Sukhna Lake Rejuvenation through Watershed Management : A Case Study

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ABSTRACT

Efficient management of natural and artificial water reservoirs is imperative for sustainable development as apart from rivers, they are the only major source of fresh surface water. Several anthropogenic activities affect the performance of these water bodies. Many a time water bodies are considered dead if these are not able to perform the required functions. The general causes which severely mar the functioning of a surface water body are siltation, eutrophication, contamination, etc. The revival measures for an impaired water body depend upon the prevailing conditions. This paper throws light on such a revival project undertaken for Sukhna Lake in Chandigarh in North India. Sukhna Lake is a man-made lake located approx. 32°42'N and 76°54' E, created by raising earth and rock filled dam across three choes. The work was completed in 1958 and since then it faced siltation problems. Within 20 years its storage capacity reduced to 40% of its original value. The problem was traced to severe degradation of the catchment area in the hills near the village of Sukhomajri, located in Panchkula district of Haryana. The villagers had small sprawls of non-irrigated land for cultivation and kept animals (mostly goat) for their livelihood. Uncontrolled grazing by the livestock led to excessive soil erosion which was the cause of siltation. A Hill Resource Management Society was formed under the initiatives taken by Central Soil and Water Conservation Research and Training Institute which also provided the initial funding to start this project. Watershed development resulted in benefits to both the Sukhna lake and Sukhomajri. The project was very successful, resulting in improved vegetative cover on the hills, increased agricultural production and income rise of the villagers. Siltation into Sukhna lake declined drastically during the successful operation period of the project with reduction in annual dredging and related costs. Of late, however, the project has started suffering several ills and other schemes are in the pipeline for keeping Sukhna Lake healthy and alive.

INTRODUCTION

Sukhna Lake in Chandigarh is a man made lake which came into existence some 50 years back. It was created mainly for recreational purposes. Its catchments lie in Shivalik hills of Northern India. However, right from its inception it has faced the problem of siltation. The increased human population in the nearby villages and their consequent economical activities have accelerated the process of deforestation and denudation of

the hills. The region around Sukhna experiences heavy rainfalls in monsoons. Thus, the loose soil continuously flows into the Sukhna Lake. During summers many shoals and water hyacinth appear in the lake bed and create serious hindrance to boating activities in lake. Dry dredging and de-silting of the lake have been tried, but they have proved to be recurring affairs and highly expensive. Earlier a number of Acts were legislated prohibiting grazing and tree felling in the hills, but they were not effective due to socio-economic reasons.

LOCATION AND CHARACTERISTICS OF THE LAKE

Sukhna lake is located at 32^0 42' N Latitude and 76 ^{0} 54' E Longitude with its concavity facing the Shiwalik hills. Its northern boundary adjoining the Shiwalik hills is natural and irregular. Its south west embankment, artificially built out of hewed stones, has a rock fill earth dam 12.8 m high. This dam is built on the confluence of three seasonal streams namely: Kansal, Ghareri and Nepli as shown in Fig 1. The lake is 1.52 km long and 1.49 km wide with initial storage capacity of 1,074 ha-m of water (Bansal, 1986). The submergence area is 228 ha at a maximum lake level of 353.57 m above mean sea level (msl) with maximum flood level being at 354.02 m above msl. After completion in 1958 the water spread area of the lake was 188 ha and the average depth was 4.69 m with deepest point at 343.2 m above msl (Singh, 1990).

The lake has a catchment area of more than 3000 ha. Out of this catchment area 76.4% lies in hilly forest catchments of Kansal, Nepli and Ghareri streams in the Shivaliks wherein the average slope is 30^0. The remaining 23.6% of Sukhna catchment's extending from northern margin of the lake to the hills comprises of agricultural fields, the area under stream beds, pastures and forest area along with the lake on the slopes of the piedmont plain.

