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FARM WATER AND RURAL POVERTY REDUCTION IN DEVELOPING ASIA†

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ABSTRACT

The study on ''pro-poor intervention strategies in irrigated agriculture in Asia'' by Hussain (2005) shows that, in 26 major and medium-size canal irrigation schemes in Asia, irrigated areas average 20% lower poverty than adjacent rainfed areas; gains are more with pro-poor management of water for farming (PPMWF) and where distribution of farmland or farm water is more equal. These findings, and the measured endorsement of participatory irrigation management (PIM) of these schemes, look robust, though they need to allow for externalities (interaction with groundwater and micro-irrigation; out-of-scheme downstream effects).

This paper explores some implications. The diagnosed ''inefficiency of gross inequality'' in irrigation echoes similar wider-scale findings on aggregate inequality and vulnerability. The choice among irrigation techniques, and science to develop new ones, need to adapt more to the needs of PPMWF. PPMWF planning must itself adapt – as must design of new schemes – to the needs for sustainable water resources, manageable health impacts, and proper treatment of displaced people. Technical and management design to reduce irrigation corruption – as it relates to poverty impact of irrigation, and to PIM – needs more review. The *causal* links from various types of irrigation to growth, distribution and poverty need more extensive modelling and testing. The important implications of this study (with the above contexts) for major irrigation in Africa – almost certainly essential for major progress against poverty there – need systematic assessment. Finally, some open issues are listed. Copyright © 2007 John Wiley & Sons, Ltd.

KEY WORDS: irrigation techniques; sustainable irrigation; irrigation corruption; poverty; participatory irrigation management (PIM); pro-poor management of water for farming (PPMWF); Asia; Africa

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RÉSUMÉ

L'étude de « stratégies d'intervention en faveur des plus pauvres dans l'agriculture irriguée en Asie » par Hussain (2005) montre que, dans 26 grands et moyens systèmes d'irrigation en Asie, les secteurs irrigués ont une pauvreté moyenne inférieure de 20% à celle des zones voisines non irriguées; les gains sont plus élevés avec une gestion « pro-pauvres » de l'eau agricole (GPPEA), et là où la répartition de la terre ou de l'eau est plus égalitaire. Ces résultats, et l'adoption mesurée de la gestion participative de l'irrigation (GPI) dans ces périmètres, semblent robustes, bien qu'ils ne prennent pas en compte les externalités (interaction avec les eaux souterraines et la micro-irrigation; effets hors périmètres en aval).

Cet article explore quelques unes des implications de ces résultats. Le diagnostic « d'inefficacité de l'inégalité » en irrigation fait écho à ce que l'on constate à plus grande échelle sur l'inégalité et la vulnérabilité globales. Le choix et la base scientifique renouvelée des techniques d'irrigation doivent davantage s'adapter aux besoins de la GPPEA. Et celle-ci doit elle-même tenir le plus grand compte – comme le doit aussi la conception de nouveaux périmètres – du besoin en ressources en eau durables, des impacts sur la santé, et du traitement approprié des

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personnes déplacées. La conception technique et opérationnelle des nouveaux périmètres irrigués en vue de réduire la corruption dans l'irrigation – dans ses interactions avec la pauvreté et la GPI – demande plus d'attention. Les conséquences des divers types d'irrigation sur la croissance, la répartition et la pauvreté doivent faire davantage l'objet de modélisation. Les importantes implications de cette étude (dans les contextes indiqués ci-dessus) pour la grande irrigation en Afrique – certainement aussi essentielle pour la lutte contre la pauvreté là-bas – ont besoin d'évaluation systématique. En conclusion, un certain nombre de questions sont énumérées.

MOTS CLÉS: techniques d'irrigation; irrigation durable; corruption en irrigation; pauvreté; gestion participative de l'irrigation (GPI); gestion « pro-pauvres » de l'eau agricole (GPPEA); Asie; Afrique

INTRODUCTION

Irrigation and the poor

These papers draw on an outstanding empirical study by Dr. Intizar Hussain and his colleagues.[1] 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 (Hussein and Wijerathna, 2004, Table I and Appendix Table A1).

Is it not obvious that irrigated rural areas will have much less poverty than adjoining unirrigated areas? No. To an economist, it is surprising. In rural Asia, most income of the poor is from hired labour. In a newly irrigated region, *initially*, wages and employment rise, so poverty falls as compared with the rainfed area. But that should draw in labour from the adjoining rainfed area – raising wage and employment rates there, cutting them in the irrigated area, and tending to close the poverty gap between the areas. Capital mobility (out of the initially higher-wage irrigated area, to the rainfed area with temporarily cheaper labour) should also reduce this wage and poverty gap. Big, persistent gaps in poverty, wage-rates, and mean income between irrigated and adjacent unirrigated areas arise from an odd combination: green revolution that keeps irrigated areas advancing faster than others; and residual underdevelopment that slows or blocks responsive mobility of labour and capital. The evidence of these papers suggests just such a failure of neo-classical convergence. It also reveals big differences, among and within systems, in irrigation's efficiency, equity, and thus poverty impact. How far does the study validate neo-classical models underlying irrigation reform?

