# APPROACHES TO RURAL POVERTY ALLEVIATION IN DEVELOPING ASIA: ROLE OF WATER RESOURCES

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## I. IRRIGATION AND THE POOR

This talk will try to set the scene for our workshop on pro-poor intervention strategies in irrigated agriculture in Asia. This workshop draws on a massive and outstanding empirical study by Dr. Intizar Hussain and his colleagues, 'Pro-poor Intervention Strategies in Irrigated Agriculture in Asia: poverty in irrigated agriculture - realities, issues, and options with guidelines'. This rests upon household surveys in 2001-2 in 26 major and medium canal irrigation systems (and adjoining rainfed areas) in India, Pakistan, Bangladesh, China, Indonesia and Vietnam. The surveys show that in the rainfed areas crop yields are typically half those in the adjoining irrigated areas, and that the landless – normally likeliest to be poor – enjoy 'much higher' wage-rates and employment. Hence typically 'poverty incidence is 20-30 per cent higher in rainfed [than adjoining canal-]irrigated settings'. Much of the difference is explained by irrigation (holding other household characteristics constant), as shown by econometric work for Indonesia [Hussain and Wijeratne 2004;[1] see also table 1 and Appendix Table 1].

Isn't it obvious that a large poverty gap persists, in a country, between irrigated and adjoining unirrigated areas? No. To an economist, it is surprising, at least in Asia, where most of the poor get much of their income from hired labour. In a newly irrigated region, *initially*, wages and employment rise. But that should draw in labour from the adjoining rainfed area, making labour scarcer, and, pushing up wage-rates and employment. The opposite would happen in the irrigated area, tending to close the poverty gap. A similar result follows if farm capital complementary with labour moves out of irrigated areas, towards rainfed areas, in search of cheap labour. Big, persistent poverty gaps between irrigated and unirrigated areas arise from an odd combination: residual underdevelopment that slows or blocks the movement of labour and capital; and green revolution (successive rapid technical progress - seeds, fertilizers - complementary with irrigation), keeping irrigated areas advancing ahead of responsive factor movements. So convergence fails: poverty gaps (and mean income gaps) between irrigated and adjoining rainfed areas persist. Yet there are big differences, among and within systems, in irrigation's efficiency, equity, and thus poverty impact. What determines the cost-effectiveness of irrigation as a sustainable remedy for poverty (a) in irrigated areas, (b) by spreading to new areas?

By placing this study into its context, we can identify, as the most important single issue for (a), *pro-poor management of water for farming* (PPMWF). Whether management of water for farming is pro-poor depends on its sustainable impact on growth, stability and distribution of consumption, and of other indicators of well-being (notably health[2]). PPMWF comprises selection and delivery of technologies, asset distributions, institutions, and markets (including incentives) conducive to pro-poor, efficient and sustainable use of water for farming. Such selection and delivery depend on decisions by managers at several levels, including but not only[3] the farm house-

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[1]Hereafter HW. Intizar Hussain and Deeptha Wijerathna, 'Irrigation and Income-Poverty Alleviation: A Comparative Analysis of Irrigation Systems in Developing Asia', IWMI, Colombo, Feb 2004.

[2]Might more be said in the studies about impact of irrigation/drainage management choices on the poor via drinking water and insect disease vectors? See M. Lipton and E. de Kadt, 'Agriculture-health Linkages', WHO, 1989.

[3] Decisions affecting farm input and output prices, rural roads, etc. can also change water use patterns and hence poverty impact of an irrigation system.

hold, the irrigation system, and the total water source. This study concentrates on the poverty impact of irrigation alternatives for *farm households* within each of the 26 *canal-based systems* (so that the '*total water source*' is a river basin). What is analysed and compared are differences, at farm-household and system levels, in poverty – and how such different decisions affect poverty via equity and efficiency impact.

However, first, such impacts occur in the context of a higher level: the 'total water source', typically in the case of a canal system the basin. Decisions, including reforms, affecting irrigation and drainage in one canal-based system may well affect water availability and distribution, and hence poverty, in downstream systems using the same river. There are also interactions - explored in this study in the context of individual systems - between total water available for surface and groundwater use.

Second, poverty impact of irrigation also depends on minor schemes – both canal systems smaller than those reviewed in this project, and very small arrangements including farmer-controlled dug wells. The sustainability, availability and distribution of water from such minor and tiny schemes, and hence their poverty impact, often depends partly on irrigation and drainage decisions in nearby major schemes.

These two contextual issues are not raised in order to slight the topic of this study: cost-effective improvement of PPMWF *within* major and medium canal schemes. Tens, probably hundreds, of millions of the Asian poor could benefit from that, especially when placed in a suitably broad context - as this study often does, notably by showing how more equal land distribution produces higher (as well as more equitable) returns to canal irrigation. However, at some stage the findings of this study – on cost-effective PPMWF *within* major and medium canal systems - should be set into a wider consideration of the impact on poverty of *all* linked forms of, resources for, and allocation and management options affecting, irrigation from a linked water source (e.g. river basin plus associated groundwater resources).

For such a wider study, the inclusion of drainage in the remit of the institutions for most of your studied canal systems renders them specially valuable as an entry point. Incentives and institutions (for households and irrigators) affecting a canal system's drainage may critically influence the system's impact on users *outside* the system: on their water availability, timing, use and distribution, and hence their poverty. Further determinants of a system's impact on water, and hence poverty, elsewhere include system-level runoff, seepage, and evaporation. The summary reports include interesting comparisons of evapotranspiration among canal systems in Vietnam, but more may be needed.

I hope we shall return to these above-system-level issues in discussion. In this talk, I shall seek briefly to place the output of these studies into six other relevant contexts.

First (sec. II), poverty depends on average consumption or well-being, the share of these received by the poor, and the fluctuations in poor people's income. On distribution, this study finds that unequal distribution of farm water and land substantially reduces the benefits of irrigation to the poor, not only by concentrating those benefits on the non-poor (irrigation equity reduction) but also by cutting their overall volume (irrigation efficiency reduction). We should put this finding in the context of two wider bodies of work, showing that unequal initial income distribution reduces the impact of growth on poverty, and that in developing countries more equal distribution of assets, especially farmland, is not only good for the poor but also efficient. And we should assess the impact of irrigation (and of PPMWF) on the vulnerability to downward fluctuations of those near or below the poverty line.

Second (sec. III), major and medium canal schemes, such as those in this project, need to be set into a context of the cost-effectiveness, in reducing poverty, of choices within and among *techniques* of irrigation, and more generally of PPMWF. This raises the issue of *new technologies*, especially those appropriate for participatory, diffused or decentralised management.[4] Technology is an essential voice, too little heard in the project reports, alongside the consensus that, in irrigation, markets (and market pricing) of water, backed by participatory management, is strongly conducive to greater system efficiency. That consensus is strongly supported by the evidence and conclusions of this project; so is the less consensual, but I think clearly correct, view that market policies are (a) pro-poor,[5] (b) complementary to greater land equality. However, much more work is needed to spell out *technical* paths from better incentives, markets, and management to better 'social efficiency of water use' - unpacked into field, conveyance, cost, and external efficiency – and better poverty impact. Water users may need more technical choices: perhaps, new technology derived from a 'blue revolution' in water science. Otherwise water users, especially if poor, may be able to respond to more sensible prices, markets, and participatory institutions only little, slowly, and (given the response) with disappointing impact on efficiency and poverty.

The third context (sec. IV) is water sustainability. Improving equity, and even efficiency, of farm water use may not benefit water use sustainability, and without careful choices of incentives and institutions may harm it. This is increasingly threatened in rural areas, especially in semi-arid zones and above all for the poorest, not only by climate change but also by rapid – and to some extent justified - shifts of farm water to urban, especially domestic, uses. How can the conclusions and guidelines of this study be interpreted or adapted to make water use sustainable?

The fourth context (sec. V) is institutional. Much is said about institutions in this study. However, while the full reports for India and Pakistan say a little about corruption and bribes, their profile is not high. Even the words (and their affines) are absent from the 272-page summary report [Hussain 2004]. While I reject the vulgar 'public-choice' view that all officials are venal maximisers, one does need to ask whether institutional mechanisms either of participation and control, or of incentive and reward, can ensure that the guidelines from this study are incentive-compatible. After all, we have known for decades that most irrigation systems *should* be so managed as to spend more on maintenance relative to new works, and to spread more water to tailenders – and we also know, at least since Wade (1982), what mechanisms, in South Asian systems, divert or corrupt efforts to this goal.

Kant distinguished between 'transcendental criticism' (your statement needs to be related to other issues) from 'immanent criticism' (there are internal questions about your statement). Unlike the above four contexts, the fifth (sec. VI) is immanent. Do the explanatory variables in these studies, as linked to the dependent variable by equations and tested, fully support the conclusions drawn? Is it really differences in irrigation status – and, more generally, in water and land access and management – that produce the stated outcomes (for yield, output, farm revenue, household income and poverty), identified in these studies? Ch. 5 of the China study is a brave and brilliant approach to this difficult issue. However, apart from the issues successfully tackled there, more irrigation generally goes with better seed varieties and more fertiliser. It may not suffice to include these two as independent variables, alongside irrigation, as multivariate regressors

[4]PIM is a *modest* illustration that farmer-, or client-plus-operator-, controlled, methods need not be confined to micro-irrigation.
[5]If applied to irrigation water; there is dissent, outside and increasingly inside the Washington Consensus, that this is true of (say) primary health care or schooling

upon poverty or average income; the *causal* links, from acquisition of irrigation to fertilisers and new seeds, may need to be modelled explicitly. Another 'immanent' issue is whether the choice of nation-specific poverty lines invalidates some conclusions (HW: 17-18).

