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ABSTRACT

Conceptual development in the theory of externalities have opened up several policy options for their internalization including payment towards environmental services. Hence as externalities are social costs, accountability is crucial in increasing environmental awareness and for collective action through education and extension more so in developing countries. Here a modest attempt has been made to estimate externalities in water, forests and environment with field data from peninsular India to reflect on the economic perception of externalities by farmers and users of environment for the consideration of policy makers to devise institutions for payment towards environmental services.

The methodology largely used here in estimation / valuation of externalities is by considering 'with – without' situations (including 'before – after' in some cases) akin to 'project valuation'. Studies cover empirical estimation of externalities *inter alia* due to over extraction of groundwater, sand mining, watershed development, conservation of forests, sacred groves, cultivation of organic coffee, use of medicinal plants as alternate medicines and the annual values presented are in 2008 prices.

The negative externality due to sand mining 24 € per acre, that due to distillery effluent pollution is 34 € per acre. The positive externality due to watershed program is around 51 € per acre, and that due to rehabilitation of irrigation tanks is 26 € per acre. The positive externality due to cultivation of shade coffee is 9 € per acre and that due to forest conservation 27 € per acre. The positive externality due to sacred grove conservation was 12 € per family. The impact of forest conservation on Non timber forest products was 88 € / per tribal household. The positive externality due to use of medicinal plants as alternate medicine is equal to 35 € per patient suffering from osteo-arthritis and 19 € per patient suffering from peptic-ulcer.

While these estimates are not sacro sanct as the methodologies for valuation of externalities are subject to further review and improvement, they however serve as initial indicators of spillovers. And they signal possibilities for consideration of policy makers for devising alternate institutions for potential payment towards environmental services.

***Keywords* — Externalities, Environmental services, Sustainable development**

I. INTRODUCTION

There are no compelling reasons to reject that India's green revolution brought food security to the masses at the cost of overdraft of groundwater, forests and environmental resources causing negative externalities in the process. However, recognition of the existence of externalities is they negative or positive by researchers in India and their valuation has been a recent phenomenon. Often, methods used to estimate and the estimates themselves are seldom available for comparative studies. Among several environmental resources, groundwater has been the closest link with food production, agriculture and rural development in India. Hence most agricultural and rural developmental programs *inter alia* watershed development, irrigation tank rehabilitation program, soil and water conservation and forest conservation have directly or indirectly resulted in groundwater recharge, while their primary objective has been the broader agriculture and rural development. Hence estimation of externalities in the ambit of its classic definition [1] is appropriate and is in order. This paper is a modest attempt to highlight results of field research undertaken by the graduate student research in Agricultural Economics in different institutions regarding methods and estimates of externalities which provide indications of their magnitude in water, forests and environment. While the results pertain to post 2000 period, they are expressed in 2008 prices.

II. MATERIALS AND METHODS

The study pertaining to externalities (Fig A) due to sand mining and distillery effluent pollution was undertaken in North Pinakini river basin [4], where sand mining has two effects: first, it inhibited riverbed's ability to hold groundwater and second it reduced the recharge of water to open wells, ponds in the vicinity. Next, effluents in such areas exacerbate the predicament as they affect groundwater quality. Hence externalities due to (i) sand mining and (ii) distillery effluent polluting groundwater in sand mining area are estimated. Distilleries are agro based industries producing ethyl alcohol for industrial use. This process which releases spent wash effluent is stored in unlined lagoons. This is polluting groundwater affecting prospects of agriculture, health, environment and rural development. This is a classic case of externality since (i) sand miners and polluter while doing their main business deplete groundwater and affect quality which are unintended side effects, (ii) there is neither any contract nor any price system between the polluters (sand miners and distillery) and the victims (farmers) governing the impact, and (iii) this lead to both inefficiency in farming as well as welfare loss. The farmers of the study area (of Kolar District, Karnataka) lead a delegation to the Government of Karnataka who constituted a panel to study the impact of sand mining to explore the possibility of banning sand mining.

Field data from thirty groundwater farmers affected in Sand Mining Area (SMA), thirty farmers affected by both Sand Mining and Distillery Effluent Pollution Area (SM & DEPA) and thirty farmers in the immediate neighborhood where no sand mining or excavation is undertaken are juxtaposed (as control). Following the studies by Hemalatha, et al [2] and Varuni et al [3] in estimating the negative externalities due to sand mining and distillery effluent pollution, this study proceeds a step ahead by computing the negative externality attributable to distillery effluents in the presence of sand mining activity.

