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WATER-RELATED SUBSIDIES IN AGRICULTURE: ENVIRONMENTAL AND EQUITY CONSEQUENCES

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Environmental and Equity Consequences[1]

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"*We do not wish to impoverish the environment any further, and yet we cannot for a moment forget the grim poverty of large numbers of people. Aren't poverty and need the greatest pollutants? How can we speak to those who live in villages and in slums about keeping the oceans and rivers and air clean when their own lives are contaminated at the source? The environment cannot be improved in conditions of poverty. Nor can poverty be eradicated without the use of science and technology*". Indira Gandhi (cited in "Rural Development-Putting the pieces in Place", World Bank, 1996).

Water-related subsidies in irrigated agriculture are virtually a universal phenomenon. It is estimated that farmers receiving water from government-built irrigation projects across the world seldom pay more than 20 percent of the water's real cost, and often much less (Postel, 1999: 230). Water-related subsidies in agriculture have been introduced for various social, political and economic reasons. Notably, these subsidies have been integral parts of the food security strategies of many countries. Today, however, the continued existence of these subsidies is a cause of growing concern for a number of reasons. First, these subsidies are proving to be fiscally unsustainable. Second, by encouraging inefficiency, particularly the wasteful use of irrigation water, they have resulted in serious environmental problems. The intensive use of complementary inputs such as fertilizers and pesticides in irrigated areas is blamed for being a principle polluter of water resources and soils (Ribaudo, 1989). Irrigation is also associated with groundwater depletion, overtapped rivers, waterlogging and salinization (SJVDP, 1991; National Research Council, 1989), the destruction of ecosystems, and the reappearance of virulent forms of malaria (Postel, 1999).

The social justification for water subsidies is also increasingly subject to question. Frequently, water subsidies have been found to be regressive. In some cases, there are also secondary equity consequences that arise from the environmental degradation associated with the unsustainable use of water. An example is a case where groundwater tables are drawn down by wealthier farmers who can afford larger electric pump sets and deeper wells, resulting in the drying up of shallow tubewells which poor farmers depend on for agriculture and drinking water.

Addressing the environmental and equity consequences of water subsidies will require broad policy and institutional reforms. Part of the process of initiating these reforms is a better understanding of the nature of these water subsidies, their magnitude and how they are distributed across beneficiaries. This is the primary focus of our paper. The paper is organized as follows. Section 1 conceptually describes how water subsidies affect the behavior of irrigators. Section 2 discusses the nature of water related subsidies in irrigated agriculture and some of their adverse environmental impacts. Section 3 then discusses the measurement of irrigation subsidies and their equity dimension using the example of canal irrigation in India. The final section concludes.

How does a subsidy for water affect the behavior of irrigators?

Let us examine the effect of subsidized irrigation water on the behavior of irrigators under two scenarios. The first scenario is the case where the irrigator does not internalize the environmental costs resulting from his water-use practices. An example of these environmental costs could be land degradation arising from the application of irrigation water in excess of the evapotranspiration rate that results in drainage water with high salinity. The second scenario is the case where the irrigator does internalize the environmental cost. While our example assumes that we have source-point pollution, this is not the usual case in irrigated agriculture. It is further assumed that all functions are known and well behaved.

Let $f(w)$ be the agricultural yield, P_y the price per unit of agricultural yield, w the amount of water used, P_w the price per unit of water. π and π_e represent the profit in the case of no environmental impact and in the case of environmental impact, respectively. $d(w)$ is the quantity of pollution created by the sector as a function of the amount of water applied, and P_d is the cost per unit of pollution. We assume that both $f(w)$ and $d(w)$ are well behaved, where $\partial f/\partial w > 0;\ \partial^2 f/\partial w^2 < 0$ and $\partial d/\partial w > 0;\ \partial^2 d/\partial w^2 > 0$.

