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People's Perception on Benefits from a Protected Catchment: A Case Study of Gundal Command in Karnataka

I

INTRODUCTION

Forests provide wide range of ecosystem services and thereby help communities to derive many direct and indirect benefits. Forest watershed services of absorbing rain water and releasing it slowly, allowing it to seep into the soil preventing run-off with sediments helps communities downstream to maximise the benefits from crop cultivation (McNeely, 1995; Kramer *et al*., 1997; ICEM, 2003; Dudely and Stolton, 2008). Thus protection of forested habitats can yield both tangible and intangible benefits to the community (Chomitz and Kumari, 1998). Disturbance caused to forest cover has been shown to have negative impacts on soil organic matter, nutrient availability and hydraulic characteristics and can thereby curtail services currently enjoyed by local communities (Mehta *et al*., 2008). Nevertheless, changes in forest cover could lead to either positive or negative changes in watershed services provided by them specific to the context (Lele and Venkatachalam, 2006) and sometimes protected forest ecosystems could negatively influence the probability of recharging the water resources reducing the income and employment opportunities in the command area (Lele *et al*., 2007). While the literature debates about the exact nature of benefits of protected catchments, we tried to assess what the beneficiaries realise from it. This paper presents results from a

study conducted in the command area of an irrigation project dependent on a forested catchment.

II

STUDY AREA

The study was conducted in nine selected villages of Kollegal taluk in Karnataka state in order to estimate benefits derived by the community from channelized water from the river Gundal. The river Gundal (Lat 12° 06" N and Long 70° 12" E) originates from *Dodda Sampige* reserve forest of Biligiri Ranganaswamy Temple (BRT) wildlife sanctuary located in Kollegal Taluk of Chamarajnagar district of Kanrnataka state, India. The river flows 53 km towards north to join river Kaveri near the village Saraguru in the same taluk. Gundal has been dammed (with length 1,219 mtr, height 31.55 mtr, and capacity 0.97 TMC) during early 1970's near village Kamagere and water has been channelized with an objective to irrigate 15,100 acre (10,100 by Left Bank canal and 5,000 by Right Bank Canal) with canals stretching 16.2 km long on both right and left sides of the dam. But, the canals have been successful in irrigating only 3,584 acre of land in total. Since the catchment of Gundal falls in BRT reserved forest, ecosystem services provided by forests feeds the reservoir. Based on existing literature (and in the absence of hydrological data in the catchment of Gundal) we assumed that rain water seeps into the BRT forest soils in the catchment helping to fill up the Gundal reservoir. Water in the reservoir provides various benefits to people, especially farmers in the command area of Gundal reservoir. Agricultural fields in the command area are distributed along the Right Bank Canal (RBC) and Left Bank Canal (LBC); together they irrigate about 12 villages, with 4,803 farms across the command. Basic information about these villages is given in Table 1.

TABLE 1. BASIC INFORMATION ON THE STUDY VILLAGES

Details	Total	Average/ village
Total geographical area- TGA (ha)	8479	1060
Total cultivable area- TCA (ha)	6629	829
Percentage of TCA to TGA	78.18	78.21
Net sown area- NSA (ha)	2697	450
Percentage of NSA to TCA	40.68	54.28
Area under canal irrigation (ha)	848	170
Area irrigated under tanks (ha)	821	205
Area irrigated under wells (ha)	891	178
Total irrigated area- TIA (ha)	2663	380
Percentage of TIA to TCA	40.17	45.84
Total number of families- TF	7511	835
Total number of agricultural families- AF	3990	443
Percentage number of AF to TF	53.12	53.05
Total population	35094	4387
Male	17694	2212
Percentage of men to total population	50.41	50.42
Female	17400	2175
Percentage of women to total population	49.58	49.58

Source: Offices of the Revenue and Agricultural Departments, Kollegal and Census 2001