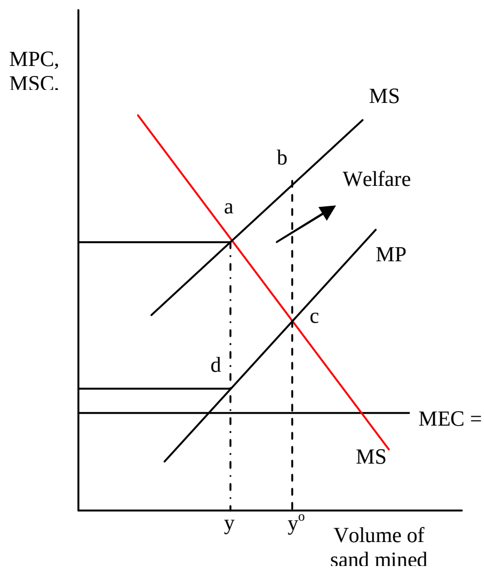


Fig. A: Negative externality due to mining of sand from river streams

Since groundwater is extracted from irrigation wells, life and age of the wells are affected due to sand mining. Due to distillery effluent pollution, the quality of groundwater will be affected which results in corrosion of pumpset and conveyance pipes and the associated expenditure on repairs and maintenance.

The groundwater extracted in each agricultural season is estimated as equal to the (Frequency of irrigation per month)*(number of months of crop)*(number of hours to irrigate the crop area per irrigation)*(average yield of well in gallons per hour (GPH) / 22611. The annual cost of irrigation is equal to amortized cost of irrigation well + amortized cost of conveyance + amortized cost of pump set and electrical installation + annual cost of repairs and maintenance.

Amortized cost is apportioning initial investment on irrigation well over the average life period of irrigation well at a real rate of 2 percent. The amortized cost varies with the type of well, status of the well, year of construction, average age of well and the negative externality due to cumulative interference of irrigation wells. The Amortized cost of irrigation well = [amortized cost of well + amortized cost of pump set and accessories + amortized cost of conveyance + annual repair and maintenance cost of pump set and accessories]. Amortized cost of well = [(Compounded cost of well)*$(1+i)^{AL}$*i] / [$(1+i)^{AL}$-1], where, AL = Average life of wells. Compounded cost of well = [(well cost)*$(1+i)^{(2004\text{-year of construction})}$. The Amortized cost of pump set and accessories = {[(Sum of compounded cost of pump set + pump set house + electricity at current price)*$(1+i)^{15}$*i] / [$(1+I)^{15}$-1]}. The working life of pump set and pump set house is assumed to be 15 years. Amortized cost of conveyance = [(Compounded cost of conveyance pipe used)*$(1+i)^{10}$*i] / [$(1+i)^{10}$-1]. The working life of conveyance pipe is assumed to be 10 years. The usual mode of conveyance is through PVC pipes. The cost of irrigation per acre inch of groundwater extracted = [Total amortized cost of irrigation / total acre-inches of Groundwater used]. The negative externality per well is estimated as equal to amortized cost per functioning well minus amortized cost per well. This methodology is adopted in other studies pertaining to watershed, where results are presented.

III. RESULTS

The Payment for environmental services (PES) is an Externality correcting charge on sand miners and is similar to a surcharge to internalize for externalities inflicted on farmers. The PES for sand miners is the negative externality per irrigation well in terms of increased cost of irrigation, due to sand mining is 79 € in sand mining area, 139 € in sand mining and DEPA area and 37 € in DEPA area (Table 1). The negative externality in terms of loss in net returns is 380 € per functioning well due to sand mining, 610 € per functioning well due to sand mining and distillery pollution and 231 € per functioning well due to distillery pollution alone (Table 2).

