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Land Reforms and Groundwater Use- The Problem of Market Failure

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Abstract

In terms of scientific nomenclature, water is considered as a renewable environmental resource. However, in economic perspective this may be viewed differently. Economists always think of the demand for and supply of a product- here it is water resource. Water does have regeneration and recycling process as like other natural resources. But, if we consider the case of ground water then the over-exploitation of it with the advent of technological break though after the green revolution period and with the rigorous implementation of land redistributive programmes in India, ground water because of its non-excludable property confronted with the 'free use' and 'free riding' problems leading to market failure. This is referred as 'Tragedy of Commons'. That is the reason for which ground water has been subsided and polluted considerably. Thus, to be thinking critically, ground water is a depletable resource and has to be carefully utilized to guarantee sustainable development for our future generations.

Keywords:Groundwater, Green Revolution, Land Reforms, Market failure, Steady-state.

I. Introduction:

Ground water is a valuable gift of mother-nature. The survival of entire flora and fauna is dependent on its existence. Hence, the issue of management of ground water is a matter of serious concern for the ecologists, social scientists, policy makers and of course for the common people. In agriculture, ground water management is an important issue. This is even more pertinent for developing country like India in which agriculture is still very much dependent on the vagaries of nature. Thus, in India- where agricultural produce is still vulnerable especially for the small and marginal farmers who has limited access to the water market- appropriate policy prescription for the efficient use of ground water resource is of extreme importance.

Resources could be classified into three categories: Depletable resources, Renewable resources and Expendable resources. They are differentiated in terms of time scale of adjustment processes. All resources are depletable; but it's the renewable resources which adjust more rapidly for self-renewing. Ground water is primarily a renewable resource, its stock is depleted in every moment and is also being renewed within course of time by rainwater and snow melting into ground water or unconfined aquifer. Ground water, even if it's renewable, over exploitation may result as a potential threat to the sustainable development i.e. development of the present generations without compromising the needs of future generations. This could only be guaranteed if the ecology is not impaired.In this paper, the effectiveutilization and management of ground water resources have been critically explicated with the help of mathematical tools and formulations.

II. Statement of the Problem:

Indian agriculture experienced two major reform programmes after independence – the structural reform programme namely Land Reforms[1]and the second one is the technological reform programme called Green Revolution[2]. Ironically, these two major programmesendedwith two contradicting outcomes. The first one gave rise to a class of small independent poor landholders who, however, are forced to accept the new methods of agriculture and the second one resultedin a class of big farmers of farm houses replacing old types of zaminders.They became the owners of technologically upgraded means of production of agricultureand particularly also of ground water.Besides, small holders who could not afford to invest in their own means of irrigation are compelled to buy water from 'water markets' which offered a good profit to the sellers because of highly subsidized power tariff. In this backdrop, supply management becomes an impossible task because of its highly politicized nature. As a result, Indian agriculture experiences steady growth in groundwater use which must be checked for sustainable development.

III. Objective:

In this paper the conceptual framework within which economists examine the elements interacting in the management of groundwater resources has been postulated, and points to the mechanisms that can pull competitive groundwater price and quality-graded quantity of groundwater, in line with their equilibrium levels, have been forwarded.Moreover, in this study we have also tried to capture the impact of land reforms on the ground water management in India.

IV. Theoretical Backdrop:

India inherited a skewed pattern of land ownership from her colonial past. The policy planners of newly independent India put their faith in socialism and land reform through 'redistribution' to provide 'justice' to the actual tiller of the lands. The objectives enshrined in the reform programme aimed to put an end to the feudal structure in agricultural sector within the constitutional boundaries. For this purpose, land ceiling acts were passed and enacted in states, operational land holdings for land lords over and above the ceiling area[3] were identified, the surplus lands were vested and were finally distributed to the small, marginal and landless rural farmers, artisans etc. The present features of land reform programme in India have been delineated in table 1.