Table I. Poverty incidence and irrigation in developing regions

Developing in:	US$1-a-day poverty[a] 1998		1987–98: (%)	2000 Irrigated area: % of cultivated area (arable+ permanent cropland)
	Incidence (millions)	% of total population	Incidence change	
East Asia (ex Japan)	278[b]	15[b]	−33[b]	32.9[b]
Latin America, Caribbean	78	16	22	11.5
North Africa, Middle East	5	0.04	−44	29.3[c]
South Asia	522	39	10	39.5
Sub-Saharan Africa	291	44	34	3.7

[a]People living on less than US$1 per day in 1998 (1993 PPP US$).
[b]East Asia excluding Japan, Republic of. Korea, Malaysia, Thailand (negligible US$1-a-day poverty in 1998).
[c]North Africa plus "Middle East in Asia".
Sources: poverty from Lipton *et al*. (2002), citing World Bank (2001); irrigation from FAOSTAT database accessed 24 Aug 2006: http://faostat.fao.org/site/419/DesktopDefault.aspx?PageID=419 and http://faostat.fao.org/site/418/DesktopDefault.aspx?PageID=418.

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The main lessons are that (1) *within-system* efficiency gains arise from reforms that free up markets, price water appropriately, or clarify individual *or collective* property rights to it; (2) to the extent that farm water is initially concentrated with the better-off, such reforms – by easing the markets by which water may be transferred to poorer farm users within the system – are likely to favour them. These lessons are in concordance with neo-classical economics. Less clearly so are others: that (3) great initial within-system inequality of land *or water* militates against their efficient use; may permit non-economic subversion of reform or direction of its gains to the rich; and may deny poor farmers credit or capacity to bear risk, impeding their ability to respond to reform by better farm water management; (4) such response may also require technical progress, or new water science. Nevertheless, (5) the cost and the harm to the poor, at system level, of *weak or absent* incentives for efficient and economical water use argue strongly for reforms such as participatory irrigation management (PIM), though (6) the study shows different degrees of reform success, benefit and sustainability; and (7) reforms increasing economic efficiency of within-system farm water use have complex, little-explored external effects on health, environment, and users in downstream systems.

What determines the cost-effectiveness of irrigation as a sustainable remedy for poverty (a) in irrigated areas, (b) by spreading to new areas? This study, in its context, suggests, 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 household, 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). It analyses and compares differences, at farm-household and system levels, in poverty – and the impact of water managers' decisions, and rules and incentives affecting them, on poverty via equity and efficiency.

However, first, such impacts occur in the context of the ‘‘total water source’’, typically, in the case of a canal system, the river 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: canal systems smaller than those reviewed in this project, and other small arrangements, e.g. farmer-controlled dug wells. The sustainability, availability and distribution of water from such schemes, and hence their poverty impact, often depend partly on irrigation and drainage decisions in nearby major schemes.

These two contextual issues are not raised to slight the topic of this study: cost-effective improvement of PPMWF *within* major/medium canal schemes. Many millions of the Asian poor can gain from that. However, the findings on PPMWF *within* major/medium canal systems should be set into a wider view of the impact on poverty of *all* linked forms of, resources for, and allocation and management options affecting, irrigation from a linked water source (river basin plus associated groundwater resources). For this wider view, it is especially valuable that drainage is part of the remit of the institutions managing most of the canal systems in this study. Incentives and institutions (for households and irrigators) affecting 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. A system's impact on water, and hence poverty, elsewhere is also affected by system-level runoff, seepage, and evaporation. The summary report on Vietnam valuably compares evapotranspiration among canal systems; this would be useful for other countries too.

Sticking with the focus on PPMWF *within* major/medium canal schemes, we can place these studies into six other relevant contexts. First, 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). Here the relevant context is evidence that: (a) unequal initial distribution reduces the impact of growth on poverty; (b) in developing countries more equal distribution of assets, especially farmland, is not only good for

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the poor but also efficient; (c) irrigation and PPMWF also affect *vulnerability* to shocks of those near or below the poverty line.

Second, major and medium canal schemes need to be set into a context of the cost-effectiveness, in reducing poverty, of choices within and among *techniques* of irrigation and PPMWF. What *new technologies* might conduce to participatory, diffused or decentralised management?[4] Types of technique (differing in capital intensity, divisibility, risk, and scale economies or diseconomies), not only social organisation, influence the extent to which such management is feasible, and hence whether, and how far, market reform (as these studies suggest for irrigation) (a) conduces to greater system efficiency, (b) tends to be pro-poor,[5] (c) is *more* productive and pro-poor where land is more equal. These things work quicker and better if appropriate, accessible technology is available to raise output, or change crop mixes, when markets improve. 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 new technology – maybe a ‘‘blue revolution’’ in water science. Otherwise, especially if poor, they may not be able to respond much, or fast, to more sensible prices, markets, and participatory institutions, reducing the impact on efficiency and poverty.