In the case where pollution costs are not internalized, the profit function is $\pi = f(w)P_y - wP_w$. First order conditions for optimality yield $\frac{\partial \pi}{\partial w} = \frac{\partial f(w)}{\partial w}P_y - P_w = 0$, or $P_y^{ND} = P_w \Big/ \frac{\partial f(w)}{\partial w}$. In the case where pollution costs are internalized, the profit function is $\pi_e = f(w)P_y - wP_w - d(w)P_d$. First order conditions for optimality yield $\frac{\partial \pi_e}{\partial w} = \frac{\partial f(w)}{\partial w}P_y - P_w - \frac{\partial d(w)}{\partial w}P_d = 0$, or $P_y^D = \left(P_w + \frac{\partial d(w)}{dw}P_d\right) \Big/ \frac{\partial f(w)}{\partial w}$. Assume now that the price of water is subsidized and that $P_w = P_w - s$. Insert the subsidized price into the optimal conditions. In the case where pollution costs are not internalized the optimal rule is $P_y^{S\&ND} = (P_w - s) \Big/ \frac{\partial f(w)}{\partial w}$, whereas in the case where pollution costs are internalized, the rule is $P_y^{S\&D} = \left((P_w - s) + \frac{\partial d(w)}{dw}P_d\right) \Big/ \frac{\partial f(w)}{\partial w}$. Given the properties of $f(w)$ and $d(w)$, it is clear that $w^{ND} > w^D$, $w^{S\&ND} > w^{S\&D}$ and most importantly $w^{ND} < w^{S\&ND}$ and $w^D < w^{S\&D}$. A similar (more complicated, but more interesting) result can be obtained for a multi-factor agricultural production function (e.g., water, fertilizers and pesticides). In the latter case we can also show a 'multiplier' effect from the interaction of water subsidies with fertilizer and/or pesticide subsidies, water being the media through which the fertilizers and pesticides are carried.

The excess water applied for agricultural production can create negative externalities that are associated with prohibitively high social costs. In many countries, and especially in the developing world, the cost associated with correcting or mitigating these negative externalities (e.g., treating saline soils, treating groundwater (GW) for residential uses) are not borne by the users of the subsidized water. One reason for this is that externalities related to irrigated agriculture are in most cases non-point source ones, so that the internalization of the negative externalities (making the polluter pay) is hard to enforce at an individual level. Another reason is the political power of the agricultural sector. Therefore, in such cases, irrigators benefit from two types of subsidies: a direct subsidy via the price of water, and an indirect subsidy related to the mitigation of the externalities created by the sector.

Water-related subsidies in agriculture and some of their harmful environmental impacts

While the conceptual example above discusses a subsidy attached to a factor of production (water), governments subsidize agricultural production via both subsidies to factors of production and via crop price protection. The following section discusses the various subsidies, how they are related to each other, and how they may create negative environmental externalities.

Agricultural price support policies

Agricultural price support policies, to the extent that they encourage the production of water intensive crops in unfavorable environments, can have negative environmental consequences. Governments have various reasons to support prices of staple crops. In the US, for example, lobbying and political pressure have led to complicated price and trade barriers for rice that prevent competition from imports. Under such a system one can find huge rice production, a highly water consumptive crop, in the middle of the San Joaquin Valley of California, where high evaporation rates wipe out more than 50% of the applied water, contributing to water logging and downstream salinization. In Turkmenistan the distorted prices and production quotas for wheat and other staple crops grown in the middle of the Karacum Desert have led to continuous over-extraction of water from the Amu-Darya, resulting in further drying the Aral Sea and creating polluted return flows (Precoda, 1991). Supporting the price paid for sugar (beet and cane) in Morocco has protected powerful farmers and corporations on one hand, while on the other hand depleting aquifers of their scarce water (Diao and Roe, 2000).