Table 1: Access to Groundwater resource for irrigation in North Pinakini river basin, Karnataka, India

Particulars	**Sand mining area**	**Sand mining & DEPA**	**Control area**
Proportion of well failure (percent)	28	38	13
Gross irrigated area per functional well (acres)	6.68	6.62	8.56
Groundwater extracted per well (acre inches)	115	113	159
Groundwater extracted per acre (acre inches)	17.26	17.07	18.5
Irrigation cost per acre inch of groundwater used (€)	2.5	3.18	1.68
Net returns per functional well (€)	610	380	990
Net returns per acre (€)	91	57	116
Amortized cost of irrigation per acre (€)	42	54	31
Amortized irrigation cost per well (considering all wells) (€)	204	222	230
Amortized cost per functioning well (€)	284	361	267
Negative externality per well (€)	79	139	37
Net return per acre inch of groundwater used (€)	5.3	3.36	6.22

Note**:** wells include open wells, Filter point wells and bore wells, DEPA = Distillery effluent pollution area

1) Negative externality= Amortized cost per functioning well minus amortized cost per well.
2) Amortized cost per well =Total amortized cost of all wells/Total number of wells
3) Amortized cost per functioning well = Total amortized cost of all wells/Total number of functioning wells

4) Proportion of well failure = Number of failed wells divided by Total number of wells
5) Net return per acre-inch of groundwater used= Total net returns/Total groundwater used .

Table 2: Externality in North Pinakini river basin, Gauribidanur taluk, Karnataka, 2004

Measures of externality in terms of (1)	**Attributed to Sand mining (2)**	**Attributed to Sand mining & DEPA (3)**	**Attributed to DEPA (4)**
Net return per functional well (€)	-380	-610	- 231
Net return per acre (€)	- 24	-58	-34
Net return per acre inch of groundwater used (€)	-55	-171.5	-116.5
Net return per rupee of irrigation cost (€)	-1.56	-2.66	-1.1
Water yield (Gallons per hour)	-229.5	-411	-181.5
Age of well (Years)	-2.98	-4.04	-1.06

Note:
1. Negative externality is obtained as the difference between economic parameters in sand mining area (SMA) over control area and SM &DEPA over Control area (from Table 1); that for DEPA (Col 5) is obtained as the difference between Sand Mining & DEPA and Sand Mining (Col 4 minus Col 3).
2. Loss due to poor groundwater quality is expressed as the difference between SM &DEPA over SMA.

The issues for discussion include: 1. Conceptual framework estimating externalities due to sand mining – how relevant, methodological plusses and minuses and 2. How to strengthen environmental institutions and environmental governance in developing countries, challenges and opportunities

The study on watershed development on commons in Attappady hills [5] considered re-vegetation of degraded common lands in the Western Ghats, one of the World's biodiversity hotspots. This required the land to be left undisturbed after planting for establishment and necessary growth. In order to encourage planting and natural vegetation, restrictions were imposed to grazing. This caused reduction in the value of non timber forest products obtained from the common lands as the majority of the farmers depended on commons for fodder. This reduced their income from common lands (from 8.05 € to 4.85 € per acre, a reduction) of nearly 40 percent. This reduction in the income was compensated by the increase in farm income as well as in off farm income. The social fencing, ban on grazing and cutting fuel wood had an impact on conservation of common lands causing reduced dependence on commons which is an improvement in the direction of conservation. This study shows that there was a decrease in dependence on common lands for usufructs like fodder, fuel wood, Non timber forest products like honey, soap nut, and medicinal plants. The reduction in gathering NTFP is due to norms imposed by the project. There is reduction in the value of usufructs obtained from common lands due to ban on cutting fuel wood and restrictions on grazing. This reduction in income is partly offset by the increase in the wage income through the watershed project. Watershed development projects should compensate for such losses till the vegetative cover is established. The issues for discussion include: 1. What is the scope for payment for environmental services of a watershed by down streamers for the upstream interventions undertaken; 2. Can the payment for environmental services take place across countries at transnational scale.