The third context is water sustainability. That need not benefit from –- indeed, without careful choices of incentives and institutions, may be harmed by – more equitable or efficient farm water use. Water sustainability 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 is institutional. The final synthesis report (Hussain, 2005) reviews how corruption affects system efficiency and equity, and is in turn affected by system management and reform. We have long known that most irrigation systems *should* be so managed as to spend more on maintenance relative to new works, and to spread more water to tail-enders – and, at least since Wade (1982), what mechanisms, in South Asian systems, divert or corrupt efforts to this goal. While rejecting 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.

Kant distinguished between ‘‘transcendental criticism’’ (your statement needs to be related to other issues) and ‘‘immanent criticism’’ (there are internal problems with your statement). Unlike the above four contexts, the fifth is immanent. Do the explanatory variables and relationships, tested in this study, 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? The China study is a brave approach to this difficult issue. 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 upon poverty or average income; the *causal* links, from acquisition of irrigation to fertilisers and new seeds, may need to be modelled. Another ‘‘immanent’’ issue is whether the choice of nation-specific poverty lines invalidates some conclusions.

Also there are global contexts. These studies strengthen the anti-poverty case for more irrigation (and better PPMWF) in Asia – and in sub-Saharan Africa, with below 4% of cropland irrigated. The Millennium Development Goal of halving dollar poverty in 1990–2015 cannot be achieved 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 reinserted into policies on trade, investment, aid, science and development. Most of the poor are smallholders or farm workers. Even more of the poor are poor because smallholders lack adequate, controllable farm water.[6] Yet there has been a long, dramatic decline in the role of smallholder irrigation, 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, even if 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? This and other open issues raised by this project are listed at the end of this paper.

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IRRIGATION, INEQUALITIES AND INEFFICIENCY

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

- higher incomes, in an average month or year, for poor *farmers*;
- higher labour demand (and so wage-rates and/or employment) for poor *farm workers*;
- higher demand for the products, or labour, of the *rural non-farm* poor;
- lower staples prices for *the urban poor*;
- smaller *shocks*. Though most irrigation is itself correlated with recent rainfall, in this study consumption in bad months falls by smaller proportions in irrigated areas than in adjacent rainfed areas (pers. comm. Intizar Hussain, 2004). In India, irrigated areas show 2.5 times lower standard deviation than rainfed areas in growth rates of crop output per year in 1971–84 (Lipton and Litchfield, 2002a). Stability benefits the poor most, due to their restricted access to credit; reduces shocks to the poor's farm revenue, employment income and food prices; cuts distress sales of crops and land (Howes, 1984; Chambers *et al*., 1989); and helps the poor to take profitable risks in production (World Bank, 2001).

Such gains can be frustrated; for example, stability can suffer if irrigation over-expansion or corruption increases tail-end uncertainty. This study shows, moreover, that 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 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[7] rather than capital-intensively;
- to apply irrigation to main food cereals and roots (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 (see e.g. Hazell and Ramasamy, 1991).

Must this create a virtuous circle, where irrigation is concentrated on small-farm users and cuts their poverty? Not if political pressure focuses land and water on 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 East and South-East Asia in this study. But even then, is irrigation concentrated on small farms – or made available where farmland is not very unequal – *inefficient*? Suppose that, in situation 1, the poorer half of farmers get 40% of land and irrigation water, but the returns to 1 ha of land and 250 l day^{-1} of irrigation water are, say, 100; but in situation 2, while the returns are higher at 250, the poorer half of farmers enjoy only 20% of land and irrigation water; 20% of 250 is more than 40% of 100, so in this case poor farmers, and possibly poor people as a whole (including the urban and rural non-farm poor), would be *worse* off in the more equitable situation.

This study provides firm, plot-level evidence that this is not the case. It has long been known – though the knowledge is still resisted – that in developing agricultures, where fixed capital makes a relatively small production contribution compared to labour, very unequal land distribution tends to reduce output per hectare, which is normally more on small and family farms (Berry and Cline, 1973; Binswanger *et al*., 1995; Lipton, 1993; Eastwood *et al*., 2008). That is mainly because they 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.

Yet irrigation continues to be inequitably distributed. The India Country Report (Hussain *et al*., 2004d) finds that "though marginal farmers gained in an absolute sense, large farmers gained proportionally more" in the systems studied, and cites 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". Then why does so much irrigation water go to larger farms? Why are they not leased to smaller farmers, or otherwise managed in smaller units, with both landowners 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

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and water. In any event, this project gives strong if initial evidence that for irrigation, as for farmland, small and equal is not only pro-poor but also efficient.

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 Chinese Country Report by Hussain *et al*. (2004b), in irrigated areas, yields are nearly twice unirrigated for cotton and 70.9% higher for wheat, though only 16.4% 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 Chinese Country Report 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%, while increasing it in poor areas by 38%; (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. Regional gaps are increasingly the main cause of inequality in China, where, as in India, both poverty reduction from, and economic return to, irrigation is increasingly higher in well-selected poor and backward areas than in advanced areas (Fan *et al*., 2000a,b). Such 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 [in South Asia] 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.

Yet ''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, given allocation of water in proportion to land, mean lower crop-per-drop on large farms also. However, 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 chance for farm *water* efficiency and equity to cut poverty even where farmland 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 production and poverty reduction than if water is allocated in proportion to land, as ''in all the systems studied'' in this project.