Subsidized water price/charge

Pricing of water has both efficiency and financial objectives. To meet the efficiency objectives, water needs to be treated as an economic good thereby taking account of the opportunity cost associated with its use (Rogers et al., 2002). To obtain first-best efficiency, a marginal cost pricing mechanism is needed (Tsur and Dinar, 1997). In practice, irrigation water is priced in a number of ways including (but not limited to) a per unit area basis, per unit area and by crop basis, and volumetric-bulk pricing. The most common practice is to price water on a per area basis, which only assures financial sustainability via cost recovery. Full cost recovery, to the best of our knowledge, including the recovery of the full investment cost, has not been practiced anywhere. Instead, governments generally compromise by recovering only operation and maintenance costs, either completely or partially.

By charging (or undercharging) water on a per area basis, the incentive to use water efficiently is missing, and the result is overuse. In addition, if per area based charges do not generate sufficient funds for adequate operation and maintenance and governments lack the financial capacity to pay for the deficit, irrigation infrastructure may deteriorate leading to lower irrigation efficiency due to seepage and wastage off-farm. In both cases, the taxpayer shoulders the subsidy and the environmental consequences. Additional means to transfer subsidies to irrigators include: extension of the repayment period, deferment of repayment, and forgiveness of repayment on problem lands (Whal, 1989). As already described in the previous section, subsidized water sends a signal to irrigators that they can be less efficient without any repercussions.

The Central Valley Project (CVP) in California, a large Federal irrigation project, was designed such that the users pay a nominal price for water. According to LeVeen and King (1985), this created a US$3.5 billion subsidy that was handed to the irrigators (they estimated an annual cost for water of $185 per acre, annual payment by water contractors of $17 per acre, and an annual water subsidy calculated as the difference between these two values--$168 per acre). LeVeen and King argue that the under-pricing of the CVP water led to over use of water that created environmental problems on the West Side of the San Joaquin Valley. This was later scientifically proven by the National Research Council (1989), and by SJVDP (1991).

Subsidized energy for pumping water

Groundwater is a major source of water for agriculture, drinking water and industry in many countries. Developing and developed countries alike have also subsidized electricity for groundwater pumping purposes. Examples include India's subsidization of electricity for pumping groundwater for agriculture (Shah, 1993; Maria-Saleth 1996a) that has resulted in significant depletion of aquifers in various states, and California's electricity price policy in agriculture (CEC, 1992; Dinar, 1994) that led to the depletion and contamination of groundwater aquifers (DWR, 1990).

Other subsidized inputs

Fertilizer and pesticide subsidies in conjunction with water subsidies also have a substantial impact on water use and environmental pollution. However, we will not address these here.

Table 1 provides a summary of the various water-related subsidies, and examples of the mechanism through which these subsidies may harm the environment and their possible adverse environmental impacts.

Irrigation subsidies and their equity dimension

Our paper attempts to argue that subsidies, if not well designed, may directly and indirectly harm the environment, and the poor. Therefore, an understanding of the equity dimension of water-related subsidies is needed. This section of the paper addresses the measurement of irrigation subsidies and the equity dimension of these subsidies, drawing on on-going work at the World Bank related to surface irrigation subsidies in India (World Bank, 2002a).

Canal Irrigation Subsidies in India

Canal irrigation accounts for nearly 30% of net irrigated area in India and subsidies for canal irrigation have been widespread across Indian states. These implicit subsidies arise from two factors: water tariffs that are set well below the supply costs of water or not charged at all (e.g Punjab) and collection inefficiencies.

Various Indian Finance Commissions have made recommendations on how to charge for irrigation water and have concluded that water tariffs should at least cover the cost of operation and maintenance (O&M) of irrigation systems plus a part of the capital cost. The latest government of India National Water Policy (2002) advocates for pricing water so as to initially cover O&M costs of providing water, and recommends eventually charging for a part of the capital costs. The Tenth Finance Commission recommended full recovery of O&M costs plus one percent of capital costs (Maria-Saleth, 1996b). Policy makers have also suggested that water rates should be revised every 5 years and should lie within the range of 5 to 12 percent of the gross revenue of farmers in the canal command area (Gulati, 1999).