In a related study, the environmental economic impact of World Bank sponsored Sujala Watershed Development Programme is reflected through the savings in cost of groundwater irrigation and augmented net returns to groundwater [6,7]. Field data were collected for 2004-05 from 30 farmers each in the upstream and downstream areas of Sujala Uttanur sub-watershed while 30 farmers in non-watershed area were chosen to represent the control. Field data from Sample farmers were classified based on (i) who possessed bore well as well as watershed structure/s, (ii) farmers who possessed no well but had watershed structure/s. Annual externality was worked for both inside and outside watershed areas to ascertain the differing degrees of predicament suffered by farmers. The cost of irrigation per acre inch was found to be 33 per cent lower in the Sujala watershed (2.82 € per acre-inch) than in the non-watershed area (4.23 per acre-inch). The amortized cost of irrigation per functioning well was 29 per cent higher outside watershed (211 €) than in watershed (164 €) and the annual externality cost incurred by farmers inside the watershed (41 €) was lower by 39 per cent than outside the watershed area (67 €). The net returns realized per acre of gross irrigated area were also higher in the watershed (207 €) by 46 per cent than outside the watershed (141 €). Annual net returns per acre from all sources in watershed was 236 € higher by 27 per cent over the nonwatershed (186 €), reflect the synergistic contribution of Sujala watershed program enlisting the participation of NGO's and farmers. The issues for discussion are : 1. If watershed programs have brought immense benefits to farmers, why the Development departments in India are still struggling with sustainability of watershed Programs, 2. Is there an inadvertent overestimation of benefits and underestimation of costs, including transaction costs of implementing watershed projects?, 3. Why the farmers with irrigation wells in the watershed program who may be relatively more benefited are not contributing towards sustainability of watershed projects, 4. Under what conditions can farmer beneficiaries be made accountable in watershed program (property rights issues)

While positive externalities due to organic farming are being mentioned, in this study a modest attempt is made to value them in India, where coffee is cultivated under shade, which is unique to India and no other country. The study is aimed at relative economics and prospect for transition to organic coffee production in India [8] using primary data from the sample of (20) Planters Cultivating Organic Coffee (PCOC), (30) Planters Cultivating Inorganic Coffee (PCIC), (10) Planters Cultivating Organic and Inorganic Coffee (PCOIC). The net returns were 262 € per acre for PCIC, higher than that for PCOC (185 €) due to cost saving by PCOC. With a 20 per cent premium for organic coffee, the net returns in PCOC are 239 €. The positive externality in organic coffee production where difference in the net return between organic and inorganic coffee plantation is considered as a proxy for externality, indicated that organic coffee production is a cost saving venture to a tune of 15 € per acre per anum. With low or zero transaction cost there is thus a wide scope for transition to organic coffee since India's coffee is virtually 'shade coffee', the precursor of 'organic coffee'. The key factor that facilitates the transition to organic is the tie up with Fair Trade Labelling Organization (FLO). Further Pigouvian subsidy of 15 € per acre per anum encourages the transition. In addition the policy could utilize WTO's Green box provision to include subsidies for shade coffee in India. Issues for discussion include: 1. Why India has not been able to market coffee as organic coffee, even though India is the only and the largest producer of shade coffee; 2. What steps India should consider while promoting its coffee as shade coffee

Tank rehabilitation is close to watershed development program as it aims at recharging the groundwater and also in managing the surface water. Irrigation tanks were the main stay for irrigated agriculture in Southern India including Srilanka. Institutions for managing irrigation tanks existed which were responsible for their sustainable use and development. The advent of green revolution coupled with governmental interventions largely reduced the sense of belongingness of irrigation tanks, thereby degrading their hydrological properties. Considering the predicament, the World Bank offered a loan for revitalizing the traditional institutions through an institutional innovation - Jala Samvardhane Yojana Sangha (JSYS) in Karnataka, India, through On-Farm Demonstrations (OFD)/Farmers Field School (FFS) and their impact on Socio-economic conditions. The economic impact of the new institutional innovation analysed [9] with field data from 135 sample farmers from 9 tank commands in India, revealed that, of the three major Farming Systems, dairy enterprise was the most successful complimentary enterprise for landless and marginal farmers suffering from lack of access to water. The net returns were the highest under Farming system I (with 361 € per acre), followed by FS-III (134 € per acre) and FS-II (397 € per acre). The effect of the institutional innovation was apparent across all the classes of farmers through use of cost effective modern technologies in tank management. The issues for discussion are 1. How relevant is recharge through irrigation tanks for sustainable groundwater irrigation in tank command areas, 2. What is the cost of groundwater irrigation under new tank institutions, 3. Whether the tank institution has reduced the transaction cost of managing irrigation tanks.