More equal land and irrigation, then, may cut poverty not only by raising the poor's share of land and water, but also by making irrigation more efficient. But how does irrigation itself affect inequality? A review of 13 FAO studies concluded that ''micro-irrigation...produces more equitable outcomes than large-scale, indivisible projects'' (Lipton *et al*., 2002a).[8] Within canal irrigation, this study shows that in developing countries ''small and

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equal is efficient'' for canal irrigation (as for farmland[9]), but the cross-system data need crosschecking against the large and unique body of plot- and household-level data in the country studies. If the finding survives such checks, it needs to be related to:

Evidence that, more equal income distribution greatly improves the poverty-reducing effect of distribution-neutral growth. Consider two economies A and B, with the same mean income and initial proportion of people below an absolute poverty line, but with higher ''income inequality'' in A. A typical poor person in A almost certainly lies further below the poverty line than her counterpart in B, as does the typical person 1% or 2% above or below the income of the typical poor person. So a given growth of mean income, if distributed just like initial income, will bring fewer people above the poverty line, and hence cut poverty incidence less, in the less equal country, A. So more pro-poor income distribution, e.g. due to focusing irrigation and/or land access on the poor – apart from its own poverty-reducing effects (see above) – increases the future poverty-reducing impact of distribution-neutral growth from other sources.

Evidence that more equal income and asset distribution may themselves increase growth: high asset inequality, and high-income inequality *in developing countries only*, substantially slow down economic growth (Eastwood and Lipton, 2000a). The nature of inequality may matter: inequality *ascribed* by virtue of birth, inheritance, kin or position is probably anti-growth, while some degree of *achieved* inequality, as a reward for economic contribution, is pro-growth. Since land and water rights owe so much to accident of birth and inheritance, this suggests that more equitable irrigation in developing countries, if sustainable, contributes 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 that the impact of better irrigation productivity or equity on poverty, while significant statistically, looks small (Hussain and Wijerathna, 2004). Across the 26 canal systems, only ''20% of income-poverty [is removed by irrigation that raises farm] productivity from US$200 ha^{-1} to US$1000 ha^{-1}', and moving from the highest to the lowest degree of land inequality ''would reduce income-poverty index from over 50% to less than 30%''. These may be pessimistic estimates. First, ''overall impacts on poverty alleviation would be greater if poverty impacts [on] the noncrop sector are also accounted''. Second, the low poverty impact of land distribution may be due to the constraint that farms ''remain [above] 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 0.5 ha does not support either assumption. 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 on the size of holding to which such land and water can be effectively assigned. If land and water can be shifted towards more and smaller holdings – and since these normally apply more labour per hectare and per litre – 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.[10]

Finally, cutting across the irrigation–inequality nexus is the head-ender–tail-ender issue. The common assumption is that head-enders start richer and with larger farms, and get more, timelier and more reliable water per hectare. Then rules, incentives or decentralisation that would redistribute water (and greater certainty) to the poorer tail-enders, 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 questions the assumption, finding that usually the middle-course users, not the tail-enders, are poorest and have most problems with irrigation delivery.[11] If poverty-reducing and equity-increasing irrigation is the goal, 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 head-ender–middle-courser–tail-ender conflict and uncertainty.

POVERTY IMPACT AND IRRIGATION TYPE: IS NEW TECHNOLOGY NEEDED?

Poverty impact of an irrigation system depends on (a) economic efficiency, i.e. the time-discounted benefit/cost ratio, and (b) the poverty-orientation of benefits net of costs. Per unit of water in the system, benefit is (1) water use

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efficiency (WUE) – i.e. conveyance efficiency (CE), times field efficiency (FE)[12] – times (2) net farm value added due to the average unit of delivered water. Cost is irrigation cost (including external costs such as those of pollution). Poverty orientation is the share of benefits, net of costs, reaching the poor, perhaps with heavier weighting for those further below the poverty line. This project 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, WUE is 40–45% (Hussain *et al.*, 2004b).[13] To improve this, almost exclusive emphasis is placed on ''reforming water management with well-implemented incentives'' based on greater price and market freedoms. Indeed, recently ''the Ministry of Water Resources has distanced itself from a water policy based on water-saving technology'' such as drip and sprinkler irrigation (Hussain *et al.*, 2004b). The Bangladesh country report (Hussain *et al.*, 2004a) reviews ''institutional factors affecting water use efficiency'' but not technical factors or options. This emphasis, by both project studies and country governments, recurs in other country reports. Yet some 60% of irrigation water does not reach the fields due to seepage, evaporation and percolation (FAO, 1996; Blackman, 2000). These issues – like water reuse (recycling), drainage, and irrigation–agriculture research 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 as improvable entirely through improved markets and institutions. The Vietnam report (Biltonen *et al.*, 2004) contains very interesting data on evaporation, its variations and its importance, but the proposals remain entirely institutional.) However, farmers' *capacity to respond* much, or fast, to better incentives and institutions depends on using, and often on expanding through research, the range of water-economising techniques. Much more emphasis on water technology and research is needed (a) if, in view of tightening environmental and urban constraints on farm access to water, markets and institutions are to immunise Asian farmers from the effects of pending sharp declines, especially in semi-arid areas, in system water; (b) to achieve fast, price-elastic, water-saving or pro-poor response to changed incentives and institutions proposed in the reports.