III

OBJECTIVES

Benefits accruing to the command area community from the catchment can be divided into direct and indirect benefits. Direct benefits may be in the form of drinking water, crop production, fish catch, drinking water for livestock, and water for washing livestock. Indirect benefits may be increase in the groundwater table, recharging of water in open wells, improvement in biomass, increased soil moisture facilitating multi-cropping in a year and so on. Group discussions in the selected villages revealed that wherever canal water reached, the perceived benefits from Gundal are mainly crops and fodder and hence, we decided to quantify how well these are realised and other benefits are perceived. We estimated the direct benefits derived by the community using either market price for their farm produce, or using shadow prices for the non-marketed produce or using the costs avoided. It is difficult to quantify and monetise indirect benefits objectively and hence, they are expressed as perceived by the community. Objective of the paper is to estimate the direct benefits accruing to the community in the Gundal command and to assess the perception on indirect benefits there by implying the perceived relevance of protected catchment to downstream communities.

IV

METHODS

We surveyed 162 respondents (3.4% of the total beneficiaries) scattered in nine different villages along six gates of RBC and seven gates of LBC. Number of respondents in each gate is fixed proportional to the total number of beneficiaries under that gate. Each respondent is approached personally with a semi-structured questionnaire, and data about his/her family, occupation, and irrigation were

collected. We also gathered qualitative data on people's perceptions about the indirect benefits like improvement in the water quality, water table, soil moisture, and biomass of the surrounding areas attributable to the flowing water of Gundal canal. Specific methods used to estimate the direct benefits are described below.

Benefit and cost of cultivation

Gross and net direct benefit that the community derives from Gundal canal is an aggregate of respective gross and net benefits from crop and fodder.

The cost incurred by a farmer is taken as the sum of cost of farmyard manure, chemical fertilizer and pesticide used and opportunity cost of family labour involved in cultivation. Seed cost is excluded as they use their own produce of the previous season. Instances of hired labour for cultivation are negligible as all the respondents we surveyed worked in their own land and hence, we calculated opportunity cost.

Opportunity cost of family labour in cultivation is calculated as the foregone wages in the locality. Two types of employment opportunities in a year- the National Rural Employment Guarantee Program (NREGP) that provides 100 days of employment for one person from each family paying Rs 82 per day and other casual labour available for a maximum of 30 days in a year on an average daily wage rate of Rs 75[1].

If a family has 'n' adult members, then probability that a person from that family getting income from NREGP work is 1/n. The probable income to any adult member of the family from NREGP is given by

[1] Daily wage rate is Rs 100 for men and Rs 50 for women.

(1/n person x 100 days x Rs 82) ---------- (A)

In a family of ‘n’ adult members, it was gathered that ‘n-1’ people can avail this casual labour as one person is engaged in the household work. Hence, probable income from other casual labour to any adult family member can be calculated as

(30 days x Rs 75) ---------- (B)

(A) and (B) provide the income that any adult member of any family could get in an year if s/he is not working in the family farm. The potential foregone wage income per person per day (W) if s/he does not work outside family farms will be the sum of (A) and (B) divided by 365 days.

W = (NREGP wage income + Casual wage income) / 365 ---------- (C)

Hence, for a family that spends three months in its own field for cultivation, the opportunity cost of family labour in cultivation can be calculated by multiplying per person per day foregone wages (NREGP + Others) with the number of adult members working (usually n-1) for number of days in their own field.

[n-1 persons x 90 days x (W)] ---------- (D)

Benefit and cost of fodder

Gross benefit from fodder is the cost saved in not having to purchase fodder at the prevailing rate of Rs 10 per cattle per day. Due to flowing water in the Gundal canal, there has been fodder growth in the area surrounding farmers' fields giving access to fodder all through the year. Hence, they graze their livestock in the fields and surrounding areas and do not spend money on fodder. This savings due to availability of fodder attributed to Gundal water flow is the gross fodder benefit and is calculated using the number of cattle and price of fodder to be bought per cattle per day (i.e., Rs 10). Net benefit accrued from livestock maintenance is the difference between money saved due to not purchasing needed fodder (i.e., gross benefit from fodder) and the opportunity cost of family labour involved in livestock maintenance.