Water User's Associations hold the key for Irrigation Management Transfer in India. However, rating individual Water User's associations is a challenging task as the effectiveness of the institution hinges up on multiple components. These are interrelated interdependent, as well as location specific. Therefore, basing the judgment on one critical variable runs a risk of erroneous results. This issue is dealt here from a multidimensional perspective [10]. While analyzing the soft spots in the policy to highlight the requirements on the policy front, the financial and administrative domain intersection emerged as crucial component. This observation was further corroborated by the analysis of the views expressed by the administrators. The understanding was further enhanced by interacting with the actors on the field namely the Presidents / Office bearers of the Water Users Associations (WUAs). The members' perceptions about rating criteria were further strengthened through two powerful psychological tools. These five steps provided us with a list of variables that really matters in rating the functioning of WUAs. All these are used here for the classification with the help of Factor Analysis. It comes out of the exercise that about 19.77 percent WUAs could be rated as below average performance on the five step rating scale. Whereas, 26.74 percent show average rating and 54.65 percent WUAs are rated as good and very good. The issues for discussion: 1. With majority of the WUAs being rated as good, why the O and M charges are still not being recovered; 2. What changes are needed to make WUAs accountable, financially and socially 3. How environmental concerns be reflected in WUAs actions regarding sustainability and safety of irrigation structures and 4. If WUAs can manage irrigation projects, what are the benefits in terms of savings in transaction costs.

Study on conservation programs in Bhadra Tiger Reserve (BTR) in India a vital habitat for wildlife and other forms of life in the ecosystem and ecosystem conservation was conditioned by use and non-consumptive use values of the forests. A sample of 120 respondents consisting of 60 each from those living in the forest fringe (locals) and 60 tourists who visited Bhadra Tiger Reserve were interviewed [11] for field data. The extent of dependence was the highest in the case of bamboo followed by fuel wood, forest soil extraction for agricultural purpose, and grazing cattle during lean season. The results on factors influencing dependence of local people on forest resources revealed that education, income and number of livestock owned significantly influenced forest resource dependence. A unit increase in the level of education of the local people from the mean, reduced forest dependence ratio of the local people (FDR) by 0.59 *ceteris paribus.* Like wise a one unit increase in the income level of the local people from the mean, reduced the forest dependence ratio by 0.60 *ceteris paribus.*. A unit increase in the number of livestock from the mean increased the forest dependence ratio by 0.30 *ceteris paribus.* The general awareness among local people regarding the ecological significance of the tiger reserve was modest. However they expressed concern for protection of forest from various disturbances. Results of Option Value of BTR estimated using CVM using multiple linear regression indicated that the mean willingness to pay for protection of BTR was Rs. 400 (US $ 40 or 6.67 €) and was influenced by annual income, gender and number forest resources used by local people. The visitation rate of tourists to BTR was mainly influenced by mode of travel, marital status and travel distance. The demand for recreational visit was price inelastic being -0.22, thus undermining the influence of cost of travel to BTR in deciding on number of visits to BTR. The total non-consumptive value of Bhadra Tiger Reserve was Rs 67,29,427 per year (US $ 1,68,235 or 112157 €) including option Value and recreational value. The issues for discussion include: 1. Economic valuation of option and non consumptive use value has implications on willingness to pay for forest conservation by users, 2. Was there a close match between the WTP obtained by CVM and the non-consumptive use value estimate obtained by Travel Cost Method? If yes, what are the reasons, and if no, how can the analysis be improved to be inclusive? 3. What are the current policies of the Government and whether these policies directly or indirectly reflect the WTP / TCM estimates of conservation values.

Study on the economic contribution of non timber forest products to forest dwellers in Karnataka [12] indicated that Lichen was annually the major income generating resource fetching € 63, (43 %) to total income from NTFP collection followed by honey which generated an income of € 27 per household. In all, collection of different NTFPs provided an average income of 148 € per household from forests of western ghats (Table 3). The economic role of non timber forest products after the advent of Forest Conservation Act, is crucial to analyze whether and by what quantity / amount, tribals have been benefitted due to conservation. The gathering of non-timber forest products has issues *inter alia* (i) increased employment opportunities due to gathering, (ii) gender issues as tribal women are involved in gathering and harvesting NTFPs, (iii) conservation issues due to non sustainable forest harvest practices. This study presents the economic contribution of non timber forest products to tribal income and employment, and indirectly the economic empowerment of women in the Western Ghats of India.