Finally (sec. VII), there are global contexts. These studies strengthen the anti-poverty case for more irrigation (and better PPMFW) in Asia – and in sub-Saharan Africa, with below 3% of cropland irrigated. The Millennium Development Goal of halving dollar poverty in 1990-2015 cannot be achieved, nor significant progress against poverty made, in regions now falling far behind that goal (most of sub-Saharan Africa and much of what may be called "inner Asia", both largely *un*irrigated regions) unless the progress of developing-country smallholder agriculture in general, and of PPMWF in particular, are aggressively re-inserted into policies on trade, investment, aid, science and development, both in poor countries and in the developed world. Most of the poor are smallholders or farmworkers. Even more of the poor are poor because smallholders lack adequate, controllable farm water. Yet there has been a long and dramatic decline in the role of smallholder farm water, and of agriculture in general, in development investment, aid, trade and science priorities. This decline must be sharply reversed. Let any developed or developing country that refuses to address PPMWF in practice, with real money, stop prating about poverty.

This also bears on the impact of liberalisation in greatly reducing price discrimination - but increasing other forms of discrimination - against farming and rural people *within* developing countries. How can the rich world assist PPMWF, given that there is, at last, some reaction against three decades of increasing abandonment of developing-country smallholder agriculture by aid donors, while they harm it through their own farm, science and trade policies?

## II. IRRIGATION, INEQUALITIES AND INEFFICIENCY

Irrigation, by raising or stabilising per-hectare farm output, may cut poverty via five main paths:

- higher incomes, in an average month or year, for poor *farmers*;
- higher labour demand (and so wage-rates and/or employment) for poor *farmworkers*;
- higher demand for the products, or labour, of the *rural non-farm* poor;
- lower staples prices for *the urban poor*;
- smaller *shocks* (in irrigated areas, smaller consumption falls in bad months [this study, Fig. 11-14, Table-fdoc., pers. comm. Intizar Hussain, 10.6.04], due partly to greater cropping intensity; and 2.5 times lower standard deviation in growth rates of crop output per year in India in 1971-84 [Lipton and Litchfield 2002, table 6])[6].

Stability benefits the poor most, due to their restricted access to imperfect or incomplete credit markets; reduces shocks to the poor's farm revenue, employment income and food prices; cuts distress sales of crops and land[7]; and helps the poor to take profitable risks[8] in production.

Such gains can be frustrated, e.g. stability can suffer if irrigation over-expansion or corruption increases tail-end uncertainty. This study shows, moreover, that - via all these paths - irrigation cuts poverty more where the poor have land, and get water. With fewer of the rural poor landless, and with the rural landed having more land to benefit from irrigation, higher and stabler farm output and revenue are then more concentrated on poor farmers with small farms Under these

[6]Hereafter LL. M. Lipton and J. Litchfield, with Rachel Blackman, Darshini De Zoysa, Lubina Qureshy & Hugh Waddington, *The Impact of Irrigation on Poverty*, FAO and Sussex Poverty Research Unit, 2002.

[7]M. Howes, *Whose Water*?, Chichester: Croom Helm, 1984: 114; R. Chambers, N.C. Saxena and T. Shah (1989), *To the Hands of the Poor: Water and Trees*, London: ITDG, 1989: 18.

[8]World Bank, *World Development Report 2000/2001*, Oxford University Press, New York, 2002: ch. 8.

conditions irrigation brings the poor more gains, not only via net farm income, but also via all the other paths, because small poor farmers are likelier than large rich ones

- to use extra irrigation labour-intensively[9] rather than capital-intensively;
- to apply irrigation to staple crops, reducing their price;
- to use irrigation for profitable but risk-reducing, not profit-maximising, ends;
- and to generate extra spending on labour-intensive rural non-farm products.

Must this create a virtuous circle, where irrigation is concentrated on small-farm users and cuts their poverty? Not if political pressure focuses irrigation and land upon the rich and powerful. However, at least where their incomes come to rely increasingly on rapid non-farm growth, such pressure need not win out, as shown for E and SE Asia in this study. But even then, is irrigation concentrated on small farms - or made available where farmland is not very unequal – perhaps *inefficient*? Consider two situations. In 1, the poorer half of farmers get 40% of land and irrigation water, but the returns to 1ha of land and 250 l/day of irrigation water are, say, 100. In 2, the poorer half of farmers enjoy only 20% of land and irrigation water, but the returns to land and water are, say, 250. Poor farmers, and possibly poor people as a whole (including the urban and rural non-farm poor), might then be worse off in the more equitable situation.

<u>The great contribution of this study is to have provided massive, firm, plot-level evidence that this is not the case</u>. It has long been known – though the knowledge is still widely resisted – that in developing agricultures, where fixed capital makes a relatively small production contribution compared to labour, very unequal distribution of land tends to reduce yields, which are normally more on smaller farms.[10] The main reason is that smaller and family farms have lower labour-related transaction (especially supervision) costs than big farms, and therefore tend to 'saturate' each piece of land with more labour, increasing its yield. This project shows that irrigation systems, possibly for related reasons tend to operate more efficiently in circumstances of not-very-unequal distribution of both land and irrigation water.

Nevertheless, irrigation continues to be inequitably distributed. ICR (pp. 37, 57-8) find that 'though marginal farmers gained in an absolute sense, large farmers gained proportionally more' in the systems studied, and cite Hooja (2000) on the Krishna Raj Sagar project, where 'per capita income from agriculture is 5.5 times higher in big farms as compared to small .. in irrigated areas, whereas it is only 2.5 times higher in case of rainfed villages'. It is, at first sight, paradoxical that irrigation water – even more than land – should be concentrated on larger farms. Why are they not leased to smaller farmers, or managed in smaller units, with both owners and new operators gaining? Presumably it is due to costs and fears of change, plus extra-market and interlocking-market advantages to large operators of land and water. Anyway, apart from suggesting this question, this project gives strong if initial evidence that for irrigation, as for farmland, small and equal is not only pro-poor but also efficient.

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[9]Hence small, fairly equal farms *within* a system normally bring higher output (not just stability) via higher cropping intensity (e.g. ILO, *Ceylon Employment Mission: vol. 2*, Geneva, 1971). *Across* 26 systems in these studies it 'varies from 68-296% .. the smaller the average landholding size, the greater the intensity of cropping' [HW].

[10]A. Berry and W. Cline, *Agrarian Structure and Productivity in Developing Countries*, Johns Hopkins, Baltimore, 1973; H. Binswanger, K. Deininger and G. Feder, 'Power, distortions, revolt and reform in agricultural land relations', in J. Behrman and T.N. Srinivasan, *Handbook of Development Economics: vol. 3b*, North Holland, Amsterdam, 1995; M. Lipton, 'Land reform as commenced business: the evidence against stopping', *World Development*, 21, 1993; R.K. Eastwood, M. Lipton and S. Newell, 'Farm size' in R. Evenson and P. Pingali (eds.), *Handbook of Agricultural Economics: vol. 3*, North Holland, Amsterdam, 2005.

This contribution needs to be set into the context of other evidence that equity is conducive to efficiency. First, how does irrigation affect mean farmer income? The farm-level links go via higher yields, cropping intensity, and value of the crop-mix. In the CCR[11] (p. 93-5), irrigated yields are nearly twice unirrigated for cotton and 70.9% higher for wheat, though only 16.4% percent higher for maize; the share of low-value crops such as maize and tubers is lower; and double-cropping is commoner. Hence farmer revenue per hectare-year is far more from irrigated plots.

The CCR confirms that China's fairly equal land (and, perhaps, the attractiveness to the rich of non-farm prospects) allows irrigation to help poor areas most – if it is feasible and allocated there. (a) 'Revenue from irrigated plots in poor areas exceeds those from non-irrigated ones [by] slightly more (93%) than in richer areas (89%)'; (b) crop revenue is a larger share of income (40% in poorer areas, 10% in richer), so irrigation increases total income in rich areas only by 9 percent, while increasing it in poor areas by 38 percent; (c) given that 'utility functions are concave, [even] if rich and poor areas enjoyed [only] equal income gains, the gains in the poorer areas will turn into larger increases in welfare'. Hence in China the association of irrigation with poverty reduction is even stronger in poor *areas*, and part of this association is causal (sec. VIII below). Regional gaps are increasingly the main cause of inequality in China – where, as in India, both poverty reduction from, and the economic rate of return to, irrigation is increasingly higher in carefully selected poor and backward areas than in advanced areas.[12] Further, the reasoning for poor *areas* seems applicable also to poor *households* within a given area. Relatedly, in this study, poor households' income in China rises proportionately more with irrigation than does rich households' income.