Broadly speaking, the Sukhna and its catchments form part of Semi Natural Drainage Ecosystem (SNDE) which itself is dependent upon Natural Hilly Ecosystem (NHE) of the Shivalik hills. The origin and functioning of drainage lines (rivulets, streams and rivers) give rise to the SNDE. Its functioning is dependent upon the inequalities in the nature of rock formation, vegetation and soils and the fact that the land areas possess some degree of slope, leads to run off accumulating quickly in small gulley which coalesces to form lager channels and ultimately these channels converge to form streams, rivulets and eventually the rivers. Thus it can be inferred that the balanced existence of the Sukhna Lake is entirely dependent upon efficient functioning of NHE and SNDE in the Shivalik hills. Any deviation in the functioning of these, results in increased water run off with heavy silt load which affects the life of the lake. That is what has actually happened in case of Sukhna which is experiencing heavy siltation load.

SEDIMENTATION OF SUKHNA LAKE

This problem of salutation started right from its creation. Indiscriminate deforestation

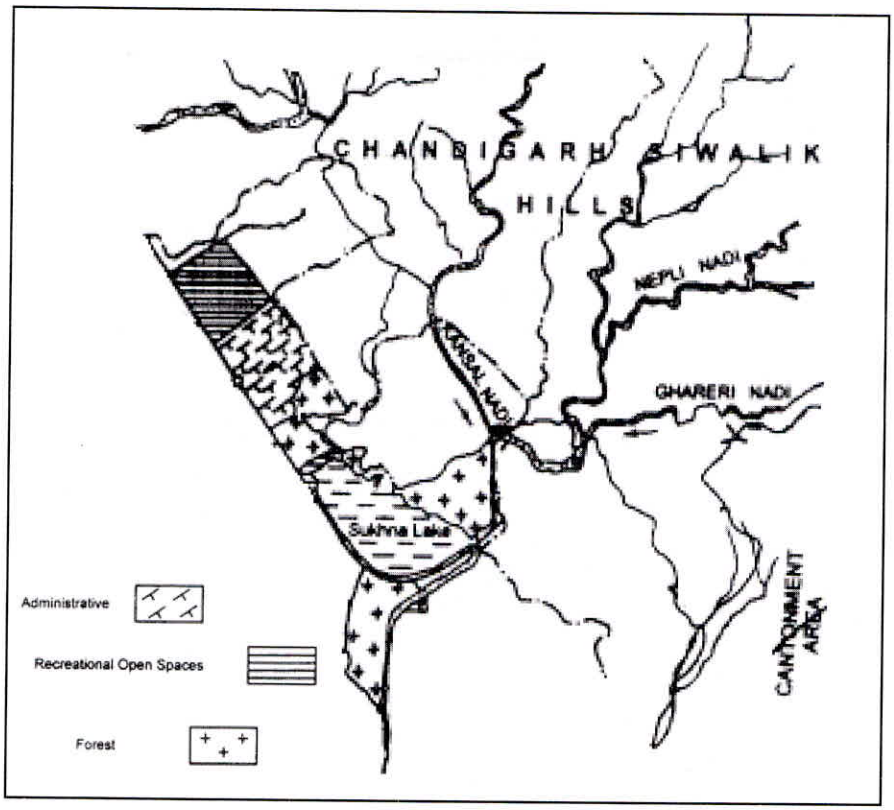


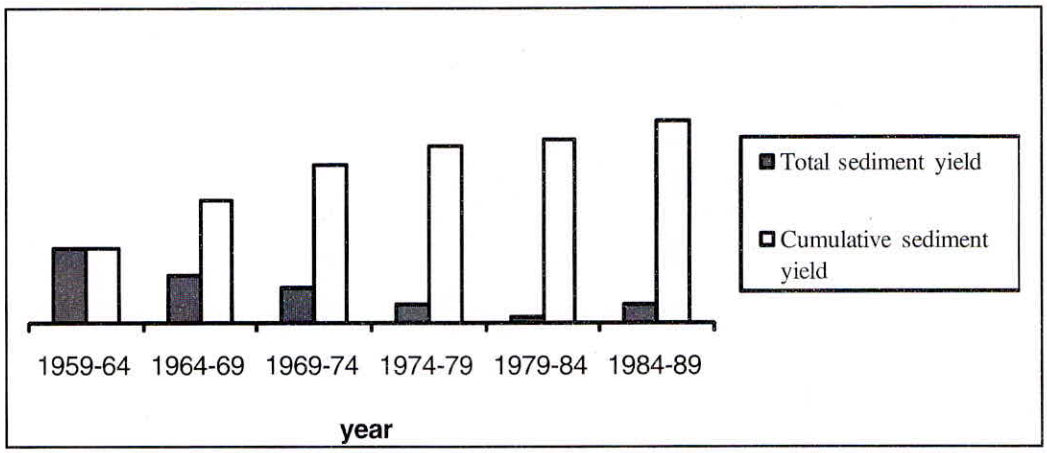
Fig. 1 : The Catchment of Sukhna Lake

reduced the forest cover of Sukhna's catchment area to 5% (Sinha, 2005). Being located at the foot hills of the Shivalik hills, the catchment soil is prone to erosion. To add to the problem, this area receives heavy rainfalls during monsoons. The slopes of the hills are very steep, average slope of sub watersheds feeding the main stream- the Sukhna choe being 30 to 40%.The slope of the Sukhna choe itself is 6%. The drainage density, on the average, was 9 kilometers per square kilometer of the catchment. The channels of the sub-watersheds, feeding the main channel, has a slope of 20 to 30%. The situation is exacerbated by the fact that on an average 