Table 1: Some examples of possible environmentally harmful consequences of water-related subsidies.

Description of the subsidy	The mechanism through which it may harm the environment	How it may harm the environment
Agricultural price support policies	Incentives for farmers to grow water-inefficient crops in unfavorable environments.	Salinization, water-logging and/or decline in groundwater tables.
Surface water price	Overuse of water and cultivation of water-inefficient crops. Use of inefficient technologies.	Pollution and depletion of water bodies. Salinization, elevated levels of water tables & drainage problems.
Electricity price	Substitution of surface water (SW) with GW, especially in places where SW supply is inadequate or irregular. Overuse of groundwater due to excessive pumping.	GW levels are lowered, aquifers are depleted and contaminated via intrusion of low quality water from adjacent aquifers or sea water intrusion.
Pesticide prices	Overuse of pesticides and inefficient application management practices leading to high rates of pesticide leaching.	Pesticides contaminate GW aquifers and may create irreversible health damages.
Fertilizer prices	Overuse of fertilizers and inefficient application management practices leading to high rates of fertilizer leaching.	Fertilizers can increase soil salinity and contaminate GW aquifers. They may also adversely affect the development of infants.

Water charges for the use of canal irrigation water are set by state governments with each state adopting different norms. In general, states rely on non-volumetric methods to charge for canal irrigation water, most commonly on a per unit area by crop basis. Charges for irrigation water may also vary by season, delivery method (individual or bulk), across regions, across schemes (minor vs major schemes) and/or within projects (reflecting dependability and continuity of irrigation services).[3] In Tamil Nadu, irrigation fees are set as a proportion of the land tax charged to farmers. The use of volumetric pricing for surface irrigation is expanding, but remains limited to a few states (Maharashtra, Uttar Pradesh, Rajasthan).

[3] In India the culturable command area of a major irrigation system is above 10,000 ha, that of a medium irrigation system is between 2,000 and 10,000 ha and that of a minor irrigation work is less than 2,000 ha.

Some states impose betterment levies on canal irrigation water or an irrigation cess in addition to water charges (Maria-Saleth, 1997).[4]

Despite the prevailing advice on water charges, in practice, water tariffs have generally been set at levels that do not cover O&M costs. Moreover, states have frequently failed to regularly revise water charges once they have been set. Lax enforcement of fee collection, a disconnect between the user charge payment and the provision of adequate and timely irrigation services, and a lack of coordination between departments in the sector have collections falling below 100% of assessed charges.[5]

Over time the cost recovery situation has worsened and the proportion of working expenses spent on maintenance and repairs has also declined. The major part of the funds designated for O&M are being incurred on establishment costs (staff salaries) rather than on actual maintenance of the system. Data from the 1990s reveal that the share of establishment costs in total O&M expenditures averaged 70% in six Indian states surveyed (Joshi and Hooja, 2000). As funds spent on works have dwindled, irrigation and drainage infrastructure have not been maintained resulting in choked drains and irrigation commands not fully receiving water. In addition to the environmental consequences this has had an adverse impact on the revenue base, posing a further challenge for cost recovery.

By all accounts, subsidies to surface irrigation across Indian states are sizeable. Based on data from the 1980s and early 1990s, Dhawan (1997) estimates that nationally canal irrigation in India is subsidized to the extent of 95 per cent. Recent data reveal that capital expenditures on irrigation at the national level have increased from about Rs 7.6 Billion in 1985 to Rs 110 billion in 2000 (constant 1999/2000 rupees) largely due to increasing costs of expanding irrigation projects to more difficult areas, and higher costs of borrowing. Revenue expenditures (which include O&M expenses as well as staff costs and other administrative costs of the irrigation departments) have also increased steadily. Revenue expenditures per gross irrigated hectare increased from Rs. 202/ha to Rs. 838/ha between 1988/89-1996/97 (constant 1999/00 rupees). This steady increase can be attributed to rapid expansion in the number of staff employed in irrigation departments and a steep rise in staff salaries and allowances. However, revenue receipts from major and medium irrigation have consistently fallen below expenditures.[6] In 2000, revenue receipts covered 10% of revenue expenditures. In the 10-year period between 1990-2000 revenue receipts as a share of revenue expenditures were less than 15% in 13 out of 14 states examined.