On distribution, this study finds that unequal distribution of farm water and land substantially reduces the benefits of irrigation to the poor, not only by concentrating those benefits on the non-poor (irrigation equity reduction) but also by cutting their overall volume (irrigation efficiency reduction). HW write: 'In the studied systems in South Asia, average land size is relatively large, distribution of land and water is highly inequitable and .. average productivity per hectare varies from US$230 to US$637 .. while in .. the systems of Southeast Asia and China .. [it] varies from US$665 to US$1444 ... In general, productivity benefits of irrigation are lower and poverty is higher .. where average landholding size per household is relatively large, distribution is inequitable, crop productivity is low and cropping patterns are least diversified .. Elasticity of poverty incidence [across 26 systems] with respect to crop productivity, land distribution, and non-crop farm and non-farm sources is estimated at -0.31, -0.48 and -0.79, respectively .. Where land distribution is inequitable, as in [S Asia], .. water .. allocated per farm household also becomes inequitable, and vice versa.' The same areas tend to have large farm size and high inequality, low productivity of land *and water*, and high poverty.

However, 'in all the systems studied, irrigation water is allocated to farm households based on size of landholdings, that is, land and water rights tend to be coupled'. So lower land productivity on large farms must, via allocation of water in proportion to land, mean lower crop-per-drop on large farms also, by arithmetic. Conversely, arithmetic imposes no such outcome where irrigation water is not 'allocated' by centralised systems, but by market and/or user-group procedures - or is dispensed in small, divisible or farmer-controlled modalities. Then, there is a better

[11] Intizar Hussain and Eric Biltonen (eds.); Study Team: Jinxia Wang, Jikun Huang, Zhigang Xu, Scott Rozelle, Intizar Hussain, Eric Biltonen, Qiuqiong Huang & Siwa Msangi. China country report. *Pro-poor Intervention Strategies in Irrigated Agriculture in Asia: China*. IWMI, Chinese Academy of Sciences & ADB Colombo 2004.

[12] Fan S, Linxiu Z and Zhang X (2000a). Growth and poverty in rural China: the role of public investments (Internat. Food Policy Research Instit., Washington DC); Fan S, Hazell P & Thorat S (2000b), Targeting public investment by agro-ecological zone to achieve growth and poverty alleviation goals in rural India. Food Policy 25, 411-428.

chance for farm *water* efficiency and equity to cut poverty even where farm *land* is inequitably and inefficiently distributed. Will small farms seize that chance, and buy and maintain more irrigation per hectare than large farms if permitted? Farms with less land per family worker have lower supervision costs of labour than large farms, and hence apply more labour per litre as well as per hectare. Types and organisation of irrigation that permit small farmers to gain by purchasing more water-per-hectare than large farmers (which pays small farmers because they can, at lower cost, put more labour into irrigation maintenance and management) are likelier to unleash such sources of production and poverty reduction than are methods where water is 'allocated' proportionately to land.

More equal land and irrigation, then, may well make irrigation more efficient, and thus doubly more poverty-reducing. But does irrigation itself increase or decrease inequality? The studies shed much light on this, but are confined to canal systems with 'allocated' water. A review of 13 FAO studies concluded that 'micro-irrigation on balance produces more equitable outcomes than large-scale, indivisible projects' [LL].[13] Within canal irrigation, this study shows that 'small and equal is efficient' for canal irrigation in developing countries (as it probably is for farmland[14]), but the cross-system data may need more cross-checking against the large and unique body of plot- and household-level data in the country studies. If (as I believe) it will survive such checks, it needs to be put in the context of two wider bodies of work.

The first is the work by Ravallion and others showing the practical importance of the near-tautology that, the more equal is income distribution, the greater *ceteris paribus* is the poverty-reducing effect of distribution-neutral growth. One way to look at this is to compare two economies A and B, with the same mean income and the same initial proportion of people below some absolute income-poverty line, but with A having higher 'income inequality' (on almost any sensible measure). It is then almost certainly the case that the typical poor person in A lies further below the poverty line than her counterpart in B, and so does the typical person 1, 2, 3… per cent above or below the income of the typical poor person. Hence a given growth of mean income, if distributed exactly like initial income, will bring fewer people above the poverty line – and hence cut poverty incidence less - in the less equal country, B, than in A. Ravallion and others have demonstrated the large extent to which unequal initial *income* distribution reduces the impact of growth on poverty. So more pro-poor income distribution, e.g. due to extra new irrigation and/or land access focused on the poor – apart from its own poverty-reducing effects (see above) – also increases the future poverty-reducing impact of distribution-neutral growth from *other* sources.

The second area of work, into which we need to set the evidence in this study that irrigation efficiency accompanies equity, is concerns the impact of income and asset distribution on growth. Eastwood and Lipton [2002], in a review of the evidence, conclude that high asset inequality, and on the most recent and full evidence (Barro) high income inequality *in developing countries only*, appear substantially to slow down economic growth. The nature of inequality may matter: *ascribed* inequality, especially as high income becomes a passport to further economic advance, is probably anti-growth, and *achieved* inequality, as a reward for economic contribution, is probably pro-growth. All this suggests that efficient, equitable irrigation in developing countries,

[13]No broad comparison of *efficiency* among irrigation types appears to exist.

[14]HW report that 'a recent study by the Word Bank (2002) in Pakistan indicates that inequity in land distribution is also one of the causes of low agricultural productivity.' Note that in *developed* countries the productivity advantage switches to larger farms, whose lower unit transactions costs in capital markets come to outweigh smaller farms' corresponding advantages in labour markets [Eastwood et al. 2005].

if sustainable, contribute to aggregate growth not only in itself, and as a source of demand for other activities, but in the macro-economy, by increasing equality of incentives and access.

A major concern, raised by this study, is the apparently very low extent to which better productivity, and even equity, in irrigation appear to cut poverty [HW: p. 20 and figs. 5-6]. Across these 26 canal systems, only '20 percent of income-poverty' is removed by irrigation that raises farm 'productivity level from US$200/ha to US$1,000/ha', and moving from the highest to the lowest degree of land inequality 'would reduce income-poverty index from over 50 percent to less than 30 percent'. These look like very pessimistic estimates (even allowing for the fact that 'overall impacts on poverty alleviation would be greater if poverty impacts [on] the noncrop sector are also accounted'). I suspect that the low poverty impact of land distribution may be due to the constraint that 'land size units remain economically viable [with] a threshold level of land size that generates livelihoods for households to be able to move out of poverty.' That constraint is required only if poor households are assumed to require *all* their (above-poverty-line) income from farming, and/or if farm productivity is assumed, below some threshold, to decline with falling farm size. The evidence, in most cases, of multi-sourced rural livelihoods and rising yields with falling farm size well below 0.5ha [Binswanger et al. 1995, Lipton 1993, Eastwood et al. 2005] does not support either of these assumptions. Hence - given the amount of land and irrigation water that can be released by politically and economically acceptable (e.g. consensual) methods from large farms – there is no obvious lower threshold or limit on the size of holding to which such land and water can be effectively assigned, whether through the market, publicly manipulated incentives, or otherwise. If land and water can be shifted towards more and smaller holdings - and given the normal labour-intensity considerations - this brings further productivity, as well as distributional, gain. Then the above pessimistic estimate (of poverty-reducing impact of higher irrigation productivity or equity) is improved.[15]

Finally, the irrigation-inequality nexus cuts across the headender-tailender issue. The common assumption has been that headenders start richer and with larger farms, and get more, timelier and more reliable water per hectare. If so, rules or incentives or decentralisation that would redistribute water (and greater certainty) to the poorer tailenders, with more labour to complement and get high returns from it, would have efficiency as well as equity advantages. Apart from assessing project performance and reform in this context, this project contains new and interesting data and insights on the assumption itself. It appears that, commonly, it is the middle-course users, not the tailenders, who are poorest and experience most problems with irrigation delivery.[16] If poverty-reducing and equity-increasing irrigation is the goal, while more crop-per-drop is always an improvement, some doubt is cast on the current emphasis on increasing the range of existing irrigation systems rather than building new ones. More outreach and offtake from a system may well raise variance due to headender-middlecourser-tailender conflict and uncertainty.

## III. POVERTY IMPACT AND IRRIGATION TYPE: IS NEW TECHNOLOGY NEEDED?

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[15] The use of national poverty lines may also have affected the results. Even with such lines better-off countries and areas have lower poverty incidence, but they are known to use higher lines [Ravallion 19**xx**]. Hence poverty incidence is artificially raised in irrigated areas, because they are better off and therefore tend to use a higher poverty line; this would lower the measured effect of irrigation on poverty, as compared with an absolute poverty line intended to have constant purchasing power across countries such as the dollar-a-day measure. See sec. VIII below.

[16] This finding, if confirmed, has interesting points of contact with the so-called 'middle ground hypothesis' of Wade [1982] and Runge [19xx]: that institutions of common property management (e.g. water users' groups) work best in conditions of *medium* resource access and uncertainty. Where there is little uncertainty and ample resource, or vice versa – i.e., in the context of irrigation, respectively very near the source (at the head) and far away (at the tail) - the cost of co-operating to deal with it is not worth bearing. Middle-grounders find collective action pays.