50% of the total rain in the Shivaliks ends in run-off (Misra et al, 1978). Thus due to higher run-off and steep slope there was accelerated pace of erosion in the catchment areas resulting in the higher rate of sedimentation in the reservoir of Sukhna Lake and stream beds as shown in Fig. 2.

The silt deposited year after year in the lake bed reduced the water storage capacity, depth; water spread area and submergence area at lake level. By 1971 about half the storage capacity of the reservoir was lost. Sedimentation further increased and in the year 1976 the loss in water storage capacity rose to about 68.5% of the total i.e. water storage capacity dropped to 338 ha-m as shown in Fig. 3.

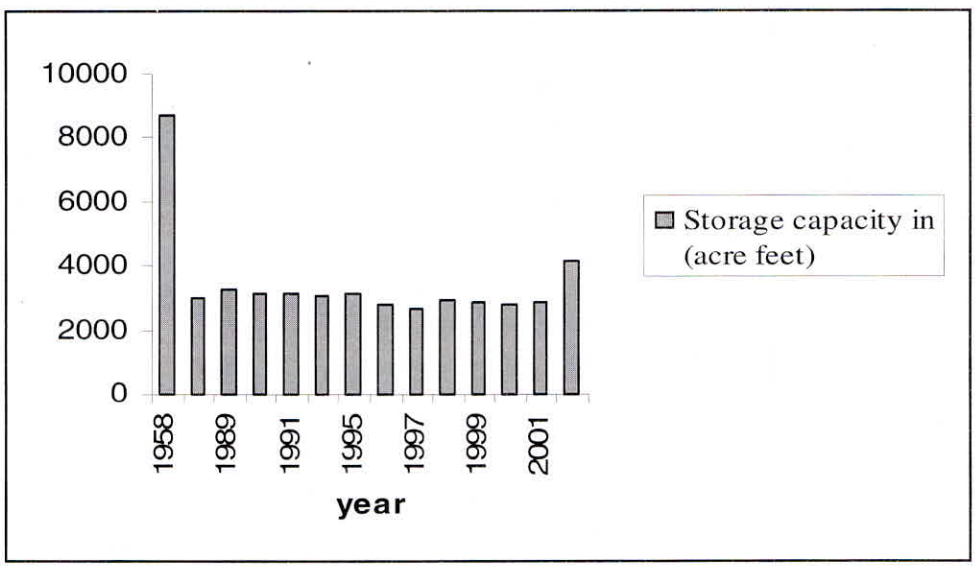
THE SUKHOMAJRI PROJECT

In the year 1975 the continuing problem of silting of the lake drew attention of the Central Soil and Water Conservation Research and Training Institute (CSWCRTI), Chandigarh. They identified a small hamlet 'Sukhomajri' located at the foot hills of Shivalik in Panchkula district of Haryana as the prime cause. Habitated by nomadic people until



Source: CSWCRTI (1993)

Fig. 2: Sedimentation of Sukhana Lake



Source: Bansal et al (1990)

Fig. 3: Storage capacity changes in Sukhna Lake

1975 Sukhomajri had no source of regular irrigation. The entire agricultural land (52 hectares) was under rain fed single cropping. Small land holdings coupled with frequent crop failures due to erratic distribution of rainfall, made agriculture least dependable as a means of adequate livelihood. Consequently, the people of Sukhomajri were forced to keep a large number of sheep, goats and cows to eke out a living. These domestic animals were allowed to graze freely in nearby hills. This open grazing followed by indiscriminate felling of trees for fuel and other domestic consumption led to denudation of hill slopes which were earlier lush green. (Fig 4 a. & b.)

