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RESEARCH ARTICLE

Cost Benefit Analysis on Pond Ecosystem Services in Peri -Urban Area

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Abstract

The fast pace of urbanization is creating threat to the natural ecosystems in peri-urban areas and because of that negative impacts have been observed on the livelihood of people and other environmental services as well. Aquatic reservoirs such as ponds, streams are the first hunt of this urban expansion. As a result, agriculture is significantly affected in these areas as well as biodiversity. Therefore, the livelihoods of small and marginal farmers are not well. Now the need has arisen to study the importance of aquatic reservoirs presence peri-urban areas. Present study is based on the survey of a village people from peri-urban area of Gorakhpur district, Uttar-Pradesh, where a pond (0.55 acre area) was revived under Mahatma Gandhi National Rural Employment Guarantee Act 2005 (MNREGA). The focus of present paper is on the cost benefit analysis of ponds/wetlands located nearby peri-urban areas. A community farmer interaction was held during this study in the marked area to understand the ground reality about the existence of pond ecosystem and their benefits. On the basis of this public participation, a cost benefit ratio was derived. It was observed that people have significantly appreciated the existence of aquatic reservoirs presence in peri-urban areas.

1. Introduction

Since ancient times, ponds have been used as an economical and efficient reservoir of water for livestock and irrigation purpose. Moreover, farm ponds were involved in providing food, cover and nesting habitat to various kind of wildlife species such as amphibians, reptiles, fish, birds, mammals can be helpful to increase watershed health, soil erosion and sedimentation control (WHMI, 2005).

Some Asian countries like Bangladesh, China, India, Indonesia, Malaysia, Thailand and Vietnam have adopted the concept of Integrated Agriculture Aquaculture (IAA) (Symoens and Micha, 1995; Mathias et al., 1998; Prien, 2002). This concept is based on the use of aquatic reservoirs adjacent to the agricultural lands for agriculture as well as aquaculture purposes. After China, India has become second largest aquaculture producing country in the world because of successfully facilitating integrated approaches for aquaculture along with agriculture (Veerina et al., 1999; Sharma and Leung, 2000). Indian states, Odisha and West Bengal have successfully extended the production of rice with fish culture (Prien, 2002).

Pond ecosystems have been reported as the most prominent means of irrigation in the Taoyuan area, Taiwan. However, in 1970s there were more than 3,290 ponds existed but only 1,800 ponds are left now which are protected by Taiwan government due of their ecological and cultural importance (Huang et al., 2012).

Huang et al. (2006) observed that the concern of food safety and environmental contamination is increasing very fast in peri-urban zones of Asian region. Moreover, usually urban farming is mainly practiced peri-urban areas other than rooftops, backyards and in community gardens (Andersson et al., 2007; Baggethun and Barton, 2013).

However, peri-urban areas are shrinking because of massive expansion of urbanization areas and population explosion which cause ecosystem disturbances. According to an estimate, world's half population are already living in cities (Dye, 2008) and it will reach up to more than two-thirds the year by 2050 (UN, 2010). Peri-urban areas are having more threat due to massive urbanization rate, continuously increasing populations and ecosystem disturbances. Moreover, it is catalyzing the impacts of climate change (Huang et al., 2012). Therefore, it is the demand of time to conserve the ecological systems, water reservoirs, peri-urban land use for a better future.

Gorakhpur is located in the *Terai* belt of Eastern Uttar Pradesh, India. In terms of population growth, it is the second largest city of Eastern Uttar Pradesh. Geographically, the city is situated on the bank of river *Rapti*. The 147 km2 area of Gorakhpur city is divided into 70 administrative wards and 175 villages covered by Gorakhpur Development Authority (GDA) (GDA Master Plan, 2021).