Poverty impact of an irrigation system depends on (a) economic efficiency – i.e., per unit of water in the system, *benefit* (viz.. (a) water use efficiency, WUE - i.e. conveyance efficiency, CE, times field efficiency, FE[17] - times (b) net farm value added due to the average of delivered water, divided by (c) irrigation *cost* (including external costs such as those of pollution); and (d) poverty-orientation of benefits net of costs. This project strongly suggests that changes in incentives and institutions, alone, can bring rapid progress in solving most major problems of Asian canal irrigation, improving its economic efficiency and poverty impact. For example, in the four Yellow River systems, water use efficiency (WUE: proportion of system water reaching the root zone) is 40-45% [CCR: 85].[18] To improve this, almost exclusive emphasis is placed on 'reforming water management with well-implemented incentives' based on greater price and market freedoms. Indeed, 'in the past several years the Ministry of Water Resources has distanced itself from a water policy based on water-saving technology' such as drip and sprinkler irrigation [CCR: 6, 89, 180]. The Bangladesh country report (BCR: 117-9) [19] reviews 'institutional factors affecting water use efficiency' but not technical factors or options, and this emphasis, both in the project studies and in the country governments, recurs in the other project studies. Around 60% of irrigation water does not reach the fields due to seepage, evaporation and percolation[20] [FAO 1996b; Blackman 2000: 6]. These issues – and also water re-use (recycling), drainage, and irrigation-agriculture collaboration (e.g. for plant/agronomic choices to increase crop-per-drop and robustness against moisture stress) – are little discussed in these papers, and seem to be regarded implicitly improvable entirely through improved markets and institutions. (The Vietnam report, VCR,[21] contains very interesting data on evaporation, its variations and its importance, but the proposals remain entirely institutional.) However, farmers' and officials' *capacity to respond* much, or rapidly, to better incentives and institutions depends on using, and often on expanding through research, the range of water-economising techniques available. Especially, much more emphasis on water technology and research is essential (a) if, in view of tightening environmental and urban constraints on farm access to water, even ideal markets and institutions are to immunise Asian farmers from the effects of the pending sharp declines, especially in the semi-arid tropics, in system water; (b) to achieve rapid, price-elastic, water-saving or pro-poor response to the changed incentives and institutions proposed in these project reports.

Focus of irrigation on the poor, not only efficiency of irrigation, may depend on choice (where feasible, which is not always) of technologies. The India country study, ICR[22] (p. 38) confirms that irrigation is more unequally distributed than land ('large farms captured disproportionately

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[17]CE = proportion of system water reaching cropland; FE = proportion of field water reaching crop; so WUE = CE.FE. There are interactions, e.g. higher FE may *lower* CE; higher WUE may (but seldom does, as the project studies show) cut the share of system benefits reaching the poor [Rural Poverty Report 2001, IFAD, Rome: 146-52].

[18]WUE of 40-45% is typical for developing countries [IFAD 2001: 146-9]. However, CCR claims CE of 40-50% in the four survey systems. Since WUE=CE x FE (proportion of field water reaching the crop), WUE of 40-50% implies FE (FE) of 80-100%, which is well above feasible levels.

[19]Intizar Hussain, with Q. K. Ahmad, Zahurul Karim, Khandaker Azharul Haq, Abul Quasem, Khalilur Rahman, Nityananda Chakravorty, Noajesh Ali, Rowshan Akhter, Mohammad Zubair, Hasan, A. F. Younus, Afzal Hossain, M. A. Karim, S.M. Hossain Siddiqui, and Newaz Khoshbu Ahmed. *Bangladesh Country Report: Pro-poor intervention strategies in irrigated countries in Asia*. IWMI- Bangladesh Unnayuan Parishad – ADB, Colombo, 2004.

[20]FAO (7 August 1996), *Implementation Completion Report, Pakistan. Second Irrigation Systems Rehabilitation Project, Pakistan.* Report no.96/028 CP-PAK. Cr.1888-PAK; R. Blackman, *Irrigation: notes for IFAD Rural Poverty Report 2000*. Mimeo. Poverty Research Unit, University of Sussex

[21]Eric Biltonen, Intizar Hussain and Doan Doan Tuan, with Nguyen Van Quy, Dang The Phong, Le Ngoc Hung, Dinh The Hung, Nguyen Xuan Tiep, Pham Van Ban, Lam Quang Dung, Nguyen Danh Minh, Le Van Chinh, Tran Anh Dung and Nguyen Manh Vu, *Vietnam Country Report: Pro-poor Intervention Studies in Irrigated Agriculture in Asia*, IWMI-ADB, Colombo, 2004.

[22]Intizar Hussain, with M.V.K. Sivamoha, Christopher Scott, Bouma Jetske, Deeptha Wijerathne and Sunil Thrikawala, *India Country report: Poverty in Irrigated Agriculture*, IWMI/ADB, Colombo, 2004.

large share of irrigation benefits, as compared to small and marginal farms'), but – surprisingly – finds that canal-irrigated area is more equitable than groundwater-irrigated area in Gujarat, Madhya Pradesh, Maharashtra, Orissa and Andhra Pradesh. However, a recent literature review reports that 'small-scale, low-cost and labour-intensive irrigation techniques .. that can be accessed by small, capital and/or credit-constrained farms .. are more likely to be of benefit to the poor than large scale, capital-intensive technologies'. In India in the late 1970s, dug wells produced the most pro-poor distribution of benefits, and large systems the least.[23] Most research also suggests that small, farmer-managed systems also raise yields more, though organisation and technology interact: in the 1980s 'in four Indian states the output impact of groundwater per net irrigated hectare was roughly double that of canals .. individually owned tubewells in Punjab and Haryana enhance farm output by about 28 quintals/ha, [double the enhancement from] level for public canal irrigation', with bought-in tubewell water and State tubewells falling between these levels. In Tamil Nadu and Andhra Pradesh the additional output due to the introduction of one hectare of irrigation facility was 12-16 quintals for tanks; 15-21 for canals; and 34-36 for wells (primarily dugwells with pumpsets). Over time, the productivity of groundwater-irrigated land has risen faster than surface irrigated. Further, stabilisation – more important for the poor, as we have seen - appears to have been more from private tubewell irrigation as in Haryana and Punjab, than from tanks (more sensitive to rainfall variations) in Tamil Nadu and Andhra Pradesh.[24]

The emphasis of the ICR team on PIM and associated water reforms, and of the World Water Commission on pricing and water markets, are important – and good for efficiency *and* equity - for most irrigation sources and delivery technologies. However, further work on the data from this project and elsewhere may be needed, before we reject the view that smaller and more divisible sources or delivery systems are usually more pro-poor. Whoever proves right, in many areas the choice among irrigation sources and delivery technologies is nil, or very restricted. Even where it is not, more equitable and productive choices need not be sustainable (that will depend on water losses, drainage and recharge – and on the extent to which better economic efficiency and access for water use increase offtake). Hence it is important to explore better techniques for irrigation water **use**, given source and delivery system. Recent micro-application methods such as treadle pumps and micro-drip systems, which favour the labour-intensive poor and give small farmers better control over irrigation water, are likely to improve both efficiency and equity from almost any sort of irrigation source – canals, tanks, tubewells or dug wells.

However, the range of irrigation source, distribution and use techniques provided by current science may not suffice for this project's proposals to lead to rapid and price-elastic gains, especially on small farms and for the poor. New techniques and even new science may be needed.

Kofi Annan, commenting on the 2001 report of the World Water Council, rightly called for a Blue Revolution. That Council advocated freer water markets, desubsidisation, and decentralisation from irrigation authorities to participatory water users' groups. These studies provide much evidence that this can cut poverty, but also that it needs to be complemented with radical increases in the poor's institutional representation and land and water access. Might this indeed require a Blue Revolution: a pro-poor transformation in the *technologies* for water management, delivery, control, economy and/or recycling, analogous (and comparable in impact) to the transformation of technologies for plants in the Green Revolution, which led to labour-intensive,

[23]D. Narain and S. Roy, *Impact of irrigation and labour availability on multiple cropping: a case study of India*, Research Report no. 20, International Food Policy Research Institute, Washington, D.C., 1980

[24]LL (also tables 4-6), citing Dhawan, B.D. *Irrigation in India's Agricultural Development: Productivity, Stability, Equity*, Delhi, Sage, 1988; and Chambers, Saxena and Shah [1989].

smallholder-friendly and dramatically poverty-reducing[25] change? The new approach to water is almost entirely institutional. But the Green Revolution transformed not institutions but germplasm, doubling or tripling crop-per-hectare via radically new *basic science* (that of Darwin and Mendel) applied as profitable new *technology* (notably rice and wheat breeding for dwarfing and pest resistance). Better technology for irrigation works, delivery, storage or timing may often be needed (e.g. to reduce evapotranspiration and seepage losses), if farmers and irrigators are to respond much, fast, or with dramatic results to market and institutional reforms. To achieve such technical progress, perhaps a science-based Blue Revolution is needed, seeking to double or triple crop-per-drop by changes in water conveyance and use efficiency, cost-effectiveness, transfer and/or storage. That can make an impact on poverty comparable to that of the Green Revolution. Much more crop-per-drop is especially important in view of the pressure to *reduce* farmers' access to water (sec. IV). Better science-based returns, too, may be needed to provide the 'political will' to overcome, or partly compensate, opponents of the often contentious institutional and market reforms shown in this report to increase efficiency as well as equity. More may be needed than the brilliant water engineering of the past two centuries, which – though needing the Newtonian revolution in physics, and by implication in mechanics and hydrology – otherwise rested mainly on adaptation of the last Blue Revolution in our understanding of farm water systems: in the Yellow-Yangtse basins, Mesopotamia, and India and Sri Lanka over two thousand years ago.