Measuring Canal Irrigation Subsidies

Theoretically, canal irrigation subsidies in a given year can be defined as follows:
$S_1 = (E_{O\&M} + rK + \partial K) + D + V - R_s$ and $S_2 = (E_{O\&M} + rK + \partial K) + D + V - R_a$, with
$R_i = R_i^f + R_i^{nf}$ for *i*=a, s, and $R_a = \alpha R_s$ where $0 \le \alpha \le 1$.

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[4] Irrigation cess is tax levied for irrigation.

[5] Often, as is the case in Karnataka and Andhra Pradesh, while service is provided by the irrigation department, water charges are collected by the revenue department.

[6] Revenue receipts include the collection of water charges as well as penalties for violating the cropping patterns (growing unauthorized water intensive crops) and/or unauthorized irrigation (irrigating area on the peripheries of the project command through gravity or through lifts, or irrigating area in the gross command area (not a part of irrigable area from the project) through unauthorized pumping of water from canals, or irrigating more area by a farmer than authorized in a given year).

The terms in parentheses represent the supply cost of water. $E_{O\&M}$ represents O&M expenditures, r is the interest rate, ∂ is the depreciation rate, K is the cumulative capital outlay, D is the cost of the net environmental impact, V is the other net costs including transaction and social costs, R_s represents assessed water charges and R_a is actual revenue receipts. R_i^f corresponds to (charges assessed)/(revenue receipts) from farmers while R_i^{nf} is (charges assessed)/(revenue receipts) from non-farm users of irrigation water. The subsidy as defined by S_1 represents the subsidy arising from government water pricing policies, whereas the subsidy as defined by S_2 also captures the efficiency of revenue collection and the political economy of the sector.

As described by Dhawan (1999) there are several possible ways to compute the cumulative capital outlay, interest rate and depreciation. For example the capital outlay could be computed by simply adding up the capital expenditures over time at historical and current prices and interest calculated by taking the average of the interest rates at which past borrowing occurred. Alternatively, one could convert capital outlays to their current value and use the current interest rate. Further refinements include computing total capital outlay only on the basis of the cost of completed irrigation projects.

In actually computing the magnitude of canal irrigation subsidies accruing to farmers in Indian states we compute the subsidy amount in financial terms, not taking the full economic costs into account. In other words, we do not impute values for D or V. Further, in the absence of adequate data on interest expenditures and capital costs the subsidy estimates have been calculated as the difference between O&M expenditures and revenue receipts.

The per hectare subsidy accruing to farmers is therefore $S = (E^f_{O\&M} - R^f_a)/H$ with $R^f_a = \alpha R^f_s$, where $0 \le \alpha \le 1$.

It is also assumed that the amount of subsidy accruing to different farmers is proportional to the canal irrigated area on their farms. In reality, farmers whose farms are situated at the head of the canal system in India have been found to receive greater benefits than tail-enders who frequently receive inadequate or erratic supplies of water. Further, wealthier and more politically connected farmers may receive a larger subsidy if irrigated area is under-reported or collection efficiency is lower on their farms. In other words, $\alpha_L \le \alpha_s$ where α_L represents collection efficiency on large farms and α_s represents collection efficiency on small farms.