The source of water supply for Gorakhpur city is mainly ground water. There are 75 power bore well, 8 mini power well, 3694 hand pumps and 450 public stand posts. About 82 MLD (Million liters per day) of water produced from ground water and not a single unit of water is produced from surface water sources. Average daily water supply is 77.60 LPCD (Liter per capita per day). Approximately 70% domestic water supply is discharged as wastewater. The total waste water generated in Gorakhpur city is 65.84 MLD (Prajapati and Singh, 2013). Since long time ago, farmers and ranchers had conserved ponds/aquatic reservoirs for irrigation and livestock as found in West-Bengal, Bihar, Odisha and Kerala. The residential areas of Gorakhpur city have been doubled during 1981-2001. In 1950s around 300 small/large lakes were present, whereas only 20-25 are remaining now (GDA Master Plan, 2021). Ponds serve various purposes such as irrigation, livestock, fish cultivation, field and orchard spraying, safety from fire, recreation, biodiversity conservation, soil erosion control, etc. Studies on pond ecosystem advantages and its conservation are very limited. Therefore, in this study we have tried to analyze the cost benefit ratio of conserving aquatic reservoirs through community participation especially for agriculture purpose (Gorakhpur DDMP, 2014).

2. Methodology of Cost Benefit analysis

A village was selected from the peri-urban area of Gorakhpur city taking into considerations of risk for ecosystem and vulnerability of village with respect to agriculture as shown in Table 1. A discussion was done with village people to indentify the resilient options of vulnerabilities among the community (Table 2). A share learning dialogue (SLD) was conducted at village level to know the cost and benefits on the resilient options (qualitative). After SLD a scale was applied from 1 (lower) to 10 (highest) with community interaction and as per this scale one resilient option was identified among 6. Quantitative costs and benefits were also estimated using secondary data and information obtained from community and other sources.

3. Results and Discussion:

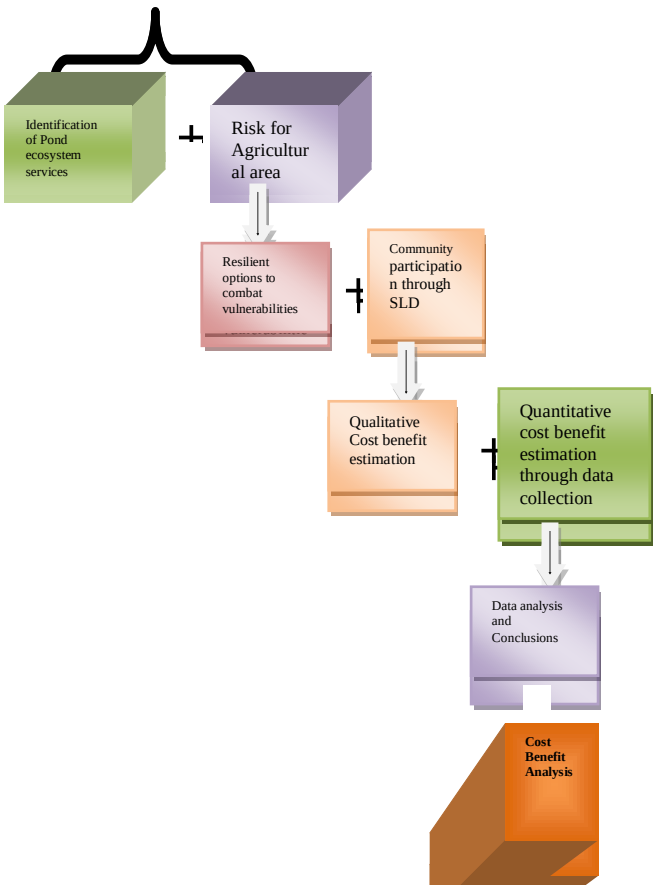

Fig. 1: Methodology employed in present study

In this study, results and discussion are in two parts one is community participation depicted and another is secondary data collected from various sources. Participatory approach from community is not considered in many studies. Hence, we have considered this approach to get real observations from local public.

Table 1: Consequences of anthropogenic activities on pond ecosystem

S. No.	Anthropogenic activities	Risk/Vulnerability
1.	Rapid conversion of land use for housing, encroachment	Irrigation problem, Crop damage due to water logging and flood, less availability of agriculture land, Dependency of farmers on single cropping pattern Insecurity of foods, dignity and debt etc decreasing of livelihood
2.	Garbage and sewage Disposal to the peri-urban areas from the city	