Focus of irrigation on the poor, not only efficiency of irrigation, may depend on choice of technologies. In India, irrigation is more unequally distributed than land (''large farms captured disproportionately large share of irrigation benefits, as compared to small and marginal farms'' (Hussain *et al.*, 2004d: 38)), but – surprisingly – canal-irrigated area is more equitable than groundwater-irrigated area in Gujarat, Madhya Pradesh, Maharashtra, Orissa and Andhra Pradesh. However, Lipton *et al.* (2002) report from a literature review 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 (Narain and Roy 1980). Most research 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 . . .[I]ndividually 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 1 ha of irrigation was 12–16 quintals for tanks; 15–21 for canals; and 34–36 for wells (mainly dug wells with pump sets). Groundwater irrigation (notably private tubewells in Haryana and Punjab) raised land productivity more than surface irrigation (notably rainfall-sensitive tanks, as in Tamil Nadu and Andhra Pradesh) (Lipton *et al.*, 2002a (also Tables 4–6), citing Dhawan, 1988; Chambers *et al.*, 1989). Tubewells (unlike dug wells) are often affordable only by the well-off. If they sell the water, or employ the poor on their farms with higher per-litre output (and hence employment), the poor get some benefit. To increase it, one approach is group credit for (a) small tubewells owned by smallholders with adjacent land, or (b) groups of the landless poor who own and sell pumped water, as with Proshika in Bangladesh. Unrestricted private tubewell expansion, however, has often led to sinking water-tables and unsustainability; this is less likely if there is a power structure permitting enforcement of appropriate pricing of water extraction and of diesel for pumping.

The Indian Country Report emphasises PIM and associated water reforms (Hussain *et al.*, 2004d). The World Water Commission stresses pricing and water markets. These probably tend to improve efficiency *and* equity for most irrigation sources and technologies, but sources and technical choices matter too. The balance of evidence remains that smaller and more divisible water sources or delivery systems are usually more pro-poor. However, *at present* the choice of conventional irrigation sources and delivery technologies is nil or very restricted in many

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areas, and elsewhere more equitable and productive choices need not be sustainable (depending on water losses, drainage and recharge, and the impact of better economic efficiency and access on water offtake). So it is important to explore new 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 irrigation source – canals, tanks, tubewells or dug wells.

Even so, the restricted range of irrigation choices provided by current science may reduce or slow the response to irrigation reform in many areas, 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, called for a Blue Revolution. That Council advocated freer water markets, desubsidisation, and decentralisation from irrigation authorities to participatory water users' groups. These studies suggest that this can cut poverty, especially alongside radical increases in the poor's institutional representation and land and water access. In some places the rural poor (and their allies) are organised, literate and strong enough to achieve much of this through the democratic process. However, especially where this is unlikely, there is much to be said for so-called ''vulgar mechanism'': appropriate technical progress can force down poverty, and empower the poor, through higher employment and cheaper food. The transformation of technologies for plants in the Green Revolution led to labour-intensive, smallholder-friendly and dramatically poverty-reducing change (Lipton and Longhurst, 1988; Kerr and Kohlavalli, 1999). Similarly, durable, substantial pro-poor response to market reform of irrigation may now require a real Blue Revolution: a pro-poor transformation in the *technologies* for water management, delivery, control, economy and/or recycling.

The new approach to water is almost entirely institutional. Yet the Green Revolution transformed not institutions but germplasm, doubling or tripling crop-per-hectare by new applications of *basic science* (Darwin and Mendel) as profitable new *technology* (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 to market and institutional reforms much, fast, or with dramatic results. To achieve such technical progress, a science-based Blue Revolution is needed, seeking to double 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. Better science-based returns are also needed to provide the ''political will'' to overcome, or partly compensate, opponents of the often contentious institutional and market reforms shown in these studies 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 2000 years ago.

ENVIRONMENT, EXTERNALITY, AND SUSTAINABLE IRRIGATION

Choice of techniques, and the possible requirement for new technology and even basic science, are crucial for three ''environmental'' issues crucial to the long-run poverty impact, acceptability and public affordability of major and medium irrigation: people displacement (Hussain, 2005); health effects (Hussain, 2005); and water sustainability, given the tightening ''water squeeze'' on agriculture, as water is diverted to residential uses – and made more uncertain, and in some areas scarcer, by climate change. In each case, environmentalists have emphasised direct, local, negative effects. Studies of canal systems should estimate these, and the cost of reducing them, but also offsetting indirect, often non-local, usually positive effects:

- 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, 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 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

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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.