National Sample Survey Organization (NSSO), under the aegis of Ministry of Statistics & Programme Implementation, Govt. of India, acknowledges fifteen states as 'major states'. They are-Andhra Pradesh, Assam, Bihar, Gujarat, Haryana, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Orissa, Punjab, Rajasthan, Tamil Nadu, Uttar Pradesh and West Bengal. We have articulated our study on the basis of the above mentioned fifteen states of India. The land reforms statistics are given below-

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Table 1: Facets of Land Reforms Programme in India(as on 31st December 2015)

Sl. No.	States/UTs	Surplus Land	Possessed Holdings	Total Number of Beneficiaries
1	Andhra Pradesh	7,91,638	6,43,948	4,66,803
2	Assam	6,13,405	5,75,337	4,45,862
3	Bihar	5,23,504	4,31,310	4,61,136
4	Gujarat	2,37,976	1,81,447	38,360
5	Haryana	1,05,783	1,01,932	29,351
6	Karnataka	1,74,087	1,66,793	57,667
7	Kerala	1,33,700	1,00,186	1,68,912
8	Madhya Pradesh	2,23,264	1,90,449	47,061
9	Maharashtra	7,25,078	6,70,815	1,39,755
10	Odisha	1,80,935	1,71,268	1,43,485
11	Punjab	11,086	87,207	77,570
12	Rajasthan	595,152	5,54,693	77,629
13	Tamil Nadu	2,08,452	2,00,322	1,50,905
14	Uttar Pradesh	3,71,323	3,43,047	3,05,394
15	West Bengal	14,08,877	13,18,159	31,37,662
Total Land (Acres)		**63,04,260**	**57,36,913**	**57,47,552**

Source: Department of Land Resources, Land Reform Division, Ministry of Rural Development.

It is true that land reform is a technology neutral scheme of the government of India unlike green revolution; still it has had profound impact on the use of ground water. Infact, as a result of land reforms, there has been a paradigm shift in the pattern of operational land holdings amongst the farmers. Prior to the implementation of land reforms, most of the lands were got into the hold of the big land lords, zamindars etc. Thus, lands were skewedly distributed in favour of the land lords. Once, land reform was implemented- most of the surplus lands were vested and distributed among the landless poor or the marginal farmers. This incidence ensured egalitarian distribution of land resource in the farming community and released huge number of beneficiaries who became the actual owner of the lands they cultivate. Now after successful implementation of land reforms, it is the small and marginal farmers who register the lion share of operational land holdings. Thus, if one considers the Edgeworth-Bowley Box of land holding of farmers, then we could see that the inequality has been reduced to a considerable extent.

Anyway, if we examine the total factor productivity of any input for particular produce- water is the most significant ingredient to be supplemented for production. It is true that land reform has released surplus lands for the poor farmers; but to guarantee gainful supply of water for irrigation is beyond the scope of land reforms. Small and marginal farmers, owing to their poor economic status and limited access to the institutional credit could not always conform to the technological inventions and innovations in agriculture. Thus, in spite of having most of the cultivable lands under their direct possession, small and marginal farmers often could not utilize their lands properly due to their inability to bear the cost of cultivation.

Hence, whatever ground water extraction is being made is used mostly by the large farmers- as they have more affordability and sometimes, greater access to the institutional credit.

Thus, if the policy makers want to integrate land reforms to the 'efficient' and 'optimal' use of ground water then they have to ensure that each and every small and marginal farmers should have easy access towards water resource either through major or minor irrigation projects or through greater provision of institutional credit to them.

Now, let us look into the matter more intuitively. Consider the following table-

Table 2: Percentage of land holdings in states according to size in 2011-12

States	Marginal (<1 ha)	Small (1-2 ha)	Medium (4-10 ha)	Large (>10 ha)
Andhra Pradesh	71.54	24.78	3.37	0.30
Assam	75.77	20.55	3.51	0.17
Bihar	93.45	6.01	0.52	0.02
Gujarat	47.70	37.54	13.47	1.28
Haryana	58.35	23.61	14.60	3.43
Karnataka	58.62	32.57	7.78	1.03
Kerala	97.13	2.66	0.18	0.03
Madhya Pradesh	53.91	33.93	10.93	1.23
Maharashtra	58.14	35.12	6.16	0.59

Odisha	77.32	21.09	1.46	0.13
Punjab	22.58	26.84	41.00	9.57
Rajasthan	45.23	27.21	20.30	7.27
Tamil Nadu	82.28	15.51	1.98	0.23
Uttar Pradesh	84.27	13.80	1.81	0.12
West Bengal	85.37	14.29	0.33	0.01

Sources: Agricultural Statistics at a Glance 2012, Ministry of Agriculture, Govt. of India.