The issues for discussion include: 1. With increasing economic opportunities for tribals and alternatives for wood and NTFPs, is there a decreasing dependence on forests? If so, is this limited or world over; 2. What institutions need to be framed to protect the interests of communities whose livelihood dependence on forests is crucial and how policies be framed to increase their stake in forest development; 3. What has been the success of JFPM and how conservation efforts be strengthened by JFM.

Table 3: Income generated by major NTFP in Karnataka western ghats area

Sl. Nr	Name of non timber forest product	No. of households involved in gathering from forests	Income generated in € per household per year)
1	Lichen (Indian stone moss)	77 (84.6)	63.13 (42.69)
2	Honey	84 (92.3)	27.16 (18.36)
3	Beeswax	43 (47.3)	6.85 (4.63)
4	*Acacia concinna*	46 (50.50)	18.16 (12.28)
5	*Sapindus laurifolia*	18 (19.8)	15.54 (10.51)
6	*Phyllanthus emblica* (Indian Gooseberry)	9 (9.9)	9.64 (6.52)
7	Turmeric	5 (5.5)	7.42 (5.01)

Sacred groves all over the world (Figs B and C) have been serving as repertoires of preserved forests for imparting the institution of preservation of ecology for posterity.

The size of sacred groves thus, is unimportant, but what is more crucial is the code of conduct instilled by them. The issue of concern here is that there has been drastic reduction in the area of sacred groves in India's Kodagu district, (referred as Devara kadu) due to encroachment for cultivating coffee and for habitat and livelihood by migrants from neighboring districts. The non-consumptive use and existence values of Kodagu village communities which led to the preservation of Devara kadu at least in their present form are grossly threatened due to lack of policy support.

The Willingness to pay of 11.7 € towards non-consumptive use value and 1.45 € towards existence value of devara kadu per family per annum is a reflection of the intention to contribute towards sustainability of the Devara kadu institution. This study has demonstrated that village communities in Kodagu have sustained the Wantrupian survival value of the devara kadu institution by contributing towards their use and existence values, and also by offering social fencing. Stewardship role of Kodagu village community offering social fencing for Devara Kadu (sacred grove) sustaining ecological and watershed functions for coffee plantations is a model worthy of emulation. In this study, willingness to pay (WTP_1) towards their own village Devara Kadu is the non-consumptive use value as indirect benefits are derived in the form of environmental benefits and increase in farm production. The Willingness to pay (WTP_2) towards preserving Devara kadu in other village is the estimate of existence value of the respondent towards his/her Devara kadu since s/he wants the Devara kadu to exist even though s/he does not derive any direct or indirect benefit from the sacred grove and does not visit the sacred grove now or in future.

The results obtained bring out the estimated willingness to pay for preservation of Devara kadu [13] in their village as well as their neighboring village. The WTP_1 the estimate of non-consumptive use value of devara kadu was much higher at 11.7 € per family than the WTP_2 the estimate of existence value of devara kadu being 1.45 €. According to standard CVM literature, "the only really valid measure of existence value is the willingness to pay amounts of nonusers". This study however suffers from this limitation, since the concept of Devara Kadu of Kodagu is neither easily appreciated nor understood by persons totally unknown to Kodagu culture and tradition.

Fig B: Sacred grove in Kodagu, India (Top) ; devotees performing traditional rituals around sacred grove (Bottom)

Fig C: Sacred grove in Oostakker, Belgium (Top); and devotees drinking holy water (Bottom).

Issues for discussion include, 1. economists have divided opinion regarding the very existence of existence value. 2. For estimation of existence value, the sample respondents need to be totally from a very different population, but not out of the users of sacred groves. Does this study suffer from that limitation and how is this reconciled, 3. With such a low existence value, is there any threat to sustenance of devara kadu institution in Kodagu