Irrigation subsidies are calculated for five states, Rajasthan, Maharashtra, Andhra Pradesh, Karnataka and Uttar Pradesh, using state budget data. These data are combined with data from the 54th round of the Indian National Sample Survey (NSS) from 1998 to derive the subsidy per canal irrigated hectare and to infer how the subsidies are distributed across farm households. In addition to the standard modules, this round of the NSS included a questionnaire on Common Property Resources, Sanitation and Hygiene, which contained information on cultivation practices of households, the ownership of irrigation technology and the use of irrigation in cultivating 5 principal crops. Combined with the village questionnaire, his module of the survey can be used to identify households with access to irrigation and determine the distribution of irrigation by source, namely canals, electric pumps, diesel pumps, conjunctive (canals and pumps) and others. The case of Maharashtra will be used here to lead the discussion because Maharashtra State has maintained a good data set.

The Case of Maharashtra

In the state of Maharashtra 43% of agricultural households use irrigation and the vast majority of households that use irrigation rely on groundwater sources. Only 5% of agricultural households use canal irrigation and 6% of total irrigated area is irrigated using canals. The main canal irrigated crops in the state are paddy, other cereals (non-rice) and cash crops.

Maharashtra has some of the highest agricultural water rates in India. In 1998, the Government of Maharashtra approved a resolution governing the annual adjustment of water charges for agriculture and other users in the state. The schedule of price adjustments was designed with the aim that water charges will eventually fully cover annual O&M expenditures and partly cover interest on borrowings. The schedule contains a built in provision to increase water rates by 15% annually (World Bank, 2002b). In 2001 water charges in the state ranged from Rs. 180/ha-Rs. 360/ha for rice to as much as Rs. 8,857 per hectare for sugarcane in the Kharif season. While the irrigation department is consistently raising the water charges, collection efficiency has been poor and the amount of outstanding collectibles was Rs. 1.4 billion for irrigation and Rs. 1.9 billion for industries and drinking water in 1997/98.

Actual O&M spending in Maharashtra in 1997/98 was approximately Rs. 4.31 billion while receipts from water revenue amounted to Rs. 816 million. Data from the state also reveal that 82% of surface water was used in irrigation. Assuming that farmers are responsible for 82% of O&M expenditures (Rs. 3.52 billion) and based on the fact that cost recovery from irrigation totaled Rs. 246.5 million we find that households with access to canal irrigation received a total subsidy of Rs. 3.27 billion. The average subsidy received by farmers amounted to Rs. 10,685/ha. If we assume 100% collection efficiency ($\alpha = 1$) as opposed to the actual rate of collection efficiency (approximately 60%) this subsidy would decrease to Rs. 10,149/ha.

Table 2 summarizes the per hectare subsidies in 1997/98 in all five states examined. Unlike the case of Maharashtra, a lack of information on the volume of irrigation water used for non-agricultural purposes and the value of revenue receipts from non-agricultural users implies that the subsidies computed for the remaining four are biased.

Table 2: The Magnitude of Canal Irrigation Subsidies in Indian Agriculture

State	Total Subsidy (Rs. Million)	Subsidy/ha (Rs./ha)	Subsidy/HH (Rs./HH)	Subsidy/ SC/ST HH (Rs./HH)
Rajasthan	182	337	1,431	783
Maharashtra (*)	3,108	10,149	11,371	6,927
Andhra Pradesh	2,021	1,382	1,956	1,183
Karnataka	259	242	376	237
Uttar Pradesh	2,777	1,117	1,303	730

SC/ST is scheduled caste or scheduled tribe
(*)Estimates for Maharahtra assume 100% collection efficiency

The equity dimension of canal irrigation subsidies

Having derived an estimate of canal irrigation subsidies we can examine how these subsidies are distributed across farm households. It would be ideal to examine the distribution of subsidies among households ranked according to a measure of welfare such as income or expenditure. However differences in the sampling frame for the consumer expenditure survey of the 54th round of the NSS and the agricultural module made it impossible to match households (HH) in the two sections. As a result, we examine the distribution of subsidies across households based on land ownership and social grouping (whether they are members of Scheduled Castes or Tribes).