Demand of ground water for irrigation is resorted to the submersible and diesel pumps. Submersible pumps require uninterrupted electric supply at the time of irrigation which also incurs substantial electric cost. On the other, use of diesel pump wants diesel, mobil, coolant etc i.e. it also involves considerable amount of costing. We find negative correlation between land holdings of marginal farmers and demand of ground water for irrigation. The reason is that due to the paucity of fund- marginal farmers, in spite of having major chunk of operational land holdings (67 p.c.), could not afford such ground water extracting instruments. That's why; the demand of ground water for irrigation is low for marginal farmers. By contrary, due to the affordability of maintaining costing for such extracting instruments i.e. electric, diesel pumps- medium (4-10 ha) and large (>10 ha) farmers (jointly 10 p.c.) have greater demand of ground water for irrigation purposes. That's why; the correlation coefficient is positive.

From a different angle, this unplanned extraction mechanism has led to over use of ground water. Why? The reason is that- "Indian farming has grown on unmetered electricity that has led to large scale transmission and distribution losses, theft and corruption" (Source: Economic Times, April 02, 2011).

In search of higher profits, many farmers over use their pumps which eventually led to over exploitation of ground water. For this reason, now-a-days what we find that ground water is subsiding deep into the earth. In this context,-

"The woes of the country's electricity sector are well-known, but the discussion of emerging ground water crisis had remained confined to the obscurity of technical debates, till recently. Over-exploitation, and consequent depletion, of groundwater in the country is rapidly evolving into a major crisis, fuelling ever-increasing demand for free power and making farm more vulnerable and unviable" (Gulati, Ibid).

Table 3: State wise Ground water utilization, availability at Present and in Future in India

States	Replenishable Annual Ground water storage (Indicator of supply)	Annual Ground water Draft (Indicator of Demand)		Ground water availability for future use
		Total Demand	Demand for Irrigation	
Andhra Pradesh	33.83	14.15	12.61	15.89
Assam	30.35	6.02	5.33	21.50
Bihar	28.63	11.36	9.79	13.85
Gujarat	18.43	12.99	11.93	5.32
Haryana	10.43	12.43	11.71	-2.70
Karnataka	16.81	10.01	9.01	6.18
Kerala	6.62	2.81	1.30	3.02
Madhya Pradesh	33.95	17.99	16.66	13.76
Maharashtra	35.73	16.95	15.91	16.32
Odisha	17.78	4.36	3.47	11.94
Punjab	22.56	34.66	33.57	-14.57
Rajasthan	11.86	14.52	12.86	0.75
Tamil Nadu	22.94	16.56	14.71	4.70
Uttar Pradesh	75.25	49.48	46.00	17.22
West Bengal	30.50	10.91	10.11	16.75

Source: Ground Water Year Book 2011-12, Ministry of Water Resources, Govt. of India.

The HYV of seeds, chemical fertilizers and pesticides applied into fields after green revolution were highly water intensive. The states like Punjab and Haryana having good irrigation and other infrastructure facilities were able to reap most of the benefits of green revolution. It is true that they register faster agricultural growth[4] particularly as opposed to the eastern part of the country; but in doing so, this tech savvy agriculture, actually, led to an excessive use of ground water in those states. This fact has been depicted in the above table which suggests that due to the over exploitation of ground water in Punjab and Haryana there is a potential threat that this two states would have to face serious dearth of ground water in future. This is a critical national issue from the point of view of sustainable development goals of UNDP. Since water, that is to say, water supplies and irrigation are in the state list of the Seventh Schedule of Indian Constitution; so, respective state governments have to play the proactive role to guarantee the future availability of ground water. It is interesting to note that in the eastern part of India viz. Andhra Pradesh, Assam, Bihar, Odisha and West Bengal- the ground water availability for future use is noticeably higher as against most of other regions. The reason may be attributed to the fact that in the eastern part of India, extent of water extraction has been comparatively lower which, conversely, guarantee the potential availability of ground water for future use.