In a related study, the proposition that individual behavior is not often consistent with neoclassical individual representation of *homo economicus* when environmental goods are offered at the hypothetical marketplace, is tested. It can be seen that individuals often behave as *homo politicus* who maximise society's utility instead of their own utility. Results of the contingent valuation exercise is carried for estimating willingness to pay for conserving a sacred grove or sacred forest in southern India. The same individual is allowed to state his/her willingness to pay for conserving the sacred forest of the same village and neighboring village. It is to be reminded that sacred groves do not have direct use value due to religious and legal restrictions. The results show that the average willingness to pay to protect the sacred grove in the same village (11.7 euros) is 8 times higher than the willingness to pay for the sacred grove in neighboring village (1.45 euros) if the respondent belonged to *kodava* clan and 14 times higher (4.3 euros for former and 0.3 euros for the latter) otherwise. The respondents belonged to the specific clan offered 3.5 percent of their mean income as payment for conserving sacred grove in their village while non clan respondents offered 1.2 percent of the mean income. In case of the sacred forest in neighboring village, the 'kodava' clan respondents offered 0.4 percent of their income for conservation while non- 'kodava' clan group were willing to pay 0.09 percent of their income. A very high willingness to pay for sacred grove in the respondents' village indicates his/her cultural ties to his/her community and its forest that leads her to maximizing the society's utility. In the other context, this cultural undercurrent is absent and hence a drastically low willingness to pay is resulted. Difference between Clan and non clan willingness to pay also can be explained based on the strength of the cultural ties to the sacred forest. The issue for discussion is the relevance of the application of game theoretic format in explaining forest conservation behavior.

Estimation of externalities in health care due to alternate medicines provides interesting clues for research in health economics. With increasing need to provide affordable access to health care to economically disadvantaged sections of the society, it has become a necessity for the developing countries to evolve appropriate health policies. The contribution of alternate systems of medicine to this end is being acknowledged. Here the costs of treatment for two common ailments (Osteo Arthritis and Peptic ulcer) under the Allopathic and Ayurvedic (traditional Indian system) of medicine in India are compared [14,15]. Costs of diagnosis, treatment and opportunity costs viz., cost of side effects, convalescence were accounted for the duration of the treatment under both the systems. It was observed that in both cases, the Ayurvedic system of medicine afforded a more cost-effective alternative, validating the need to incorporate such systems into mainstream health-care policy.

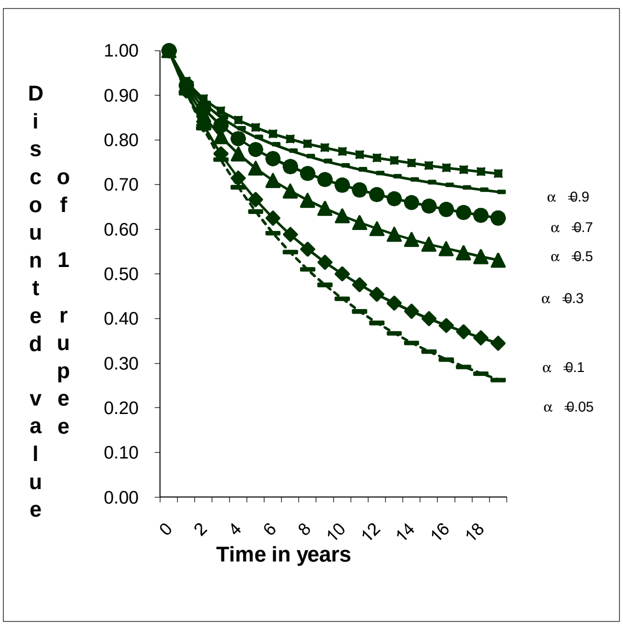
In the case of Arthritis, the cost of diagnosis works to Rs. 2200 in Allopathy. In Ayurveda, the diagnostic cost incurred is Rs 1500. The difference in treatment cost for a course of medication (for 3 to 4 months for Ayurvedic treatment and for one year for Allopathic treatment) between the two systems works to Rs 1470. This is inclusive of the cost of treating side - effects in Allopathic treatment, that includes the cost for treatment of gastric problems due to ingestion of Glucocorticoids. The cost of suffering or convalescence is estimated using the per capita income for Kerala (Rs 9066 per annum or Rs 25 per day). Hence, given a 15 day rest prescribed by Allopathy, the cost of suffering works to Rs 375. The savings resulting due to the Ayurvedic treatment is Rs 2095. If this saving is apportioned to the different medicines based on the proportion of cost of the medicines to the treatment cost, the savings per unit of medicines vary from Rs 99.5 for Gugguluthittakam to Rs 36.75 due to Dasamula hareethaki.

