terms of quantity and quality of downstream water. The implementation of the multiple use system will require efforts on two counts, first to integrate them in existing resources and second to modify the design of future projects to make them suitable for multiple use.

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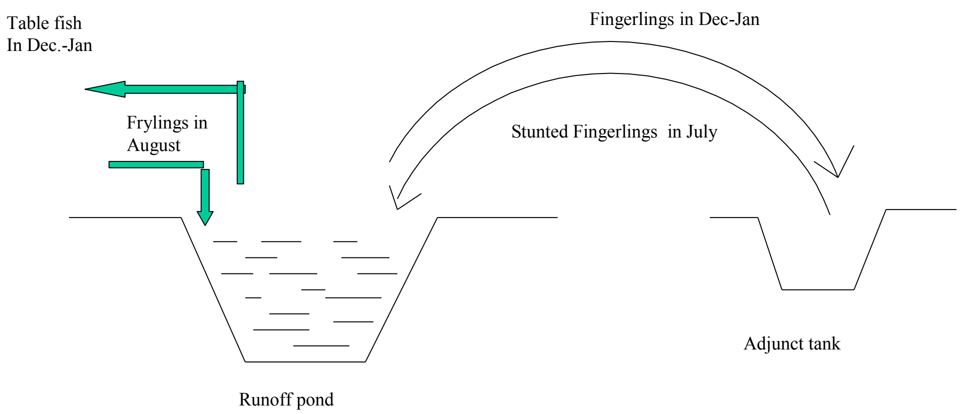

Fig. 1 Schematic diagram of adjunct tank system for intensive aquaculture

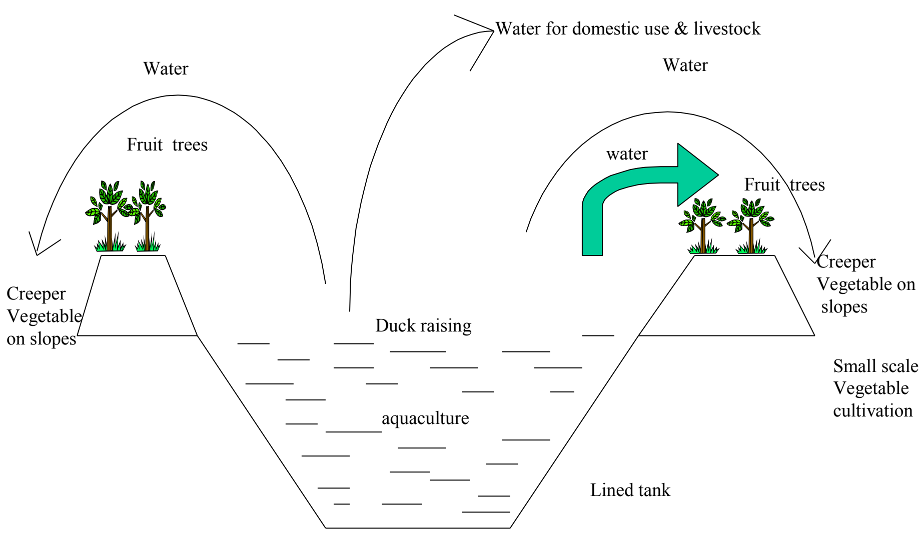

Fig. 2 Schematic diagram of multiple use system based on lined tank on top areas of watershed in hills and plateau areas

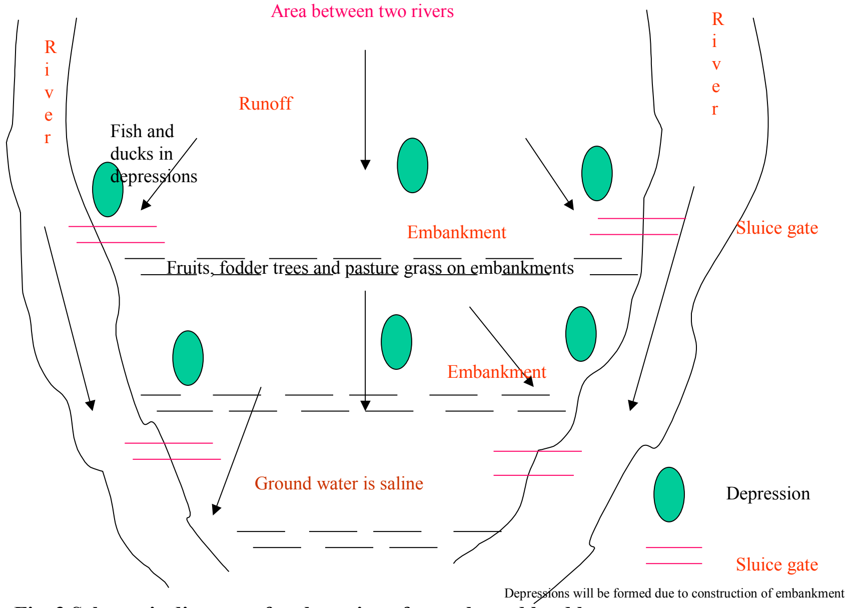

Fig. 3 Schematic diagram of reclamation of waterlogged land between two rivers in mouth of delta

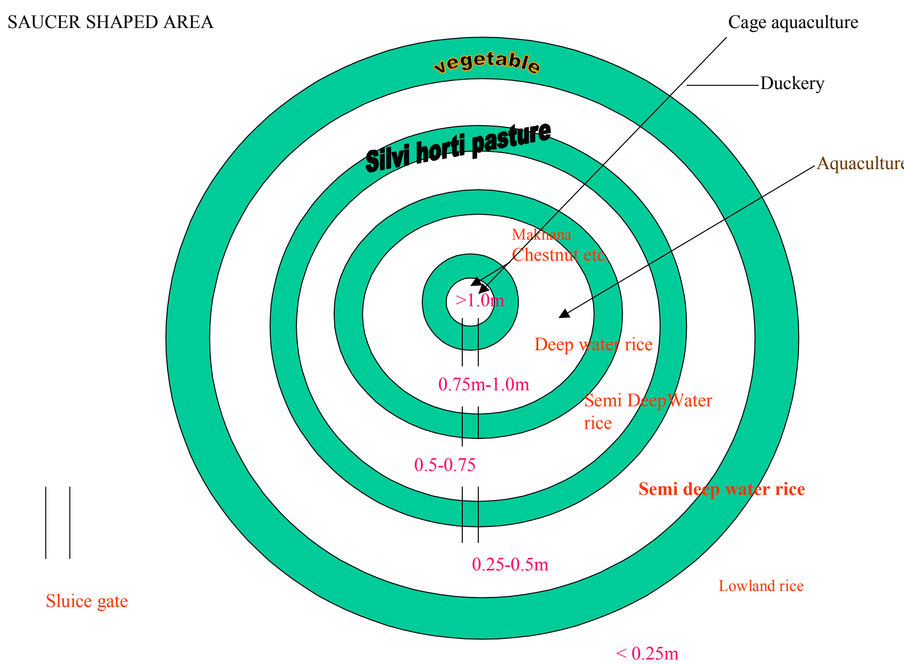

Fig. 4 Schematic diagram of reclamation of saucer shaped waterlogged area