Table 3 summarizes the distribution of canal irrigation subsidies in the 5 states and in all-India. Of the 13% of agricultural households in India with access to canal irrigation, 64% are marginal farmers, 19% are small farmers, 11% are medium farmers and 7% are large farmers.[7] Although marginal farmers constitute the majority of agricultural households in the country using canal irrigation, they receive roughly 27% of canal irrigation subsidies (i.e. they operate 27% of the canal irrigated area). Approximately 32% of the subsidies accrue to large farmers who represent 7% of households that benefit from canal irrigation and less than 1% of all agricultural households. Thus canal irrigation subsidies are quite regressive.

Table 3: The Distribution of Canal Irrigation Subsidies

	% of Ag HHs with access to canals					Distribution of HH using canals (%)					Distribution of canal irrigated area (%)				
	All	Marginal	Small	Medium	Large	All	Marginal	Small	Medium	Large	All	Marginal	Small	Medium	Large
Andhra Pradesh	19.92	13.36	3.36	1.67	1.53	100.00	67.07	16.87	8.37	7.69	100.00	34.32	22.84	16.73	26.11
Karnataka	15.63	7.38	3.77	2.77	1.72	100.00	47.17	24.14	17.69	11.00	100.00	17.15	21.52	25.77	35.56
Maharashtra	4.67	2.07	1.47	0.76	0.37	100.00	44.43	31.40	16.32	7.85	100.00	21.62	33.39	23.51	21.48
Rajashthan	10.40	3.39	2.34	2.03	2.65	100.00	32.54	22.47	19.50	25.49	100.00	8.64	10.49	16.30	64.56
Uttar Pradesh	12.46	8.96	2.16	0.95	0.39	100.00	71.91	17.37	7.59	3.13	100.00	39.80	24.11	20.03	16.06
All-India	12.69	8.16	2.36	1.33	0.85	100.00	64.28	18.58	10.48	6.66	100.00	26.70	20.71	20.35	32.23

The distribution of canal irrigation subsidies varies significantly across states. The distribution of subsidies is most inequitable in Rajasthan where 10.4% of agricultural households use canal irrigation. In Rajasthan marginal and small farmers with access to canal irrigation, who represent 55% of all canal users in the state, receive 19% of the total subsidy. In Maharashtra, less than 5% of agricultural households use canal irrigation. Among canal irrigation users in Maharashtra, 76% are small and marginal farmers and these farmers receive approximately 55% of the total irrigation subsidy. In Andhra Pradesh, canal irrigation is used by 20% of agricultural households of whom 84% are small and marginal farmers. Small and marginal farmers in Andhra Pradesh capture 57% of the total subsidy. In Karnataka 16% of agricultural households use canal irrigation. Small and marginal farmers constitute 71% of all canal users and receive 39% of the total subsidy. Finally, in Uttar Pradesh, 13% of all agricultural households use canal irrigation, 89% of these

[7] Households that reported cultivating crops are defined as agricultural households. Agricultural households that own less than 1 hectare (Ha) were classified as marginal farmers, those with 1 to less than 2 Ha were classified as small farmers, those with 2 and less than 4 Ha are classified as medium farmers. Households owning 4 or more hectares are classified as large farmers.

households are small and marginal farmers and these farmers receive 64% of total irrigation subsidies.

Only a small share of the poor are likely to benefit from irrigation subsidies. This is primarily because the large share of the rural poor are often landless and therefore are excluded from benefiting from irrigation subsidies. 1999/00 NSS data indicate that only 28% of the rural poor in India had access to irrigation. The figures for the states of Maharashtra, Andhra Pradesh, and Karnataka are 11%, 13% and 11%, respectively. The numbers are higher in Rajasthan (43%) and Uttar Pradesh (66%).