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

Displacement of population by irrigation works

''Large irrigation projects have been [mainly criticized for negative impacts through] large-scale displacement of population'' (Hussain *et al.*, 2004d). There are no estimates of numbers displaced, or costs of displacement or resettlement, for systems in this study.[14] 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 stop displacement or get compensation, though ''in [India's] Ganges-Kobadak Irrigation and Rehabilitation Project net farm income [rose from] US$ 500 US$ 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'' (Hussain *et al.*, 2004a). Displacement, and NGO opposition to it, discourages donors (and many democratic governments) from supporting *any* irrigation, especially new works such as the Narmada (India) and Three Gorges (China) systems, from which the World Bank withdrew despite favourable cost–benefit expectations. The sociologist who drew up the World Bank's guidelines for dam-driven relocations wrote: ''Forced population displacement caused by dam construction is (its) single most serious counter-development consequence'' (Cernea, 1991). Costing and compensating displacement effects of alternative irrigation strategies requires review in any analysis of irrigation policy. Persons and groups displaced by irrigation must be consensually resettled or compensated, not necessarily to cut poverty (displacement of livelihoods by new works is often far outweighed, even for the very poor, by the new livelihoods they create), but out of simple justice. If that is denied, and even with likely huge net gain to gross domestic product (GDP) and to the poor from imminent works, the opposition from a few concentrated, substantial losers may defeat the support from many, but dispersed, gainers from the potential activity.

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. The Indian Country Report recognises, too, the poor's greater *exposure* to irrigation-induced ''malaria, filaria[sis] and many other water-borne diseases (Hussain *et al.*, 2004d: 40)'' because they are likelier to drink, or live near, dangerous drinking water.[15] Irrigation may improve drinking water quality, but need not: in Bangladesh ''safe drinking water [and] access to sanitary latrines [were] more prevalent in the irrigated areas'', but for the two systems with data (Pabna Irrigation and Rural Development Project (PIRDP) and Ganges-Kobadak Project (G-K)) substantially *smaller* proportions of landless households had hand-pumps for drinking water in the irrigated area than in the adjacent rainfed control area, and in G-K this was also true of sanitary toilets (Hussain *et al.*, 2004a). 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, Nagarjuna Sagar Left Command (NSLC), was the incidence of toilets notably higher (24% as against 10%); in one system, Krishna Delta System (KDS), 15–25% *fewer* households contained toilets or drinking-water facilities in the irrigated system area than in the adjacent control area (Hussain *et al.*, 2004d). Also ''widespread arsenic contamination of groundwater'', while it ''might be a consequence of groundwater over-exploitation'' (Hussain *et al.*, 2004a), may well also be linked to – and could be delinked from – surface

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irrigation, which may contaminate alternative drinking-water sources, and indeed crops. This and other drinking-water pollution from irrigation may be remediable with good design and drainage choices.

These studies show that better irrigation can fail to bring the poor better drinking water/sanitation. These – where provided, maintained and delivered – normally arrive via 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 implementation of irrigation and drinking water improvements (Polak *et al*., 2003)?

This is a plea for joined-up analysis and action, not an attack on irrigation. It is unlikely to worsen the poor's water/sanitation environment overall. The yield, employment, food-price, and hence consumption and nutrition effects of fertilisers and improved seeds – which do far better with irrigation – usually make its net health impact on the poor positive;[16] but it could be better. Effects on drinking-water contamination and disease vectors require more emphasis on choice of techniques, development of new techniques (e.g. of arsenic filtration), and collaboration between water, agriculture and health authorities (Lipton and de Kadt, 1988).

Soil-water environment effects and the "water squeeze"

Will participatory and price reforms increase incentives for soil/water-friendly water use? They do raise incentives to use water more carefully, because the user pays for it; but that will cut seepage,[17] evaporation and/or percolation (SEP) only if (a) the water-buyer is the same as the water-loser, or (b) participatory cooperation 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 these, and/or other measures raising crop-per-drop, deter all behaviour that increases salinity or waterlogging: overwatering (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 cooperating user group – is crucial, if environmentally sensitive water use is 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 often justified. Fifty countries suffered severe water constraint or were water-stressed (below 1600 m^3 per head per year) in 2000, up from 40 in 1990 and still rising (IFAD, 2001). Most such countries are not in South or East Asia, but they include Pakistan, and many *regions* (mainly semi-arid) in other project counties are stressed. Farm use comprises over 90% of water offtake in developing countries, yet typically generates only 15–35% of GDP. Domestic and industrial users, even poor ones, are often eager to obtain reliable water at full market price, while free or subsidized farm water encourages waste. Yet such arguments are incomplete: farm water *used* is not 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 (Eastwood and Lipton, 2000b); and unequal (and on the evidence of this project 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 (Wolff and Stein, 1998). Must such

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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. centre-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 can 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 m^2, 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;
- Even if drip or sprinkler methods (or others) increase system-wide field efficiency substantially, cost-effectively, and affordably for the poor, they need not “save water”. Higher yield effects, and hence economic returns, to fertiliser use in the Green Revolution (via higher-yielding rice and wheat varieties) led farmers, not to obtain the same yield by using less fertiliser, but to obtain much higher yields by using more fertiliser. 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;
- 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.