## IV. ENVIRONMENT, EXTERNALITY, AND SUSTAINABLE IRRIGATION

Choice of techniques, and the possible requirement for new technology and even basic science, are crucial for 'environmental' issues. These are, perhaps, rather little discussed in these studies, but are crucial to the poverty impact, acceptability and public affordability of major and medium irrigation. First are alleged negative side-effects as new irrigation displaces persons. Second is impact of irrigation on health. Third is sustainability, given the tightening 'water squeeze' on agriculture, as water is diverted to residential uses - and (probably) made more uncertain, and in some areas scarcer, by climate change. In each case, environmentalists have rightly emphasised direct, local and often negative effects. Studies of particular canal systems need to estimate the scale of these, and the feasibility and cost of alternative ways to reduce them. But in all three cases we must also consider indirect, often non-local, and generally positive effects, viz.:

- Displacement of people and jobs in the area of irrigation works has to be offset against new workplaces created through higher, and less seasonal, output, not only in the catchment areas of such works, but also through processing the farm production or treating it as a wage-good to support non-inflationary expansion of non-farm production.
- Health damage from irrigation, through waterborne diseases and extra insect vectors, has to be offset against health gain through better nutrition, to the extent that irrigation provides higher incomes and thus food entitlements for the formerly undernourished poor; the health effects of irrigation on drinking water, too, can be positive as well as negative.
- Irrigation normally raises water offtake, but African experience shows that the main alternative to meet growing needs for food and workplaces - expansion of crops into, or more intensive cropping of, unirrigated land – is often far more blatantly and dangerously unsustainable. Moreover, in face of growing rural water shortage, irrigation can (expensively) be made environmentally friendlier by selecting or developing techniques to raise economic efficiency of water use, and to reduce salinity and irrigation.

[25] M. Lipton with R. Longhurst, New Seeds and Poor People, London: Routledge, 1988; J. Kerr and S. Kohlavalli, 'Impact of agricultural research on poverty alleviation', Internat. Food Policy Research Inst, Washington DC, 1999.

The institutional, pricing and market-development reforms proposed in this project, if properly modified to allow for externalities, can help with all three environmental issues. However, for adequately fast and large environmental gains from these reforms, technical and scientific progress is needed.

(i) Displacement of population by irrigation works: 'Large irrigation projects have been [mainly criticized for negative impacts [through] large-scale displacement of population' [ICR: 58; cf. 40]. There are no estimates of numbers displaced, or costs of displacement or resettlement, for systems in this study.[26] Perhaps most systems are too old for relevant data to be available. In the event of system expansion or rehabilitation, however, the issue could return. The poorest farmers are least likely to have the influence to guard, or compensate, them against displacement; yet 'in the G-K Irrigation and Rehabilitation Project .. net farm income [rose from] $500 $970/ha/year, [but] benefits .. are mainly enjoyed by the large landholders as they have more land to operate and can take a disproportionately larger share of the irrigation water' [BCR: 10]. Displacement, and NGO opposition to it, discourages donors (and many democratic governments) from supporting *any* irrigation, especially but not only new works such as the Narmada (India) and Three Gorges (China) systems, from which the World Bank withdrew despite apparently favourable cost-benefit expectations. The sociologist who drew up the World Bank's guidelines for dam-driven relocations wrote: 'Forced population displacement cause by dam construction is (its) single most serious counter-development consequence'.[27] Costing and compensating displacement effects of alternative irrigation strategies requires review in any analysis of irrigation policy. It is imperative that persons and groups displaced by irrigation be consensually resettled or compensated, not necessarily for reasons of poverty reduction (displacement of livelihoods by new works is often far outweighed, even for the very poor, by the new livelihoods they create), but for reasons of simple justice. Also, if such justice is denied, and even with likely huge net gain to GDP and to the poor from imminent works, the opposition from a few concentrated, substantial losers will usually defeat the support from many, but dispersed, gainers from the potential activity of those works.

(ii) Health effects: Negative health effects of irrigation, if any, also target the poor. They tend to have least disease resistance, access to affordable care, insurance, or capacity to bear the costs of enforced idleness. ICR (p.40) recognises, too, the poor's greater exposure to irrigation-induced 'malaria, filariasis and many other water-borne diseases' because they are likelier to drink, or live near, dangerous drinking water.[28] Irrigation may improve drinking water quality, but need not. The Bangladesh study claims that 'safe drinking water [and] access to sanitary latrines [were] more prevalent in the irrigated areas', but for the two systems with data (PIRDP and G-K) substantially *smaller* proportions of landless households had hand-pumps for drinking water in

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[26]Some 830,000 were displaced by 50 large dams evaluated in 'World Bank Lending for Large Dams: A Preliminary Review of Impacts,' *OED Précis* 125, Operations Evaluation Dept., World Bank, Washington DC, 1996. Displacement of 1.2-2 million people by the Yangtze/Three Gorges dam is projected by R. Siebert, *No Chance for Participation. Dam Building on the Mekong River,* Deutsche Stiftung für internationale Entwicklung: Development and Cooperation 4/2001: 201.

[27]Cernea, M. 1991. 'Involuntary Resettlement: Social Research, Policy and Planning.' In *Putting People First. Sociological Variables in Development Projects*. 2nd Edition. New York: Oxford University Press.

[28] LL write: 'Irrigation, particularly involving canals, reservoirs and tanks, .. encourages waterborne diseases due to inadequate drainage and renders the microenvironment hospitable to [vectors of] malaria and schistosomiasis. Untreated contaminated water [causes] serious diseases, from diarrhoea .. to cholera. It is likely that the poor are more .. exposed to [disease] sources through their work and in their homes (e.g. living beside rivers and canals, or on rivers); [less] able to prevent infection by .. sterilising water and water utensils [, and] to have access to prompt, appropriate medical treatment when they are infected .. These problems are much less serious with some sorts of irrigation .. field-to-field water in paddies (such as liyaddes in Sri Lanka) does not stagnate so is not a serious problem. In addition, tubewells can mean cleaner drinking water .. though pollution problems (from fertiliser) need watching'.

the irrigated area than in the adjacent rainfed control area, and in G-K this was also true of sanitary toilets [BCR: 76-8]. In three of the four Indian systems, 10-20% more households had an internal source of drinking water in the irrigated than the adjacent unirrigated area, but only in one, NSLC, was the incidence of toilets notably higher (24% as against 10%); in one system, KDS, 15-25% *fewer* households contained toilets or drinking-water facilities in the irrigated system area than in the adjacent control area [ICR: 138]. Further, 'widespread arsenic contamination of groundwater', while it 'might be a consequence of .. groundwater over-exploitation' [BCR: 113], may well also be linked to - and could be delinked from - surface irrigation as it may contaminate alternative drinking-water sources, and indeed crops; this and other drinking-water pollution from irrigation is perhaps remediable with good design and drainage choices. These need review.

These studies show that, at least in India and Bangladesh, better irrigation may well fail to bring the poor better drinking water/sanitation. The two - where provided, maintained and delivered – normally arrive via by separate systems, technologies, construction, management systems (participatory and/or bureaucratic), maintenance, and market/pricing regimes. Are big economies of scope, and hence cheaper and safer domestic as well as farm water for the poor, sometimes obtainable by joint planning and implementation of irrigation and drinking-water improvements?

This is a plea for analysis and joined-up action, not an attack on the health effects of these irrigation systems. The income and output data in these studies show that the systems provide incomes and food to improve the poor's nutrition, and it is unlikely that they actually worsen the poor's water/sanitation environment in general. Especially with the yield, employment, food-price, and hence consumption and nutrition effects of fertilizers and improved seeds – which do far better with reliable irrigation - its net health impact on the poor is surely positive and big;[29] but it could be far better. Effects on drinking-water contamination and insect vectors of disease need, perhaps, more review and action – and more emphasis on choice of techniques, development of new techniques (e.g. arsenic filtration, minimizing insect-borne disease in the wake of seepage) and collaboration between water, agriculture and health authorities[30] - than implied in these studies and their recommendations.

(iii) Soil-water environment effects and the 'water squeeze':
So also do environmental impacts. It is hoped that participatory and price reforms will increase incentives for environment-friendly water use. They do raise incentives to use water more carefully, because the user pays for it; but that will cut seepage,[31] evaporation and/or percolation (SEP) only if (a) the water-buyer is the same as the water-loser, or (b) participatory co-operation involves water users grouped by an entire shared water system affected by losses from SEP on any member's irrigated land. These are stiff conditions. If neither is near being met, SEP need not decline - may even rise – after otherwise desirable institutional or market reforms. Nor need such reforms, and/or other measures that raise crop-per-drop, deter all behaviour that increases salinity or waterlogging: over-watering (e.g. to drown weeds) will be deterred if water is properly charged for, but inadequate drainage need not be. The availability of low-cost techniques for appropriate water management - techniques either directly benefiting the user or readily supervised by or for a co-operating user group - is crucial, if environmentally sensitive water use is

[29]'While [irrigation-related people displacement and water-borne disease] carry heavy private and social costs, insufficient attention to the "without-irrigation scenario" in programme evaluation gives rise to a devaluation of the positive economic and social impacts of irrigation works' [LL, citing Carruthers, Blackman and other data].
[30]M. Lipton and E. de Kadt, *Agriculture-Health Linkages*, Offset Publication no. 104, WHO, Geneva, 1988: 33-35.
[31]Before dismissing, as 'waste', the impacts of seepage from canals, one must estimate its effect in *increasing* groundwater. In the Punjab, in 1934 rainwater contributed 80% of recharge. By 1980, it fell to 51%; of the rest, 39% was via seepage from canal irrigation and 10% from return flows from irrigation by groundwater (Chambers et al. 1989: 29; LL: 19). More canal irrigation led *via seepage* to more groundwater irrigation.

sought. As with displacement, so with environmental hazard: the strength of environmental lobby groups nationally and internationally - and the greater ease of mobilising losers (especially if concentrated) than dispersed gainers - means that the 'anti-irrigation' deterrent effect on politicians and sources of funds far exceeds what might be justified by an objective review of total costs, benefits, or poverty impact.