Few Scheduled Caste/Scheduled Tribe (SC/ST) households benefit from irrigation subsidies. In large part, this is due to the fact that a large majority of SC/ST reside in areas where surface irrigation is not feasible. Less than 6% of rural SC/ST households use canal irrigation. Nine percent of rural SC/ST households in Rajasthan use canal irrigation. The comparable figures for the other states examined in detail are 5.4% in Andhra Pradesh, 6.5% in Karnataka, 1.5% in Maharashtra and 9% in Uttar Pradesh.

The average subsidy received by SC/ST households is almost half the value of that accruing to non SC/ST households. This is primarily because the average farm size of SC/ST households is much smaller than that of non SC/ST households. Even among small and marginal farmers, the subsidy received by SC/ST households is significantly less than that of non-SC/ST households. For instance, in Rajasthan the average subsidy received by marginal SC/ST households was Rs. 298 while that of non SC/ST marginal farmers was Rs.527. Similarly in Maharashtra, marginal SC/ST farmers received an average subsidy of Rs. 4,354 per households compared to a subsidy of Rs. 6,067 received by non SC/ST households. In Karnataka the magnitude of the canal irrigation subsidy received by SC/ST households is similar to that received by non SC/ST households for all farm sizes except for large farmers.

In summary, users of canal irrigation water in India enjoy sizeable subsidies. As the subsidies computed here do not include interest or depreciation costs, they are downwardly biased. Using data from 1992/93, Dhawan (1997) estimates that interest costs and depreciation accounted for 52% and 31% of the unit costs of canal irrigation, respectively. These estimates indicate that the actual subsidies accruing to farmers may be as much as five times larger than those computed here. It also appears that the benefits of irrigation subsidies are not distributed equitably. While marginal and small farmers in the majority of states examined receive more than half the total irrigation subsidy in the state (as they operate more than half the canal irrigated area), the benefits they enjoy are small in comparison to their representation in the agricultural population in the states. Large and medium farmers, who represent a small fraction of agricultural households, and an even smaller share of the rural poor, receive a disproportionately large share of the benefits.

Conclusions

This paper has discussed how a water subsidy may affect the behavior of irrigators and has described the various water-related subsidies in irrigated agriculture and their environmental and equity consequences. Using the example of canal irrigation subsidies in India, several of the assumptions involved in computing irrigation subsidies have been outlined. The example from India has also enabled us to get an insight into the equity consequences of irrigation subsidies.

Water-related subsidies directly affect equity as the size of the subsidy accruing to farmers is generally proportional the amount of land owned. Therefore these subsidies are more likely to end up in the pockets of larger and wealthier farmers. These subsidies also have an indirect equity effect. As O&M deficits arising from irrigation subsidies compromise the service and physical delivery of the irrigation system, poor households are more likely to be adversely affected since they, unlike their wealthier counterparts, are often likely to be those at the tail end and are least able to afford the sizeable investments required to acquire alternative sources of irrigation or to cope with the environmental consequences (e.g. water logging and salinization).

Throughout this paper, the relationship between water-related subsidies and environmental harm have been treated in a very stylized way by assuming that only one subsidy is involved in the agricultural production process. However, a government's agricultural policy usually has multiple objectives and addresses numerous crop prices and several factors of production simultaneously. This complicates the calculation of the subsidy level, the environmental harm, and the subsidy distribution among beneficiaries. Using our examples, a subsidized water price coupled with a subsidy for pesticides might be more harmful than the sum of harm by two separate subsidies for water and for pesticides. In calculating the level of subsidy and the environmental damage arising from the subsidy it is also important to consider the possible substitution among factors of production. Finally, the analysis and discussion presented here has been very general in that we have barely touched upon the meaning of subsidy beyond 'price'. However, in the water sector in particular, the way a price for water is calculated might affect the subsidy, even if all costs are addressed. Several of these considerations include: (a) life spans of irrigation projects that are much longer than the engineering life of the infrastructure; (b) discount rates incompatible with market rates; and most importantly (c) inflation-free payment by users.

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