Opportunity cost of family labour in grazing is the value of time a family spends on grazing. A family that spends 4 hours per day on grazing spends 180 days in total per year on grazing. Hence, the total opportunity cost of family labour in grazing is

[180 days x one person x (W)]

To sum-up, benefit from crop comes in the form of harvest and the cost of cultivation includes input cost and the opportunity cost of family labour involved in cultivation. Benefit from fodder is the cost avoided in not having to purchase fodder and cost is the opportunity cost of family labour involved in grazing.

V

ANALYSIS AND RESULTS

This section provides an analysis of direct and indirect benefits accruing to the community from Gundal water. Direct benefits are benefits from crop and fodder production, water use, and water for livestock maintenance whereas indirect benefits are improvement in water quality, soil moisture and biomass in surrounding areas. The gross and net benefits from crops and fodder are calculated as mentioned in the previous section. The annual per capita gross and net benefits from crops and fodder are Rs. 11,333 and Rs. 7,804 respectively (Table 2).

TABLE 2. GROSS AND NET BENEFITS FROM CROP AND FODDER IN STUDY VILLAGES

Benefit	Average annual benefit per acre (Rs)	Average annual per capita benefit (Rs)*
Gross crop benefit	14,012	9,245
Net crop benefit	8,324	6,019
Gross fodder benefit	4,178	2,088
Net fodder benefit	3,349	1,785
Total gross benefit	18,190	11,333
Total net benefit	11,673	7,804

Source: Primary survey
Note: * Average family size is 5 persons

The average annual gross and net benefits per acre for the sampled respondents in the Gundal command area are Rs 18,190 and Rs 11,673 respectively

(Table 2). When we extrapolate this to total area irrigated in the command by the canal (i.e., 3,584 acre) the total annual gross and net benefits would be Rs crores 6.5 and Rs 4.2 respectively.

This apparently high value of the benefits from crops and fodder indicate what the catchment is worth but the incremental value of this benefit will be clearer when we compare these figures with that of farms in the neighbourhood, that are rain-fed. As implied in Table 3, the incremental value of net crop benefit per acre amounts to Rs 8,667. This resonates Kaiser and Roumasset (2002) as a small investment in conservation can protect a natural asset of rather enormous value as the catchment here is better protected and seemingly delivers tangible benefits of above mentioned magnitude.

TABLE 3. AVERAGE ANNUAL BENEFIT

Benefit	Irrigated farm	Non-irrigated farm	Incremental benefit from Gundal water
Gross crop benefit per acre (Rs)	14,012	2,620	11,392
Net crop benefit per acre (Rs)	8,324	-343	8,667

Source: Primary survey

This gap between irrigated and rain-fed farms in Gundal command implies the fact that just the geographical location of being in the command does not ensure benefits. Realisation of the benefits depends on existing water management institutions. There is no institutional set-up to use canal water for drinking purpose even when it is of better quality than other sources for drinking, thus curtaining

another potential realisable benefit. Thus the benefit estimates here are the lower bound potential change in benefits realised from a protected catchment.

Determinants of net benefits (crop and fodder) from Gundal water

Benefits realised by agricultural fields in the Gundal command is affected by number of factors apart from the regular availability of water. We aimed at establishing a relation between the benefit derived and the factors affecting it and also quantifying the extent of contribution made by all those factors to the net benefits derived by farmers.

The functional form of net benefits derived is as follows from a correlation matrix of all possible variables related to the net benefits in a Gundal farm.

Net benefits per farm = f (Qp, Qr, Qm, Qc, Qo, Ac, Gn, Ma, Fz, Pe, Fl, Wl)

Qs are Quantities of paddy (p), ragi (r) sugarcane (c) and other crops (o) produced

Ac – Area under cultivation

Gn – Gate number

Ma – Quantity of manure used

Fz – Quantity of fertilizer used

Pe – Quantity of pesticide used

Fl – Family labour involved in cultivation

Wl – Number of wells a farmer uses

The results of regressing the dependent variable net benefit per farm against the above mentioned independent variables are given in table 4. Apart from the intuitively correct relationships between net benefits and dependent factors (for example, with production of cash crops), there are a few surprises. These include the

negative relationship between manures and fertilisers with net benefits of a farm. This probably implies the high input costs compared to the prices of outputs.