A broader environmental issue concerns the increasing squeeze on rural irrigation water. This comes from four sources: rising population; rising per-person domestic and industrial demand; climate change and hence (probably) increasing rates of evapotranspiration; and increasing pressure to use full market pricing to 'ration' water. Such pressure to economise farm (and other) water is largely justified. 50 countries, mostly not in S or E Asia (though including Pakistan), suffered severe water constraint or were water-stressed (below 1600 cubic metres per head per year) in 2000, up from 40 in 1990 and still rising [IFAD 2001: 91]. Most such countries are not in S or E Asia, but they include Pakistan, and many *regions* (mainly semi-arid) in other project counties are stressed. Farm use comprises over 90 per cent of water offtake in developing countries, yet typically generates only 15-35 per cent of GDP. Domestic and industrial users, even poor ones, are often eager to obtain reliable water at full market price, while farmers waste free or subsidized water. Such arguments are incomplete: farm water *used* is by no means necessarily *used up*; farm water subsidies only partly offset heavy, and in Asia (notably China) sharply rising, anti-farm biases, mainly in rural allocations of social services and infrastructure;[32] and unequal (and on the evidence of this project also therefore less efficient) farm water distribution means that the poor would be hardest hit by careless methods of cutting farm water use. Nevertheless, substantial cuts are both likely and to some extent justified on water-squeeze and other grounds.

How does the apparently macro-level threat of rural water depletion bear upon the micro-level issues facing poverty-oriented irrigation reformers? An important example concerns the use of drip and sprinkler irrigation to reduce SEP from transmission systems, whether from canals or from groundwater, and thus to raise the proportion of irrigation water reaching the fields. It has been estimated that sprinklers and drip systems frequently raise field efficiency from the normal 40-45% to 70-80% and 90% respectively.[33] Must such technology, and irrigation reforms that induce users to adopt it, economise on increasingly scarce water in a pro-poor way?

- Most such systems, e.g. center-pivot sprinklers, are designed for capital-intensive use on large farms. Hence they are not readily affordable (given imperfect credit markets) by the poor, and incentives to use them may lead to larger farm size. For both reasons, they may well displace labour, reducing wage-rates or employment levels for the poor.
- However, very low-cost micro-drip irrigation ('pepsi system') with minimal capital, suited to holdings as small as 100 square metres, has been developed by farmers and researchers and is spreading fast in many areas, including Western India (e.g. through the NGO, International Development Enterprises). Active work continues on similarly cheap sprinkler micro-systems.
- Drip or sprinkler systems that cut SEP between the secondary canal (or tank or well) and the field do, as such, raise field efficiency, but may be dwarfed by - and indeed (through timing of water use) may even increase - SEP *within* the canal, tank or well system, or from the field.
- Assuming drip or sprinkler methods (or anything else) do increase overall system field efficiency substantially, cost-effectively, and affordably for the poor, they need not 'save water'. In general, higher yield effects, and hence economic returns, to <u>fertilizer</u> use in the Green Revo-

[32] R. Eastwood and M. Lipton, *Rural-urban dimensions of inequality change* , Working Paper #200, World Institute for Development Economics Research, June 2000.
[33] P. Wolff and T.M.Stein, 'Water efficiency and conservation in agriculture: opportunities and limitations', *Agriculture and Rural Development* <u>2</u>: 2-20.

lution (via higher-yielding rice and wheat varieties) led farmers, not to obtain the same yield by using less fertilizer, but to obtain much higher yields by using more fertilizer. Similarly, if sprinkler or drip systems raise yields of water (e.g. by permitting horticultural or other more water-demanding crop-mixes), farmers may be induced to use, not less water, but more water.

- Finally, suppose drip or sprinkler systems reach the poor cost-effectively, and cut system water offtake. To the extent that this is achieved by reduced seepage or percolation, recharge of the system and/or transmission efficiency to downstream systems will be cut. Whether water use falls or rises at regional or national level remains to be established.

These remarks question neither the environmental importance of reforms, emphasized in this project, that induce farm-level water saving, nor the importance of new sprinkler or drip micro-technology in achieving faster, more cost-effective and more pro-poor response to such reforms. However, aggregate effects on water availability, use and stress cannot be crudely estimated from physical calculations that neglect price-elasticities, nor from single-farm effects alone.

## V. IRRIGATION CORRUPTION: HOW MUCH DOES IT HARM THE RURAL POOR?

Classic fieldwork in Andhra Pradesh by Wade [1982][34] showed that release of irrigation water into and out of secondaries normally involved corrupt payments. Though usually small as a proportion of production costs (and even of legitimate irrigation charges, if any),[35] these payments are nevertheless damaging. They harm the poor by favouring those with connections and capacity to bribe; worsen distribution between heads and tails; and discourage production and risk-taking by creating - often deliberately, to suit the interests of the corrupt - uncertainty about when, where and how much water will arrive. Further, tens of thousands of small per-hectare corrupt payments can provide huge income to the manager of a single large canal. To obtain such access, and avoid unremunerative postings, engineers or other managers must often pay heavy bribes to their superior, and recover them through illicit payments from farmers. Wade found that such bribes were funnelled upwards through the political system as an important source of support for parties. New irrigation construction and rehabilitation was similarly rewarding, but the crucial maintenance activity was not, so there were incentives to disregard and downgrade it. Abundant journalism,[36] much NGO and popular protest, and some recent research suggest that such conditions persist in many Asian canal systems, and create strong incentives to officials and politicians to resist or subvert reforms, such as participatory irrigation management, that might threaten incomes from bribery and corruption.[37] This challenges the view [ICR: 88] that 'most

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[34]Wade, R. (1982) 'The System of Administrative and Political Corruption: Canal Irrigation in South India', *Journal of Development Studies* 18, 3: 287-328, and 'Corruption – where does the money go?' EPW, 20 Oct: 1606.

[35] Compare a recent study of the Chishtian scheme: 'The average bribe amounts to a small levy: about US $1.4 per hectare, i.e. about 2.5 % of the average rent [is] appropriated illegally'. J-P. Azam and J-D. Rinaud, 'Encroached entitlements: corruption and appropriation of irrigation water in Southern Punjab (Pakistan)', *Development Studies Working Papers* N. 144, Nov. 2000, www.dagliano.uni-bocconi.it

[36]For example DAWN, Lahore, 26.5.2004: 'In .. a meeting .. attended by [many] farmers from throughout [Southern Punjab, they] alleged that irrigation official Superintending Engineer Niazi was involved in corruption by fleecing the poor farmers, and he has made millions of rupees and was not relieving his charge despite his transfer orders'. See also The Hindu, 21.7.2003 http://www.hinduonnet.com/thehindu/2003/07/21/stories/2003072108660300.htm; and Mustafa Talpur, 'Corruption, mismanagement in irrigation water distribution', DAWN, 20-3-2000.

[37]'Conventional approaches to [improving] irrigation schemes focus on .. technical, financial and/or organizational capacities of the irrigation agency and .. water users. Such approaches often overlook a number of significant problems which are causes of inefficiencies in the first place. These problems relate to the fact that efficiency deficits may be .. in the interest of most of the influential stakeholders involved. Since problems of this kind may emerge both in systems administered by a state agency and in farmer-managed irrigation systems, it is essential to focus more attention on their analysis and prevention'. B. Huppert and W. Wolff, 'Principal-agent problems in irrigation – inviting rentseeking and corruption', *Quarterly Journal of International Agriculture* 41, 1-2, 2002: 99.

often, corruption is due to lack of information or knowledge about procedures'. This project's excellent analysis and reform recommendations require, for effect, much more active engagement with the question of irrigation corruption.

Both efficiency-increasing and poverty-reducing impact from participatory irrigation management and water desubsidisation are established by this project. These recommendations will, almost certainly, in general decrease corruption in irrigation water allocation and probably in system maintenance [ICR: 54, citing Chambers].[38] Fisman and Gatti [1999] find 'a very strong and consistent negative association [running causally from decentralisation to corruption] across a sample of countries. This association is robust to controlling for a wide rage of potential sources of omitted variable bias as well as endogeneity bias'.[39] However, most irrigation systems will not at once decentralise; decentralisation permits participation, but does not imply it, let alone the sort that cuts corruption, viz. equitable participation with open information and redress; and even these together would still leave much scope for irrigation corruption.[40] At each stage, reform threatens 'influential stakeholders'. Much more work should be done, on the basis of the data collected in this project, to establish the determinants of irrigation corruption, and the measures likeliest to reduce it.

Irrigation delivery in Pakistan is permeated (and corrupted) by corruption. write: 'However, the inequitable distribution is mainly due to the interference of water users with the management of the system, as farmers try to influence the decisions of the Provincial Irrigation and Power Department (PIPD) staff. Such interferences are increasingly reported in the media in Pakistan' (see above, fn. 36) and 'by officials from the irrigation bureaucracy .. donors .. and by policymakers' [Azam and Rinaud 2000: 6-7, and citations respectively from Ullah, World Bank and Government of Pakistan]. In this context, PCR[41] provides fascinating insights into the impact of irrigation management transfer to farmers' organisations (IMT, similar to PIM in India) in one of the four canal systems studied, Hakra 4-R.