To tackle the problem, CSWCRTI decided to take engineering and socio economic simultaneously. On engineering side, earthen dams were planned at various sites and constructed in the following years as depicted in table 1

On socio economic front, the interest of the local people was strongly tied up with the protection of hilly area, to ensure sustainable results. The water stored because of the construction of the dams was used to make the regular irrigation possible. With this immediate, direct and visible benefit the farmers could be motivated to protect the hilly areas. A development plan was accordingly chalked out. The earthen dams together

Table 1 : Details of rain water harvesting dams at Sukhomajri

Dam no.	Year of construction	Catchment area (ha)	Storage capacity	Command area(ha)
1	1976	4.3	8000	6.0
2	1978	9.2	55600	20.0
3	1980	1.5	9500	2.0
4	1985	2.6	19300	5.0

Source: CSWCRTI (1993)

created storage of 8.33 ha m which could be used for irrigation for enhancing agricultural productivity. In this project of runoff harvesting and recycling, it was important to conceive a system of vegetation that by and large induced more water while safeguarding against rapid siltation of the storage reservoirs. Accordingly maximum emphasis was given on raising grass rather than thick cover of trees and bushes. To stabilize bare slopes shallow contour trenches, 2.5m x 0.3m x 0.3m, were dug out and 'bhabhar' grass (*Eulaliopsis binata*) was planted on their ridges as well as on other slope areas where construction of such trenches was not possible (Sinha, 2005). Check dams were provided in the gully bottom to stabilize the gully and thereby to stop its widening and deepening. The area was completely protected against grazing and illicit cutting. In order to minimize seepage loss and also to have better control over irrigation water in undulating fields the water conveyance system was constructed with 15cm diameter cast iron pipes laid under ground 0.8m to 0.9m below the surface. Suitable command area development including land leveling and grading was also carried out for which the cost was shared between the people and the government on a 50:50 basis. Improved seeds and fertilizers were

provided to the farmers on payment basis in the areas where irrigation water was made available. The total food grain production in the village went up from 450 quintals in 1975 to 1824 quintals in 1986 from the same area. The average net sediment inflow rate in the lake reduced from 141 to about 15 tones per year per hectare of the catchments. The economic viability of the project was found to be high with benefit cost ratio of 2.75:1. Further, the benefit cost ratio for agricultural practices rose from1.6 (1977) to 2.5 (2000) whereas the same rose from 1.1 to 1.9 for dairy sector (CSWCRTI, 2000). This clearly induced decreased dependence of the people on cattle rearing and increased practice of agriculture as given in table 2.

Table 2 : Changes in production in Sukhomajri village

Commodity	1977	1986
Wheat (tonnes)	40.6	63.60
Maize (tonnes)	40.9	54.3
Grass (tonnes)	.04	3
Goats (numbers)	246	10
Buffaloes (numbers)	79	291
Milk (liters/ day)	334	579
Tree density (number/ha)	13	1292

Source: CSWCRTI (1993)

MANAGEMENT BY SOCIAL FENCING

A novel management strategy was formulated and adopted in this project for making the impressive results lasting and sustainable. This was meant to ensure people's involvement and participation. Initially a bargain was struck with the villagers to allow them to collect dead and dry wood and pruned branches for their domestic consumption rather than chopping the whole tree. They were also allowed to cut grass from the forest area for feeding their cattle but not to graze their animals in hilly watersheds and indulge in illicit cutting of vegetation.