Table 2: Resilient options of to minimize the risk/vulnerability

Vulnerability	Resilient options
Crop damage due to water logging and flood	• Loft farming/aquaculture • Permanent bed raising • Proper drainage system • Cultivation of water resistant crops
Non-availability of aquatic reservoirs	• Digging ponds and make bund around the farm • Use of surface water for irrigation • Minimum ground water extraction • Conservation of open/agriculture area
Dependency of farmers on single cropping pattern (insecurity of food, dignity and debt etc.)	• Time and space management • Proper distribution of natural resources
Dwindling of livelihood	• Fishery and duck farming • Aquaculture

Table 3: Advantages of pond ecosystem

S. No.	Resilient options	Advantages		
		Economic	Social	Environmental
1.	Pond conservation	Irrigation, wages, management of water logging/flood, animal husbandry, profitable livelihoods (fishery, washer men etc (10)	Cultural, drinking, animal bath, distribution of equal recourses (7)	Increasing ground water table, improve soil fertility and promote water cycle (3)
2.	Use of surface water/water conservation	Save the fuel, low labour cost (3)	Alternative options of irrigation, mixed farming and marketing (4)	Flood management (2)
3.	Ground water extraction through bore well	Timely irrigation facility, enhanced production (5)	Lesser conflict, agricultural interest increase among farmers and social harmony(3)	-
4.	Conservation of open/agricultural area	Less damage to the crops due to Water logging /flood, continuous agricultural activities (7)	Livelihood of community, social harmony, cultural activities (5)	Increasing of ground water, buffering capacity of the flood/water logging(4)

5.	Promote the agricultural sub-system like pond, animal, forestry and off farm activities	Increase cropping intensity, Increase in overall income, minimum risk (8)	Livelihood and food security ,dignity (5)	Increasing buffering capacity of the flood, biomass, soil fertility and oxygen flow (2)
6.	Bonding around farm	Weed control and less use of fertilizers (7)	Equal nutrition to the soil, check the runoff of rain water (2)	Ground water recharges, maintain moisture level in soil prevents from erosions (1)

All scores for cost and benefits were obtained from the feedback of community afterwards cost-benefit ratio had been calculated. According to the local community, the highest cost-benefit ratio was found for the conservation of ponds among six resilient options. A theory of change was developed for quantitative analysis as shown in Fig. 2. During the development of theory of change, it was tried to find out the eight determining parameters for a basic cost benefit analysis towards improvement of socioeconomic condition and sustainable management of ecosystem.

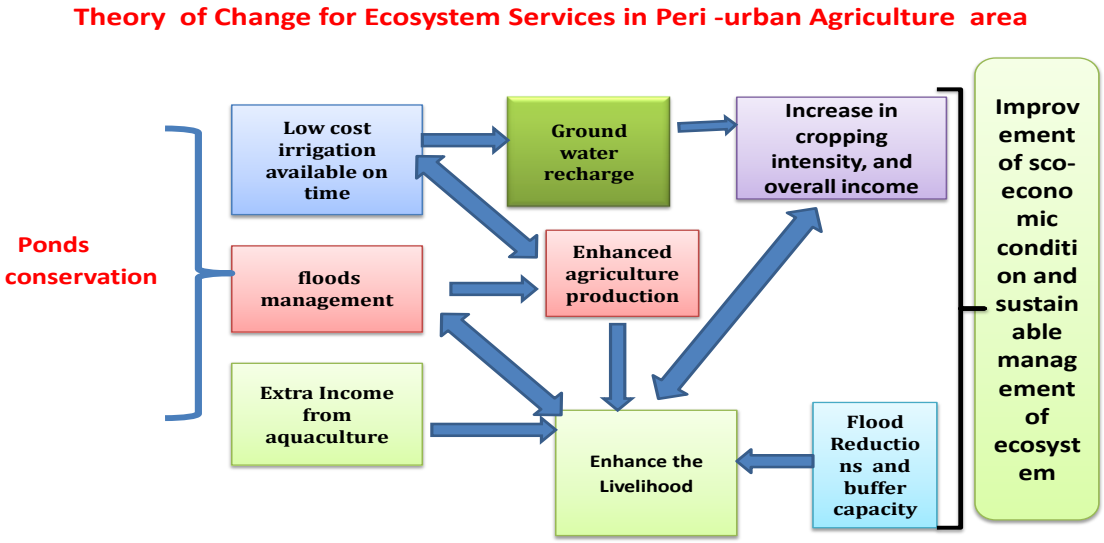

Fig. 2: Theory of change for pond ecosystem in peri-urban areas

4. Advantages of pond ecosystem

Three advantageous aspects of pond ecosystems like economic, environmental and social were considered during the study (Fig. 3). Some Social benefits cannot be measured quantitatively like religious values, cultural activities etc.