Reforms to induce farm-level water saving are environmentally important, as is new technology in making response to reforms faster, more cost-effective and pro-poor. However, aggregate effects on water availability, use and stress cannot be crudely estimated from physical calculations that neglect price elasticities, nor from single-system effects alone.

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

Classic fieldwork in Andhra Pradesh (Wade, 1982) showed that release of irrigation water into and out of secondaries normally involved corrupt payments. Though usually small as a proportion of production costs,[18] these payments are 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 were similarly rewarding, but maintenance was not, so there were incentives to disregard and downgrade it. In short, corruption corrupts. Much journalism,[19] 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.[20] This challenges the view (Hussain *et al.*, 2004d) that “most often, corruption is due to lack of information or knowledge about procedures”. This project’s excellent analysis and reform recommendations require, for effect, more active engagement with the question of irrigation corruption.

Both efficiency-increasing and poverty-reducing impacts from PIM 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 (Hussain *et al.*, 2004d, citing Chambers).[21]Fisman and Gatti (2002)

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find "a very strong and consistent negative association [running causally from fiscal decentralisation to lower corruption] across a sample of countries [and] robust to potential sources of omitted variable [and] endogeneity bias". However, most irrigation systems will not at once decentralise; decentralisation may not include financing; 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.[22] At each stage, reform threatens "influential stakeholders". More work, using data collected in this project, may suggest determinants of irrigation corruption, and measures likely to reduce it.

Irrigation delivery in Pakistan is permeated (and corrupted) by corruption. "[T]he 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 [and] by officials from the irrigation bureaucracy donors and by policymakers" (Azam and Rinaud, 2000). In this context, the Pakistan Country Report (Hussain *et al*., 2004c) provides fascinating insights into the impact of irrigation management transfer to farmers' organisations (irrigation management transfer (IMT) to farmers' organisations (FOs) – a process similar to PIM in India – in one of the four canal systems studied, Hakra 4-R.

Collection and recording of correct water rates (*abiana*) were much better in the Hakra 4-R system, but 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 distributory, in the study area of the project, was in such [an improved] physical conditions as was Hakra 4-R reflect[ing] efficient management [by the (FO) as compared with] Punjab Irrigation Department" (Hussain *et al*., 2004c). However, the reports are mixed. Below 5% of farmers reported "no bribery" as an important "water-related benefit to farmers" from IMT; 23% "complained against the office-bearers of [the post-IMT FO] 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 farmer"; 41% of tail-end farmers, as against 58% of head-ender farm households, "believed that the FO was able to complete its operations successfully" (Hussain *et al.*, 2004c: 186, 189–90). Thus corruption is far 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" (Hussain *et al*., 2004c).

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 the Chishtian system, South Punjab (Azam and Rinaud, 2000), 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.[23] 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" (Lipton *et al.,* 2002a, citing Wade, 1982, 1988). Poorer and lower-lying users must compete with the more powerful head-enders and better-off, creating a bribe market that both bleeds money from the rural poor and makes irrigation arrivals less reliable.

Research increasingly confirms that efficiency and equity in canal systems are badly damaged by corruption. Desubsidisation and PIM change the forms of corruptibility, and may greatly reduce its scale and impact. Hence, however, the gainers from corruption 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 harm to efficiency, and to the poor, 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, e.g. by developing the suggestions in the final synthesis report (Hussain, 2005) that equity in irrigation systems, plus increasing reliance on groundwater, reduce corruption.

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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 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''?

From irrigation to disimpoverishment: are other things equal?

In this context the Chinese Country Report (Hussain *et al.*, 2004b) is of great interest. Irrigated plots, compared with others, have much higher yield, cropping intensity, 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%, while increasing it in poor areas by 38%. [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. Even then, irrigation significantly raises yields for most crops, but holding the variables in (a) above constant at their means, and with village and plot fixed effects, reduces the estimated impact of irrigation on revenue-per-hectare from about 80% to about 40%. 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 fewer small farms and lower per-acre costs), so ''irrigation benefits farmers by 18% in poor areas versus 13% in rich areas'' (Hussain *et al*., 2004). In the Chinese Country Report the careful modelling of land quality, plot and household variables and effects is of great value.[24] These methods might well be applied to other country reports, and to the comparisons of yield, poverty and revenue across systems and countries – comparisons at present on a ''with and without irrigation'' basis. Even the Chinese Country Report, however, does not explore whether extra farm income is due to irrigation or other associated 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).

From land inequality to low irrigation impact: is there a ''minimum viable holding''?

HW summarise project evidence that the much lower return to canal systems in South Asia than in East and South-East Asia is due in part to more unequal land and water.[25] 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.'' Even these may be understated, because ''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''. There is no clear case for such a lower limit on landholdings. It cannot be used to enforce enlargement of existing micro-holdings; enforcing it only on reform land is inequitable. In most studies, the

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"inverse relationship" between size and yield (resting on small farms' lower unit supervision costs and hence higher labour/land ratios) is continuous right down to the smallest farm-size groups.[26] These are thus "viable" in the sense of "efficient". Third, tiny agricultural holdings are normally *part* of the total livelihood of poor households, so it is not valid to regard such holdings as "unviable" because income from them *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.