From table 3 it is important to note that if we regress future ground water availability (y) to two separate variables as cited in col 2 (X_1) and col 4 (X_2); then we are left with the following regression equation-

$$y = 0.950 + 0.838x_1 + (-1.004)x_2$$
$$t \quad (26.493) \quad (-22.240)$$

Thus, both X_1 and X_2 are statistically significant at 5% level. From the regression results it is reasonable to infer that too much irrigation is a serious threat for future availability of ground water either for agriculture or for domestic, industrial uses.

The demand for water and land so as to have greater production, in the present day India, has been continuously increasing due to its demographic changes. Therefore, without compromising with the rate of yield, an economically trustworthy water management mechanism is necessary. As per researches and studies (Kodary et al, 2017) suggest that water saving is upto 80% and yield increase is upto 100% for different crops by adhering to micro irrigation. To define, micro irrigation is the small scale application technique of irrigation above or below the soil surface in which either discrete or continuous drops of water spread out through water emitters. There are certain kinds of micro irrigation techniques; viz. drip irrigation, sprinklers- and all of them are technically feasible and economically viable. Moreover, they can be applied not only for large farms areas but also in the tiny acres of lands. This sort of irrigation technique has the added advantage of being suitable for hilly and undulated areas, coastal sand terrains, and to a great extent in the drought prone areas. Hence, for effective management of ground water the potential and prospect of micro irrigation is precisely high for tomorrow. The government of India, has realized the importance of micro irrigation into agriculture and sponsored scheme to support its prospect. Pradhan Mantri Krishi Sinchayee Yojana (PMKSY, launched in 2015), aimed at making India drought-proof and producing "more crop per drop", is a sincere endeavor by the government.

It's true that micro irrigation is still unequivocally not popular in all parts of India; but, it is becoming acceptable as an important means of alternative irrigation technique.

Table 4: Ground Water Development and Micro Irrigation coverage in India

States	Ground Water Development (%)	Percentage of net sown area under micro-irrigation
Andhra Pradesh	45.0	10.5
Assam	14.0	0.0
Bihar	44.0	1.9

Gujarat	137.0	8.1
Haryana	67.0	16.3
Karnataka	32.0	60.2
Kerala	64.0	0.3
Madhya Pradesh	57.0	17.2
Maharashtr a	47.0	8.3
Odisha	28.0	86.7
Punjab	172.0	11.3
Rajasthan	26.0	38.4
Tamil Nadu	77.0	1.8
Uttar Pradesh	57.0	14.3
West Bengal	40.0	0.3

Sources: 1) Agricultural Statistics at a Glance 2012, Ministry of Agriculture, Govt. of India.
2) Central Water Commission; Agricultural Census 2011, Govt of India.

The multifaceted nature of water resource management has made it an inter-disciplinary subject. The neoclassical economists have so far been focused on the decision making rules for water resource allocation and distribution. In addition, there have been cost-benefit analyses by the environmental economists as means to examine the investment option of the governmentin the mid-20th century (Tietenberg 2003).

Most of the Environmental economists, geographers consented Hardin's (1968) "tragedy of the commons" thesis. According to it, there would be one form of market failure for an open access resource- like ground water for which one can't deny the access or benefits of using ground water as it is non-excludable as per its property; whilst, because of this non-exclusion principle there will be over exploitation of it and it will suffer the community as a whole- it is a case of negative externality.

The modern economic analysis of natural resource problems is considered by most authors to comment with the article by Hotelling (1931) which identifies the need for an inter-temporal approach to exhaustible resource economics:

"the static equilibrium type of economic theory is plainly inadequate for an industry in which indefinite maintenance of a steady-state is a physical impossibility".