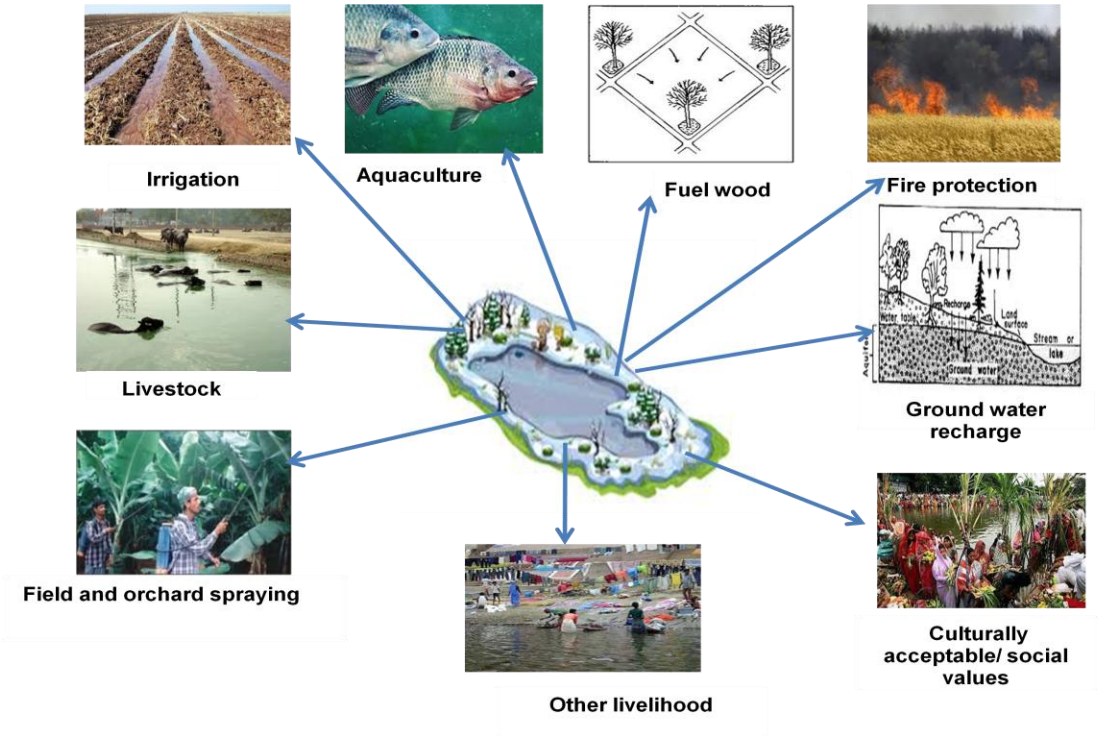

Fig. 3: Advantages of pond ecosystem

(i) Irrigation

Ponds are an important source of irrigation water especially in the rural as well as in peri-urban areas, where does not have the organized irrigation system. Water requirement for irrigation is always found greater than other purpose. However, pond capacity must be adequate to meet the requirement of crops in growing season and also try to overcome the water losses. The irrigated area covered by a pond may be about five times more than the capacity of pond. The required storage capacity of a pond used for irrigation depend on various factors such as water requirement of the crops, expected rainfall during the growing season, efficiency of irrigation method, water loss due to evaporation, seepage, expected inflow to the pond etc. Ponds provide irrigation water, freshwater habitats that enhance biodiversity as well as the most important fact their involvement to harmonize the local micro-climate, regulate flooding, provide water for fighting fires, and create a unique rural landscape (Huang et al., 2012).

(ii) Fish production/ aquaculture

Many land users have found fish production as good enough profitable business. Good fish cultivation in the ponds can also provide recreation and also enhance the source of income. In 1997, Asian countries produced total 91% of the global aquaculture production ~36 million tons, particularly dominated by China followed by India (Prein, 2002).