In the case of Peptic Ulcer, the patient can save Rs 1124 for a course of three to four months of Ayurvedic treatment compared with six to eight months of Allopathy. This saving, when apportioned to the individual medicines ranged from Rs 34 due to Sitavadakam to Rs 129 due to Vilvadilehyam. The findings of the study clearly indicate that the alternate systems of medicine are cost effective and hence should form an integral part of the health policy of a nation. This is especially true in the case of countries that already have a tradition of using such pluralistic systems. Hence, it is necessary that such decentralized systems of treatment be encouraged and brought to the mainstream to enable access to a healthy living even to those with relatively scarce entitlements.

Issues for discussion are 1. The basic difference in the two systems of medicine, is the presence of clinical tests in one and the virtual absence in the other. That being the case, how can the costs of alternative systems of medicine be measured and be compared, 2. If alternate systems of medicine are cheaper and effective, why the market for allopathy medicine is still encroaching the market for alternative systems of medicine. 3. What policy support is required to promote good alternative systems of medicine at least for chronic illnesses, 4 What are the implications of reduced health costs of using alternative systems of medicine on farm economy.

For estimation of externalities the choice of discount rate as well as discounting method are crucial. Financial institutions have been charging simple interest rate on agricultural borrowings. However, when borrowers default, they are charged at the compound (exponential) interest. Due to recurrent droughts in agriculture, default by farmer borrowers has been a rule than an exception. Thus, such farmers are put to financial stress in addition to drought. The 'exponential' discounting overestimates the interest payable by borrowers due to the exponential growth. This 'interest rate' is subsumed to incorporate (i) opportunity cost of capital, (ii) uncertainty in investment and (iii) intensity of time preference. The 'hyperbolic' discounting separately incorporates the intensity of time preference (Fig 1).

Figure 1: Hyperbolic discount function with varying levels of intensity of time preference 'α' at rate of interest=10percent



This article has three purposes: (a) to analyze the differences in loan repayment using exponential and hyperbolic discounting for groundwater irrigation to financial institutions; (b) to compute the real rate of change in investment per irrigation well in hard rock areas and (c) draw implications on the choice of discount rate and discounting method while analyzing natural resource economics and ecological economics issues. Apparently, the above analysis has two messages : (i) the nominal rate of interest used for amortizing investment on irrigation well to cost the groundwater, can be around 3 to 6 percent and (ii) the real investment per well is falling.

Considering the associated risks and uncertainties in agriculture in general and in groundwater irrigation in particular, which are reflected in huge loan waivers by the Government of India (a mammoth Rs. 60,000 crores = US $ 15,000 million in the 2008 annual budget), financial institutions can choose to adopt 'hyperbolic' discounting method to compute the dues in long term groundwater irrigation loans including agriculture loans. This will reduce the loan burden on farmer borrowers and serve the purpose of equity. While amortizing investment on irrigation wells, resource economists need to consider a realistic nominal growth rate of around 3 to 6 percent. However with the real rate of change in investment per well being negative ranging from –0.17 percent to –2.50 percent, natural resource economists / ecological economists valuing contribution of groundwater irrigation on farms irrigated by wells can use a social rate of around 2 percent hyperbolic, considering the intergenerational equity and sustainability in groundwater use, the societal concerns.

Issues for discussion:

1. If financial institutions adopt hyperbolic discount rate while lending, which discount rate they should adopt for savings and deposits? Obviously hyperbolic interest rate will fetch lower returns on deposits and savings. How then the financial institutions survive?
2. Which methodology (hyperbolic, compounding, simple interest rate, …) should be used to determine the growth rates in agriculture?
3. Can agriculture be made to grow at compound growth rate considering the limits applied by law of diminishing marginal returns to scientific progress

after the green revolution, resulting in stagnation in productivity of major crops

4. How to match the (endogenous) natural growth rate in agriculture / farming with (exogenous) financial growth rate

IV. CONCLUSIONS

The bunch of studies on the valuation of externalities in water, forests and environment have apparently brought out not only the estimates of spillover effects but also the associated inefficiencies, welfare losses and equity implications. It is in order for the policy makers to consider these estimates of externalities and devise institutions for internalizing them in order that the polluters pay for inflicting damages on victims. A massive awareness and education program is vital in developing countries towards sustainable extraction and use of natural resources. The results signal towards inefficiencies and welfare losses due to externalities and necessitate the policy makers to devise the Pigouvian taxes and subsidies to internalize them.

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