Given the fact emerging from responses that canal water flow is erratic and undependable, we would expect farms at tail-end gates to be worse off with respect to net benefits and this could be expressed as a significant negative coefficient for gate number with net benefits. But such a trend along the canal gates does not emerge from regression. We looked at the distribution of land holding sizes across the gates to see whether that also is neutral to distance from the dam, as that could be instrumental in affecting net income (r = 0.59, significant at 0.01 level).

TABLE 4. RESULTS OF OLS REGRESSION

(DEPENDENT VARIABLE: NET BENEFIT PER FARM)

Independent variables	β	Standard error
Constant (α)	-2821.12	5151.04
Quantity of paddy produced (Qp)	0.48**	49.51
Quantity of ragi produced (Qr)	0.04	342.24
Quantity of maize produced (Qm)	0.29**	70.11
Quantity of sugarcane produced (Qc)	0.93**	3.29
Quantity of other crops produced (Qo)	0.004	20.73
Area under cultivation (Ac)	0.11**	909.71
Gate number (Gn)	-0.01	654.50
Quantity of manure used (Ma)	-0.20**	260.88
Quantity of fertilizer used (Fz)	-0.28**	113.76

Quantity of pesticide used (Pe)	-0.01	1664.86
Family labour size (Fl)	0.04*	1184.79
Number of wells (Wl)	0.10**	3287.91

Source: Primary survey
Note: R^2= 0.91 and F-Ratio= 124.98 significant at 0.01 level
** Significant at 0.01 level, * Significant at 0.10 level,

Distribution of land holding is more or less even across the gates except for a few large holdings located near gates that are closer to reservoir. Thus if water supply is erratic and uneven and the holding size is neutral to gate number, there could be some exogenous factor affecting net benefits. It turned out that fields located at the tail-end of Gundal canal are nearer to Kabini canal and receive water from Kabini canal. As we cannot quantify the crops grown using both water from Gundal and water from Kabini, the study fails to bring out the real relation between the gate number and benefits derived from Gundal.

Cropping pattern and cropping intensity

Flowing water of the river Gundal was channelized and diverted into two canals (RBC and LBC) so as to reach more number of farms than it used to do earlier when it was just a flowing river. In other words canal irrigation is a mode of maximising the benefits from the protected catchments. As water availability from Gundal canals could not explain the variation in net income across sample farms due to over lap of tail-end farmers with the command area of river Kabini, it could be explained by a temporal analysis of change in cropping pattern and cropping intensity before and after the canal irrigation. In the absence of secondary data on these aspects for the command area villages, we opted to collect the information by respondents' recall.

Though the river Gundal was also used for irrigation by neighbouring farmers, the access to irrigation benefits confined a few determined by the location of their land. The common opinion among respondents was that after the onset of canal irrigation, there has been a noticeable change in land use system, cropping pattern, and cropping intensity in the entire Gundal command. There has been a shift in crops from less water intensive crops to water intensive crops. Farmers in the area (but not near the path of Gundal) who used to grow rain-fed crops like ragi, maize, horse-gram, groundnut and other minor millets; turned to paddy and sugarcane. Closer to the reservoir (up to the Gate 3) this sometimes is a constraint, with the damp soil condition, as they can only grow paddy in all seasons. Some farmers had to stop farming because of stagnant water in their fields.

Maize and ragi have different reasons other than water availability for the change in number of farmers growing them like increased in demand for maize in the poultry farms and shortage of labour and low prices for ragi and horse-gram. Labour availability has decreased because most of them have moved to cities after acquiring education or skills, often moving up the economic ladder better than farmers. On the other hand, there has been a drastic increase in the number of farmers cultivating water intensive crops like paddy and sugarcane (Figure 1). With irrigation from Gundal, there is decrease in the number of farmers with no crops in their land (Figure 1) or a reduction in fallow.