Available stored water was used as a tool for further strengthening and consolidating the system. In India water right is appendix to land. Irrigation water in our country is traditionally allocated only to those who own agricultural land. Those having more land automatically get more water and the landless remain totally deprived of it. In this project a departure was made from the traditional system and it was decided to allocate water first to 'people' and secondarily to 'land'. A new method was designed to ensure water right for every family including landless one living in the command. Under the system each family gets equal share of water and is given a coupon for fixed quantity of water to be drawn in a certain period. If any family is unable to utilize a part or whole of such water, it can sell it back to the society that manages the system at a fixed price or to any

other family at a price mutually agreed upon. All such sales have to be decided before the sowing of a crop starts. This method has been named 'Haqbandi' (rule of right) and has made every family a stakeholder in the project providing adequate incentive to safeguard and protect the project. The project is managed and run by 'Water Users Society' subsequently renamed as 'Hill Resource Management Society'. Every family living in the command has a member in this society which looks after protection of hilly areas from grazing and illicit cutting of vegetation, distribution of irrigation water among its members and maintenance of dams as well as all appurtenant works. It has a board of directors including some specialists. This system based on 'Social Fencing' has worked wonderfully well and fully deserves replication elsewhere.

RECENT PROBLEMS FOR THE LAKE

Sukhomajri village provides an example of sustainable lake siltation control through improved watershed management. A sound land care system, based on the principle of social fencing, was not only capable of triggering a range of farm and non-farm activities, but also regenerated biotic resources. However, the sustainability of this unique resource management program is threatened by the arbitrarily division of the 400 ha hill tract between Sukhomajri and the neighboring village of Dhamala by the Forestry Department in 1995. The upper caste village of Dhamala was given a richer portion of the forest. Instead of sharing forest produce and grazing rights in the whole area, the two villages are now competing for forest products. This leads to social tensions and may cause a conflict in the area.

An important challenge related to watershed protection initiatives is the question of scaling up the local example and replicate it on a larger scale. Sukhomajri village has become a model of community-based watershed management for the rest of the country. Following the successful example of Sukhomajri, several other eco-restoration projects have started. In Madhya Pradesh, a state-wide watershed program of water and soil protection has generated considerable benefits. This program shows that watershed protection can be successfully replicated on a larger scale (Agarwal and Mahapatra, 1999).

PRESENT SCENARIO

The Chandigarh administration is keen upon rejuvenating the Sukhna Lake. To control the inflow of silt to Sukhna lake and for improvement of natural habitat for wildlife, its forest department has carried out soil conservation measures like construction of silt retention dams and development of water bodies, check dams, gully plugging, choe training works, spurs and graze stabilizers. Kana and arundonox have been planted along choe bank to stabilize the soil. Silt retention dams and check dams have been successful in retaining water which is available throughout the year for wildlife. Massive afforestation (table 3) supplemented with soil conservation measures have resulted in sharp decline in inflow of silt to Sukhna Lake. It is proposed in the action plan of 2008-

2009 that construction of two silt retention dams, 10 check dams, desiltation of 10 dams, raising of existing water holes-4 numbers, construction of two watch towers, live hedge planting -10000Rmt., opening of choe bed – 500 cubic meter and repair of four causeways will be carried out to conserve the soil around choe banks, 150000 stem cuttings of aundo- donex and ipomea will be planted along choe banks.

CONCLUSION

Silting is the major problem ailing the Sukhna Lake. However the Social fencing

Table 3 : Plantations around Sukhna Lake

Year	No. of trees and shrubs
2000- 2001	49600
2001- 2002	56358
2002-2003	25000
2003-2004	35070
2006-2007	50000
2007-2008	30000

Source: Greening Chandigarh action plan (2008)

as seen in Sukhomajri project and the massive plantations by Chandigarh administration every year have reduced the perils to the lake. This project has enabled siltation in Sukhna Lake to reduce by 95%, saving the city of Chandigarh about US$200,000 annually in dredging and related costs. Vegetation cover on the hillside increased from thirteen trees per hectare to 1,292 trees per hectare, raising the value of the forest to an estimated US$20 million capable of generating at least US$700,000 per annum (www.watershedmarkets-). Although the Sukhomajri project itself is facing backlash now but still this project paved a way to socio economic development as well as rejuvenation of a dying lake.

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