(iii) Field and orchard spraying

Generally, the small amount of water is needed for spraying. Hence, it can be useful in water conservation. For example, about l00 gallon water is required for one acre and it is found enough for the most of the common crops (USA Agriculture Department, 1984).

(iv) Protection from fire

A dependable water supply is always needed to fight from fire. The pond is located close to agricultural lands and houses can provide safety from fire. In summer season during crop harvesting time, maximum incidents of fire happen in wheat crops. Therefore, it would be better to have any aquatic reservoir near by the agricultural fields and residential area (Huang et al., 2012).

(v) Vegetables production

Vegetables production on the pond bank throughout the year will provide an additional benefit over traditional pond management systems. Generally, small farmers do not have facility of irrigation for vegetable production. In this regard, vegetables production through integrated pond management can increase availability of vegetables for family consumption. Moreover, cash from the selling of vegetables will also increase the total income of the households. This approach of vegetables production has exhibited remarkable benefits to the poor farmers in terms of income generation and family nutrition. Production of fresh vegetables in peri-urban areas throughout Southeast Asia has attracted special attention (Jansen, 1992; Midmore et al., 1996). So, pond waters can help to make free the vegetables from the potential contaminants and toxic chemicals and pathogenic microorganisms (Huang et al., 2006). Some post-harvest losses of horticultural products are also reported, which can be minimized by proper handling and storage. Consequently, it will raise the livelihood of the small farmers living in peri urban areas (Prajapati and Srivastava, 2013).

(vi) Recharge of ground water

Rate of natural ground water recharge is essential for efficient ground water resource management. It is important in the regions where high demands of ground water than supplies, because it is the key to economic development. The infiltration capacity of some common soil groups are reported as given below (MOR, 1996):

Soil Group	Infiltration capacity (cm/h)
Sandy soil	7.5 - 11.5
Sandy lome	4.0 - 7.5
Clay soil	0.13 - 4.0

Fresh water ecosystems are providing most of the fresh water to the urban cities for drinking as well as other human uses (Baggethun and Barton, 2013).

(vii) Livestock

Any aquatic reservoir present in our surrounding or grazing area is good to use for our live stock's drinking, bathing purpose. An average daily consumption of water by different kinds of livestock is high. The amount of water consumption depends on the average daily need of single animal, number of livestock, and period of their presence nearby.

(viii) Social and cultural values

Human societies have some peculiar moral, spiritual, educational, aesthetic, place specific values, which are well linked with ecological systems (Baggethun and Barton, 2013). These values may retain some kind of emotional attachments towards the natural systems (Martínez-Alier et al., 1998). At several places, it is well observed that natural ecological systems and biodiversity, both are deeply interlinked with spiritual aspects (Stokols, 1990; Baggethun and Barton, 2013).

Analysis of Cost and benefits in long term:

We have tried to find out the cost-benefit ratio for next coming 10 years. Table 4 shows IRR, NPV and benefit cost ratio which reflects the positive sign of profits. Total net present value (NPV) cost, total net present value benefit as well as net benefit has been reflected in Table 5 which has given again a positive sign of sustainability of pond ecosystem in long terms (Sassone, 1978; Jenkins and Harberger, 1995).

Table: 4

Net Present Value (NPV)	202405.69
BCR	1.52
IRR(Estimated)	47.00%

Table: 5

Total NPVs Costs	385583.42
Total NPVs benefits	587989.10

Net Benefits (PV Benefits - PV Costs)	202405.69

5. Conclusion

During this study, it has been observed that conservation of pond is profitable, if it would be managed in a proper and scientific way. The study proves that there are significant benefits to the community after conserving natural ecosystems for e.g. pond and other water bodies. Qualitative (participatory) as well as quantitative approaches were found to be beneficial in the conservation pond ecosystem. The study also shows that the investment in ponds have a total NPV of Rs. 202405.69 and benefit to cost ratio (BCR) is 1.52 at 12% social discount rate. Evidence presented through qualitative CBA show that there are many aspects related to opportunity cost, social cost and environmental cost of conservation of a pond that are not measurable in economic terms, but its benefit is quite important to the community/society as a whole. In the light of high economic, social and environmental benefits, natural ecosystem based livelihood systems among small and marginal farmers are highly justified. Based on the findings and conclusions it is recommended that land use should be preserved to sustain livelihoods in peri-urban areas.

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