Clark (1990) also asserts recognizing the capital theoretic nature of resource stock is essential to a clear understanding of resource economics. From this view point, resource management simply becomes a special problem in capital theory.Nandagopalet al (2004)depicted in their joint study that the ever increasing demands for global water supply has put a serious threat to future food production. They argued that efficient water supplies can be ensured by means of conservation, recycling and improved water-use methods instead of opting for large development projects.

Presently, the United Nationsin its "2030 Agenda" has put forward 17 provisional Sustainable Development Goals. Goal 6calls for universal and equitable access to safe and affordable drinking water i.e. sustainable water security for all. This goal could be accomplished through efficient allocation of water resources by means of integrated water management system. By efficient allocation, we mean Pareto optimal allocation of resources[5].

V. Mathematical Model:

There has been two broad basis of classification for natural resources- 1) physical properties of resources and 2) time scale of adjustment of resources. Based onthese two properties, natural resources are classified into biological, non-energy mineral and energy;and environmental resources in terms of its physical property (Sweeney, 1992). Amongst this nomenclature, environmental resources include water as like air, forests etc. Again, in view of time scale of adjustment of resources, water is a renewable resource. It involves continuous regeneration process.Then, what is the necessity of ground water management? The reason is that the rate of decay or extraction of ground water is much more than it's recycling, which eventually assigns depletable characteristics into ground water resources.

The present paper has been developed with the mathematical formulations of ground water-as adepletable resource, with the help of steady-state growth model of capital. Let's start with the model-

At the outset, let us proceed with the elementary theory of capital. Let us consider machine for extracting ground water viz. electric pump or diesel pump set as a durable asset. It has been found that western and southern India came to depend heavily on subsidized electricity to pump groundwater while eastern states came to depend mostly on diesel pump sets (Mukherjiet al., 2012).Let v_t be the rent for its services during a period t and $p_t$be its price at the start of the period. Prices are measured relative to a numeraire asset, which is an investment, yielding a rate of return r_t. Since 1/ p_t machines can be bought with a unit of numeraire asset each of which yields a rent v_{t+1} in period t+1 and can be sold for p_{t+1}.

In equilibrium, the total returnfrom buying machines $(v_{t+1}+ p_{t+1})/ p_t$ equals the total return from holding the numeraire asset-

$$(v_{t+1}+ p_{t+1})/ p_t= 1+r_{t+1} \qquad \text{..................(1)}$$

Out of equilibrium, the opportunity exists for making pure profits by arbitrage. Equation (1) can be rewritten as-

$$v_{t+1}= r_{t+1}p_t-(p_{t+1}- p_t) \qquad \text{...............(2)}$$

i.e., a difference between the interest rates must be accounted for by a change in the price of the asset. If $v_{t+1} < r_{t+1}p_t$, the value of capital is appreciating, i.e. $p_{t+1} > p_t$. Conversely, if $v_{t+1} > r_{t+1}p_t$, the value of capital is depreciating, i.e. $p_{t+1} < p_t$. Now, equation (1) can be expressed in continuous time form:

$v(t) = r(t)p(t) - \dot{p}(t)$……………….(3)

where $\dot{p}(t)$ is the time derivative for p(t) and is the increase or decrease in the price of capital. In capital theory, equation (3) is the short-run equation of yield (Dixit, 1976) or the arbitrage equation (Dasgupta and Heal, 1979).

Now, consider the case of renewable resources. If we consider, in broader sense, ground water as a renewable resource, it involves a process of regeneration. In continuous time, the stock grows according to the function-

$\dot{s}(t) = g(x(t), q(t), t)$………………(4)

where s(t) is the stock and q(t) is the rate of harvest.

Here, we assume equilibrium has been reached where the growth in each period equals the harvest; that is $\dot{s} = g(x^*, q^*) = 0$.

(x^*, q^*) conforms to the set of equilibrium value for the respective variables. This is called steady-state equilibrium.