Collection and recording of correct water rates (abiana) was much better – indeed tolerable only in – Hakra 4-R system and only after IMT. Both abiana finance and - partly as a result - canal maintenance improved substantially 'due to reduced corruption and higher participation after IMT [so that] 'No other distributary, in the study area of the project, was in such a better physical condition as was Hakra 4-R .. reflect[ing] efficient management [by the Farmers' Organisation as compared with] Punjab Irrigation Department' [PCR: 198].

However, as regards quality of irrigation, the reports are mixed. Below 5 per cent of farmers reported 'no bribery' as an important 'water-related benefit to farmers' from IMT; '23 percent .. complained against the office-bearers of [the post-IMT farmers' organization] for favouring their friends and relatives'; barely 10% said that water supply had become more reliable; and '51% .. reported no change in benefits for the small and the poor farmers'. 41% of tail-end farmers, as against 58% of head-ender farm households, 'believed that the farmers' organisation was able to complete its operations successfully'. [PCR: 186, 189-90]. These are signals that corruption is far

[38]Though not necessarily in construction (nor, therefore, rehabilitation).
[39]R. Fisman and R. Gatti, 'Decentralization and Corruption: Evidence Across Countries,' www.worldbank.org/ research/abcde/washington_12/pdf_files/fisman.pdf, Oct 1999; also as Working Papers -- Governance. Corruption, legal reform. 2290, World Bank, 2000.
[40]See ICR: 119 on *thokdari* group management of rotational irrigation in Uttar Pradesh.
[41]Intizar Hussain, with Waqar A. Jehangir, Muhammad Ashfaq, Intizar Hussain, Muhammad Mudasser and Aamir Nazir, *Pakistan Country Report: Pro-poor Intervention Strategies in Irrigated Agriculture in Asia: Issues and Options*, IWMI-ADB, Colombo,2004.

from cured by this form of decentralized participation. However, '57% of the farmers rated the working of FO to be very good or good .. 68% .. believed that there was improvement in equity in water distribution .. due to greater control over water theft, which was very common before IMT' [PCR: 184-5].

Both inequitable distribution and water theft, reduced by IMT (and PIM) but prevalent in typical canal systems throughout (at least) South Asia, are largely aspects of corruption. In Chishtian canal system, South Punjab [Azam and Rinaud 2000: 8], a few farmers 'appropriate illegally a sizable quantity of water, by tampering with 9 outlets, worth on average US$55 per hectare per year .. while the losses are spread over a larger number of farmers located downstream, supplied by 40 outlets, losing .. US$7 per hectare per year .. bribes paid to the irrigation department officials [are US$140-430] per outlet per year. Similar figures were obtained .. in other areas of South Punjab'. Indeed, these authors can compare the extent of corruption across systems by measuring the number of cases of enlarged outlets, since these are almost always illegal and tolerated only due to a bribe.[42] Elsewhere in Asia too, better-off head-enders bribe or pressure officials to turn a blind eye to 'illegal enlargement of official canal outlets, breaking off gates so the outlets cannot be shut, cutting extra outlets in the canal banks, or blocking the flow of water immediately downstream of an outlet to force more water through .. Use of .. these methods in upstream villages squeezes water supply to villages downstream, so that farmers lower down have to exert themselves even more to protect their supply.'[43] Poorer and lower-lying users must compete in the bribe market with the more powerful head-enders and better-off, creating a bribe market that raises the money bled out of the system and the uncertainty and unreliability of irrigation arrivals.

It is a commonplace, increasingly backed by research, that efficiency and equity in canal systems are severely damaged by corruption. Desubsidisation and decentralised or participatory management change the forms of corruptibility, and may greatly reduce its scale and impact. Hence, however, the gainers from corruption try to resist or subvert such reforms. A key issue for making canal (and much other) irrigation more efficient and more pro-poor is how, when and where to stop, deter, or reduce poverty and efficiency harm from, irrigation corruption: whether by price, administrative or penal acts; by exposure or 'vigilance'; or by choice of techniques (e.g. computerisation). The rich data in this project permit, and demand, systematic attention to such issues.

## VI. IRRIGATION AND OTHER POVERTY-REDUCERS - AND OTHER IMMANENT ISSUES

This paper started by pointing out that, to an economist, it is NOT obvious that poverty (which varies inversely, and quite closely, with the returns to unskilled labour) is *persistentl*y or *much* lower, or the return to investment in farming *persistently* or *much* higher, in irrigated areas than in adjacent and otherwise similar unirrigated areas. If it were, one would expect poor workers, and investors, to shift from unirrigated areas, towards irrigated areas offering, persistently, much greater rewards. These shifts, and their effects on labour and capital markets, would not be immediate or total, but eventually would gradually shrink the poverty gap between irrigated and unirrigated areas. Is there anything in these papers that allows us to shed light on that 'poverty gap'?

(i) <u>Irrigation-to-disimpoverishment: are other things equal?</u> In this context CCR, chapter 5, is of special interest. Irrigated plots, compared with others, have much higher yield, cropping in-

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[42] 'Our data from the field provide a unique opportunity to test such a micro-economic model of corrupt behavior, because the deal between the rich farmer and the irrigation official leaves a measurable mark on the irrigation infrastructure, as the delivery of additional water requires the enlargement of the outlet' [Azam and Rinaud 2000: conclusions].
[43] LL, citing R. Wade [1982] and R. Wade, *Village Republics*, Cambridge University Press, 1988.

tensity, value of crop-mix, and hence revenue per hectare. The differences (and their poverty impact) are more for poorer areas: 'irrigation increases total income in rich areas only by 9 percent, while increasing it in poor areas by 38 percent. However, 'our findings so far do not prove anything beyond correlation since we have only been comparing unconditional means of irrigated and non-irrigated plots. In fact, the observed differences may be partly (or could even be fully) due to other factors (such as land quality or management ability) that are correlated with irrigation.' Hence effects of plot irrigation on yield are estimated by crop (a) allowing for plot size, land quality, topography, distance from home, single versus multiple cropping, and whether surface or groundwater irrigation is used; (b) with and without household (or alternatively village) fixed effects, thus allowing for the possible yield impact of (say) education – an impact likely to be correlated with that of irrigation, since both are commoner in less remote, better-off areas with more infrastructure. The results confirm that irrigation significantly raises yields for most crops (wheat by 17.7 per cent), as well as cropping intensity.

Holding the variables in (a) above constant at their means, and with village and plot fixed effects, the impact of irrigation on revenue-per-hectare falls from about 80 per cent to about 40 per cent. However, that is still large, and given the low inequality of land in China bound to affect poverty substantially. Though irrigation raises yield by less in poorer areas, that is more than offset by their higher share of crops in total income (and probably also by less-small farms - not necessarily plots - and lower per-acre costs), so '.. irrigation benefits farmers .. 18% in poor areas versus 13% in rich areas' [CCR: 90-102].

Both this careful analysis and modelling of land quality, plot and household variables and effects in CCR are of great value.[44] It is very desirable to apply these methods to other country reports, and – perhaps most of all – to the comparisons of yield, poverty and revenue across systems and countries - comparisons which at present tend to be on a 'with and without irrigation' basis.

CCR does not, however, explore whether the above extra income is due to irrigation or other direct farm inputs. This is hard to do, both because irrigation makes possible or profitable the use of fertiliser or new seeds, so that a causal model, not a simple multiple regression, is needed – and because of problems in establishing levels of fertilisers, better seeds, and irrigation used on different *plots* (not just farms).

(ii) From land inequality to low irrigation impact: is there a 'minimum viable holding'?: HW summarise project evidence that the much lower return to S Asian irrigation systems than in E and SE Asian systems is due in part to land and water inequality.[45] Across the 16 systems studied, 'improving .. equity index from 1 (highly inequitable) to 6 (fairly equitable) would reduce income-poverty index from over 50% to less than 30% .. Equitable distribution of land and water resources would have even greater poverty-reducing impacts'. However, 'equity in land distribution here means promoting redistribution of land to the extent that land size units remain economically viable and is according to a threshold level [variable with land quality, productivity, and non-farm opportunities] of land size that generates livelihoods for households to be able to move out of poverty'. It is not clear that there is any case for such a lower limit on landholdings. First, clearly it cannot be applied to existing micro-holdings, and enforcing it only on reform land seems inequita-

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[44] So are the disaggregations by crop, not discussed here.

[45] They cite in further support Hussain, Intizar; Sakthivadivel, R.; Amarasinghe, Upali; Mudasser, Muhammad; Molden, David. 2003. Land and water productivity of wheat in the western Indo-Gangetic plains of India and Pakistan: A comparative analysis. Research Report 65. Colombo, Sri Lanka: International Water Management Institute, and a recent World Bank study of Pakistan.

ble. Second and much more important, the bulk (though not all) the evidence suggests that the 'inverse relationship' between size and yield – resting on small farms' lower unit supervision costs and hence higher labour/land ratios is no evidence that the inverse relationship – is continuous right down to the smallest farm-size groups.[46] These are thus 'viable' in the sense of 'efficient'. Third, tiny agricultural holdings are normally *part* of the total livelihood of households around the poverty line. It is therefore not a valid objection that income from such holdings *alone* cannot suffice to prevent poverty. Fourth, there is no evidence that such part-time farms are less efficient than full-time farms of similar size and conditions.