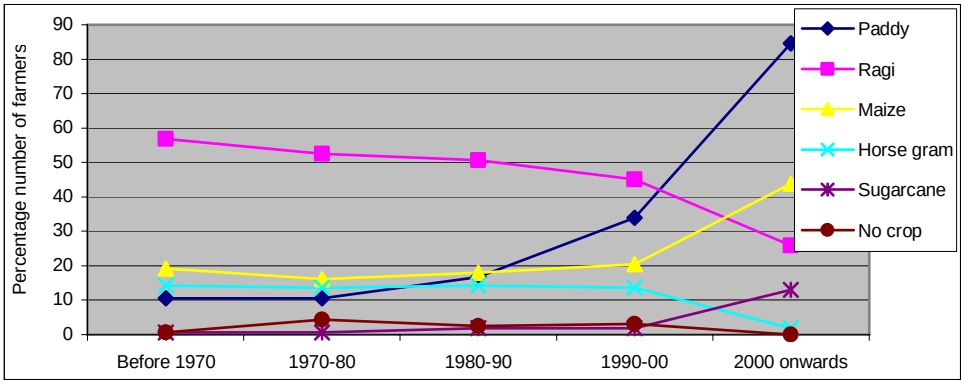

Figure 1. Percentage of Respondents Growing Different Crops over Time

Interactions revealed that after Gundal water got channelized, cropping intensity has increased. Farmers revealed that before Gundal dam, due to inadequate water supply their cultivation was not intensive with only single crop grown a year. After the arrival of canal water, at least two crops are raised by many in a year, which can be seen as the maximum cropping intensity value of 200%. The average cropping intensity value for all the respondents is found to be 90% which means there are still some land lying uncultivated because of various reasons such as financial and labour problems, water scarcity and water logging. About 43% of the land remains uncultivated due to lack of financial resources. This implies that unless the financial problem of the small farmers is tackled with proper credit facilities, irrigation would not help them to increase their net benefit from protected catchments. Water scarcity such as no rains seems to be the other problem leading to 30% of total area under permanent fallow. This problem was leading to conflicts potentially affecting the institutional mechanism of water use and sharing. However as the intention of this paper is not to look at the net benefit of canal irrigation (but to look at the actual benefits of Gundal water to the people in its command) we have not quantified these costs.

Water use and management

Apparently realisation and equitable distribution of hydrological benefits of the forested catchment is enhanced by canal irrigation. Though farmers derive better net benefits with irrigation as indicated earlier in this section, some of them still buy water because of irregular supply, and lack of full information about the date and time of water release. Among the 160 respondent farmers 5 were (3%) purchasing water.

There exists a Water Users' Association (WUA) (*Bramhalingeshwara Sangha)* for the RBC but, LBC doesn't have any association. The pattern of water release (time and frequency) is decided based on the water level in the dam by the irrigation department officials and the WUA office bearers. Among the total respondents along RBC, only 34% are members of the association and rest of them (66%) are unaware of existence of the association. The association meets once in three months. Nearly 8% of the respondents only are paying water usage charges. For only 6% of the respondents WUA seems to be useful. The problem with the WUA has been that, farmers do not want to contribute to it in the light of past inaction of the association. Malfunctioning of the canals also might have contributed to such a perception on WUA because only 43% of the respondents perceive that canals are functioning well. In order to improve the functioning of the canals 9% and 23 % of the respondents opined that canals should repaired and be rebuilt respectively.

Benefits from water can be maximised in Gundal by having a proper distribution system including proper maintenance according to villagers. The institutional problems that hinder people from getting the maximum benefits from canal are water conflicts within gates, lack of mechanisms for using good quality canal water for drinking, non-inclusiveness of WUA, lack of awareness about the

benefits from WUA among farmers, lack of small credit facilities to farmers and wastage of water due to lack of participatory monitoring.

Livestock and canal water

As no incidence of fish catch from the canal water was found, the only other direct benefit to the command area farmers was water for the maintenance of cattle. Livestock numbers have dwindled in Gundal command over the years mainly because of labour problem according to respondent farmers. Moreover, hybrid cows are now popular that do not need pastures and are kept a few in numbers. 71% of respondents own cattle and only 3% of them own sheep. Irrigated crops generate more crop residues and cows are fed with the crop residues.