VI. Analysis:

Technological reform in Indian agriculture i.e. green revolution and institutional reform, namely land redistributive programmes have resulted in upsurge in the rate of return of ground water. At the same time, both the reform programmes have increased the use of diesel as well as submersible pumps in irrigation.In the early decades of both the reform programmes, rate of return from ground water outweighs the rental of submersible pumps resulting an appreciation in the relative demand for ground water. This led to over-exploitation of ground water and thus, eventually, resulting subsidence of ground water. However,after five decades of green revolution and after more than sixty years of implementation of land reform programme, Indian agriculture has come into the cross road with diminishing marginal productivity of land, thus resulting low rate of return of ground water, with high rental of machines for extracting ground water, as land reform programme has raised the accessibility of small and marginal peasants towards those machinesby way of availability of institutional credit.

VII. Summery and Conclusion:

In light of the above analysis, the paper recommends removal of energy subsidy to individual person rather cooperative groundwater management should be advocated. The cooperatives should be given a quota depending on the number of member farmers. The development and importance of

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water conservations should be pursued among the member farmers so that they can be aware of the danger of groundwater depletion.

Notes

1. Land Reforms is an age old redistributive programme of landed property started way back in the British India. In Indian Constitution in respect of delegation of power there are 3 lists, namely- Union list, State list and Concurrent list. Agriculture and Land specifically, rights in or over land, land tenures signifying the relation of landlord and tenant etc come within the purview of the State list of Indian constitution. There are certain pioneering states viz. Uttar Pradesh, Madhya Pradesh, Bihar, Assam etc which had introduced zamindari abolition Bills by 1949. Constitution of India was first Amended on host of factors. Two new articles, namely- 31A and 31B were introduced to uphold land reforms act and to validate its enactment pertaining to zamindari abolition. In West Bengal, the Estate Acquisition Act was passed in 1953 which was followed by the Land Reforms Act, 1955.

2. India is an agrarian economy having more than 50 per cent of the total workforce contributing around 17-18 percent to the country's NDP dependent on agricultural activities for their livelihood. Indian agriculture experienced upsurge in foodgrain production- particularly in cereals, pulses and oilseeds- since mid 1960s resulted from the introduction of high yielding verities of seeds supplemented with fertilizers, pesticides and irrigation. All these high yielding varieties, chemical fertilizers, pesticides etc are highly water intensive. This technological break though in Indian agriculture has been named as Green Revolution. It's still very much relevant for the agrarian development in the present day policies.
   To quote-
   "At present, Indian farmers are adapting farm mechanization at a faster rate in comparison to recent past. Although, the sale of tractors in India cannot be taken as the only measure of farm mechanization but to a great extent it reflects the level of mechanization." (Source: Former Chief Economic Advisor-Arvind Subramanian, The Economic Survey 2017-18).

3. Land ceiling limits is not unique and it varies between states.It is shown in the table below:

Table 5: Ceiling Limits for Land Holdings (Acres)

	Irrigated with Two crops	**Irrigated with One crop**	**Dry land**
Andhra Pradesh	4.05-7.28	6.07-10.93	14.16-21.85
Assam	6.74	6.74	6.74
Bihar	6.07-7.28	10.12	12.14-18.21
Gujarat	4.05-7.28	6.07-10.73	8.09-21.85
Haryana	7.25	10.90	21.80
Karnataka	4.05-8.10	10.12-12.14	21.85
Kerala	4.86-6.07	4.86-6.07	4.86-6.07

Madhya Pradesh	7.28	10.93-14.57	21.85
Maharashtra	7.28	10.93-14.57	21.85
Orissa	4.05	6.07	12.14-18.21
Punjab	7.00	11.00	20.50
Rajasthan	7.28	10.93	21.85-70.82
Tamil Nadu	4.86	12.14	24.28
Uttar Pradesh	7.30	10.95	18.25
West Bengal	5.00	-	7.00

Source: Agricultural Statistics at a Glance (2015), Ministry of Rural Development, Government of India.

4. After the initiation of Green Revolution in 1965-66 and upto its initial stage to 1972–73, an all-India growth rate of 2.08 per cent per annum was registered; however, it was achieved mainly due to the sharp increases in yield in the north-western region of Punjab, Haryana and western Uttar Pradesh (Bhalla and Chadha, 1982).
5. Pareto optimality is a state of allocation of resources from which it is impossible to further reallocate resources so as to make preference or criterion of one individual better off without making at least one individual worse off.

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