(iii) <u>The poverty line</u>: This project involves comparing the poverty impact of irrigation in 26 systems (and their rainfed peripheries) in six countries. Where HW and others make comparisons of the poverty impact of irrigation across countries or systems, they use *national* poverty lines, concluding, for example, that across systems 'the incidence of poverty varies from 6 percent to 77 percent .. [and] depth of poverty varies from 3 percent to 68 percent'.

In my view, such comparisons are better made using a standardised poverty line that reflects constant purchasing power across countries, such as dollar-a-day. HW rightly point out that such lines have many deficiencies and problems, and that national lines reflect carefully considered national criteria and (in Asia) are calibrated with estimated basic food requirements. However, Ravallion has established that national poverty lines tend to increase, and quite substantially, with real income per head, i.e. the conception of a 'basic minimum' is – quite understandably, even with these purportedly absolute (not relative) poverty lines – geared to the national average, norm or median. Work in Indonesia and Kenya suggests that there are similar distortions among areas (and hence irrigation systems) within the same country: richer - perhaps because more irrigated or urbanised - regions are assigned higher poverty lines (even though these are purportedly absolute and nationally standardised), often via the choice of components in regional cost-of-living indexes.[47]

This matters, because international assessments of poverty differences among systems and countries in poverty, and even between irrigated and unirrigated areas, will be systematically biased upwards if richer areas have higher poverty lines. The proportion of poor people in richer areas – which are likelier to have irrigated their cropland – is raised, not only by effects of irrigation (and other real effects), but also by the fact that the richer areas and countries have higher poverty lines, so that more people lie below the line than would be the case if the poverty line of poorer (or non-irrigated) areas were used.

## VII. 'AFRICA 3%, ASIA 40%': IRRIGATION ACCESS AND GLOBAL POVERTY

Huge regional differences in the irrigated proportion of cropland coincide with successes or failures in poverty reduction. In sub-Saharan Africa only around 3% of cropland is irrigated; the estimated poverty headcount was 47.7% in 1990 and 46.3% in 1998. The regions that have the greatest proportion of cultivated area irrigated, East Asia and Pacific and North Africa and Middle East, experienced the greatest poverty reduction. This is no mere coincidence; differences across regions, countries and states within countries in irrigation almost certainly reflect differences not only in poverty incidence, but also in prospects of reducing it through agricultural change that af-

[46]Below some tiny farm size, the cost of land or fencing 'wasted' on inter-plot partitions may exceed the benefits of higher labour/land ratios, but the persistence of urban allotments, and even rural and urban back gardens, show that this size is tinier than any 'threshold' under serious consideration.
[47]On these issues see M. Lipton and M. Ravallion, 'Poverty and policy', in J. Berhman and T.N. Srinivasan, *Handbook of Development Economics vol. IIIB*, North-Holland, Amsterdam, 1995.

fordably raises (a) demand for, and hence returns, to labour; (b) availability of food staples; (c) stability of both across seasons and years. The speed of poverty reduction, and the risk of relapse, in India is closely related to irrigation that cuts impact of 'unstable agriculture and droughts'.[48]

Table 1: Poverty incidence and irrigation in developing regions

| | $1-a-day poverty[a] 1998 | | | % Irrigated area per Ha cultivated area (arable+ permanent cropland) 1999 |
|---|---|---|---|---|
| | Incidence (mns) | % of total population | % Change incidence 1987-98 | |
| E Asia, Pacific | 278[b] | 15[b] | -33[b] | 20 |
| Latin America, Caribbean | 78 | 16 | 22 | 12% |
| North Africa, Middle East | 5 | 0.04 | -44 | 27% |
| South Asia | 522 | 39 | 10 | 6% |
| Sub-Saharan Africa | 291 | 44 | 34 | 3% |

[a] People living on less than $1 per day in 1998 (1993 PPP $US) [b] East Asia
Sources: LL, citing World Bank (2000, 2001); irrigation from FAOSTAT database

Further, 60 per cent of food production in Asia (Pakistan 80%, China 70%, India and Indonesia each 50%) came from irrigated land, as against 9 per cent in sub-Saharan Africa.[49] It is most improbable that the weak poverty-reduction performance of sub-Saharan Africa can be much improved without much more irrigation. Farmer-controlled micro-systems are both fashionable and an important part of the solution, but their area spread has hitherto been very slow. Medium and major schemes, including gravity-flow systems based on canals and dams, are almost certainly needed, The past record is bad, though not uniformly so, and some of the reasons for weak performance and low benefit/cost ratios have receded. On the cost side, inter-regional comparisons made by the World Food Conference in 1974 estimated that per-hectare cost oft new schemes in sub-Saharan Africa was 64% more than in the Far East and 55% more than in Latin America (but actually 3% less than in the sandy and porous soils of the Near East), and rehabilitation cost 20% more than in the Far East and Latin America (but 11% less than in the Near East) [LL]. However, Africa's cost disadvantage may have been reduced by learning, by rising labour costs in Asia, and by reduced dependence in Africa on overseas consultants and construction companies with powerful market positions. On the benefits side, the steady undermining of world farm prices by EU and US farm and trade distortion continues, but the 'natural protection' of much African agriculture by transport costs may mean that this has reduced the benefits of irrigation there less than in other areas. Certainly, favourable returns from African irrigation require more fertiliser use and better seeds, but also enable these advances, and raise the returns to them.

I hope IWMI and others, in following up the findings of this project, will carefully review the implications for existing *and potential* irrigation in sub-Saharan Africa. One obvious lesson is that the efficiency - as well as the distributional and poverty-reducing impact - of irrigation is

[48] Ray, Susanta K., Hanumantha C. H. Rao, and K. Subbarao (1988), 'Unstable Agriculture and Droughts: Implications for Policy', *Studies in economic development and planning*, 47. New Delhi: Institute of Economic Growth
[49] Wallingford Hydraulic Research Laboratory, *Priorities for Irrigated Agriculture*. Water Resources Occasional Paper no. 1. Department for International Development, London, 1997.

probably much reduced by extreme land inequality, as in Southern Africa, and by the fact that irrigation inequality is even more extreme; giant farmers have secured free, or heavily subsidised, water for capital-intensive use, leaving almost no water control for the labour-intensive small-farm poor. Poverty reduction demands attention to this issue.

## VIII. SOME OPEN ISSUES

We need to continue to review these and other issues raised by these excellent and thought-provoking studies. One key point is this. Aid to agriculture has fallen by about two-thirds in absolute real value since the late 1980s. There is no evidence that domestic public, or domestic or foreign private, investment has replaced much of this decline. Accordingly it is not surprising that the rate of growth of foodgrain yields – much the most important component of total farm output growth – has fallen from about 3% per year around 1975-85, to about 1% per year since 1995 [IFAD 2001; OECD database]. Unless there is a revival in agricultural growth, and hence in demand for labour and supply of food, there is little hope of improving on the characteristic poverty trajectory of 1990-2004: little growth of GDP per head, and hence little or no poverty reduction, in Africa; sharply reduced conversion of growth (itself accelerated) into poverty reduction in Asia.[50] Revived agricultural growth, in turn, depends partly on seed improvement, partly on policy reform (including land reform), but also substantially on reviving aid to, and investment in, agriculture in general and, in particular, the spread and rehabilitation of irrigation (compatibly, of course, with the increased rural water efficiency, and desubsidisation, needed in face of growing urban, domestic and industrial demand for water, and of climate change).

So we need to look at the results of this project and to ask: what do they tell us about the causes of collapse in irrigation investment, and about cost-effective, pro-poor ways to remedy that collapse?

Can more land and water equity raise incentives for governments, donors, and private providers to invest in sustainable irrigation, including (but not only) maintenance and rehabilitation?
Was the fall in irrigation investment due to a falling rate of return – and to what extent can ERR be increased, in specific types of case, by more equitable distribution of water, irrigated land, or access to irrigation? Has the retreat of irrigation been due to rising construction and rehabilitation costs (per hectare or per unit of value added), and what can be done to cut such costs? Can better cost recovery be linked to investment in more, more secure or better irrigation (or linked drinking-water and sanitation) for the communities from which costs are recovered?
Falling farm prices have helped make irrigation investment and rehabilitation less attractive; does this indicate concentrating new irrigation in areas with high transport costs, where costs of trade (and hence competitiveness of imports) are higher?
Has *technical* efficiency (field efficiency x conveyance efficiency) been cut by trends in seepage, evapotranspiration or percolation, and with what effects on recharge, salinity and waterlogging?
Do these studies show that we have sufficient feasible remedies in the realm of prices and institutions, or is there a major role for technical innovation, and perhaps for basic science?
Finally, the main single fact militating against aid to agriculture, and especially to irrigation, has been the growing doubt about side-effects: on health, on uncompensated land loss from new works (especially among indigenous populations), and on environmental sustainability. Do the studies in this project tell us anything about the validity of such objections (as compared to the anti-poverty benefits), both for existing irrigation and for potential new irrigation? Do they suggest ways to build or manage new irrigation that will increase environmental and health gains, reduce costs and risks, and compensate losers?

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[50] The two continents contain well over 90 per cent of the world's dollar-poor.