About 63% of the respondents were using canal water as drinking water for livestock and 27% of the respondents are also using canal water for washing livestock. Villagers take cattle to the canal (though sometimes to the near by tank) for feeding cattle with water and also for washing. Time spent on these activities is accounted for in the net benefit estimations as the opportunity cost of labour involved in grazing cattle.

Indirect benefits

Flowing water of Gundal from BRT sanctuary has made people to realise some indirect benefits like improvement in the water table, soil moisture, and tree biomass of the surrounding area. The foremost benefit is the availability of fodder throughout the year (we have quantified the fodder benefit under direct benefits). Though we cannot quantify the indirect benefits in terms of numbers, we made an attempt to assess them based on the perception of the respondents about improvement

in groundwater quality, soil moisture, and biomass in the surroundings of the command though indirect benefits because of their non-tangible nature may not be perceived well (McNeely, 1995).

Farmers recognise that water in open wells and bore wells near the reservoir (up to 5th or 6th gates along both the canals) are benefitted a lot by the water in the reservoir. The total area irrigated in the command by other sources mainly tanks and wells are 3,332 acre 4,660 acre respectively. This indirect benefit from the Gundal water as recharge into the tanks and wells is recognised by respondents though we still lack hydrological proof.

Unlike direct benefits in crops and fodder, indirect benefits in improving the soil moisture, biomass and water quality are not perceived well. Only 7% of the respondents agree that Gundal flows affect water quality positively. Similar is the perception with respect to soil moisture and biomass where only 9% of the respondents acknowledge the improvement.

Apart from the probable influence of Gundal water on soil moisture, respondents fail to relate Gundal water to tree benefits in terms of better establishment of trees species in the command area, improving the diversity of the farming system. Estimated benefits from fodder availability (earlier in the section) implies that there probably is some improvement in the soil moisture and biomass in Gundal command and gives room to think that the low affirmation about indirect benefits in general (biomass and soil moisture) is because people fail to perceive and visualise the indirect benefits.

While the above analysis shows direct and probable indirect benefits attributable to a forested catchment, people in Gundal command perceive

provisioning services from the forest ecosystem (like food, timber, fodder, green and dry leaves, fuelwood, and other non-timber forest produces) better than other ecosystem services providing regulatory or support functions. This is interesting as they themselves are not beneficiaries of most of the former set of services except crop production. In the absence of locally available knowledge on how hydrological services contribute to provision of food, water and biomass, indirect benefits are difficult to be perceived.

VI

CONCLUSION AND POLICY IMPLICATIONS

There are studies reviewing the land use options for a catchment ecosystem for the downstream beneficiaries as also studies of potential value of various services provided by these ecosystems to the beneficiary communities. Few look at the quantum of benefits actually realised and perceived by any set of stakeholders of particular service flows and factors determining this realised value.

Quantifying the major direct benefits (crops and fodder) realised by 4% of the beneficiary population in a command area of an irrigation project dependent on protected catchments, this paper arrives at an estimated lower bound (as some direct and all indirect benefits are not quantified) annual net benefit of more than Rs 4 crores for 3,584 acres of command area. This works out to be Rs 8,667 more per acre, compared to un-irrigated farms in the area. Perceptions on direct and potential indirect benefits (biomass and recharge of water bodies) seem to be influenced by awareness on actual hydrological regimes.

Though establishment of the dam and irrigation canals are not absolute essentials as a free flowing river could bring in hydrological benefits from the forested catchments, realisation of the above direct benefits depends on many factors

including the reservoir. Important among them are – a) functional systems to deliver the service in line with crop requirements; b) inclusive institutional mechanisms for equitable distribution, conflict resolution, monitoring and maintenance; c) cropping pattern and cropping intensity adopted by the beneficiaries; and d) the right quantity and methods of input use. The latter two in turn depend on access to micro-credit and technical know-how. Advent of canal irrigation saw the cropping pattern changing in favour of water intensive crops as also an increase in cropping intensity. The shift in cropping pattern, low recognition of indirect watershed benefits as well as a significant negative relationship between input use and net benefits have repercussions for realised benefits in the long run. Thus we question canal irrigation in the study area as a socio-ecologically sustainable mode of harnessing benefit flows from a forested catchment.

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