The poverty line

This project compares the poverty impact of irrigation in 26 systems (and their rainfed peripheries) in six countries. HW find that across systems "the incidence of poverty varies from 6% to 77% [and] depth of poverty varies from 3% to 68%... For all the systems studied, around 40% of households have incomes below the specified national poverty lines. However, there are significant variations in poverty [lines] across systems." For example, in the India study "poor households [were] those that earn less than 3,155 [Indian rupees] per capita per year (the official poverty line for AP) or less than 3,736 per capita per year (the official poverty line for MP)"; for rural Pakistan "the study used two poverty lines. Rs 730 [Pakistan rupees]/capita/month and 530/capita/month]"; in Bangladesh "national income-poverty line of Tk 10,200 per person per annum was used to estimate poverty in the selected systems" (Hussain *et al*., 2004c). In my view, poverty comparisons are better made using a standardised poverty line that reflects constant purchasing power across countries, such as dollar-a-day. National poverty lines reflect national criteria, and 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. There are similar distortions among areas (and hence irrigation systems) within the same country: richer (including more irrigated) regions are assigned higher poverty lines (even though these are purportedly absolute and nationally standardised), often via choice of components in regional cost-of-living indexes (on these issues see Lipton and Ravallion, 1995). Hence international estimates of poverty differences among systems and countries in poverty, and between irrigated and unirrigated areas, will be systematically biased upwards, if national poverty lines are used. The proportion of poor people in richer areas – who 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.

"AFRICA 4%, ASIA 40%": IRRIGATION ACCESS AND GLOBAL POVERTY

Huge regional differences in the irrigated proportion of cropland link to successes or failures in poverty reduction. In sub-Saharan Africa only 3.7% of cropland is irrigated; the estimated poverty headcount was 47.7% in 1990 and 46.3% in 1998. The regions with the greatest proportion of cultivated area irrigated, East Asia and Pacific and North Africa and Middle East, experienced the greatest poverty reduction. Differences across regions, countries and areas within countries in irrigation almost certainly reflect differences not only in poverty incidence, but also in prospects of reducing it through agricultural change that affordably 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 are closely related to irrigation that cuts impact of "unstable agriculture and droughts" (Ray *et al*., 1988).

Further, 60% of food production in Asia (Pakistan 80%, China 70%, India and Indonesia each 50%) came from irrigated land, as against 9% in sub-Saharan Africa (Wallingford Hydraulic Research Laboratory, 1997). It is 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, and form a significant part of NEPAD's (New Economic Partnership for African Development) Comprehensive African Agriculture Development programme, which has received considerable financial commitments by national governments and donors. The past record of major

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irrigation in Africa is mixed, but some of the reasons for weak performance and low benefit/cost ratios have receded. On the cost side, interregional comparisons made by the World Food Conference in 1974 estimated that per-hectare cost of new schemes in sub-Saharan Africa was 64% more than in the Far East and 55% more than in Latin America (but 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) (Lipton *et al*., 2002). However, learning may have reduced Africa's cost disadvantage, as may rising labour costs in Asia, and 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 high transport costs may mean that this has reduced the benefits of irrigation there less than in other areas. Very favourable returns from African irrigation require more fertiliser and better seeds, but irrigation also raises returns to these, and hence stimulates them.

Follow-up of this project should review possible ''Asian lessons'' for existing *and potential* irrigation in Africa, and perhaps initiate parallel studies there. One lesson is that in Southern Africa the efficiency and equity of irrigation are probably much reduced by extreme land inequality, plus even greater irrigation inequality. Big farmers have secured free, or heavily subsidised, water for capital-intensive use, leaving little water control for labour-intensive small farmers. Poverty reduction demands attention to this issue.

SOME OPEN ISSUES

Aid to agriculture has fallen by about two-thirds in absolute real value since the late 1980s. Domestic public, or domestic or foreign private, investment has not made good much of this fall. Relatedly, the rate of growth of food grain yields in developing countries – the main 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 and FAOSTAT databases). Without a revival in agricultural growth, and hence in demand for labour and supply of food, there is little hope of improving on the 1990–2004 experience: little growth of GDP per head, and hence little poverty reduction, in most of Africa; sharply reduced conversion of growth (itself accelerated) into poverty reduction in Asia.[27] Revived agricultural growth depends partly on seed improvement, partly on policy reform (including land reform), but also on reviving aid and investment in agriculture – in particular, the spread and rehabilitation of irrigation, compatibly with increased rural water efficiency – and some water desubsidisation, needed in face of growing urban, domestic and industrial demand for water, and of climate change. In this context, there are open issues, on which further analysis of project findings may shed light:

What does this project tell us about the causes of collapse in irrigation investment, and about cost-effective and pro-poor ways to remedy that collapse?

Can greater land and water equity increase the incentives for governments, donors, and private providers to invest in sustainable irrigation, including but not confined to maintenance and rehabilitation?

Was the fall in irrigation investment due to a falling rate of return – and to what extent can it 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 local output against imports) are higher?

Has *technical* efficiency (i.e. field efficiency $\times$ conveyance efficiency) been reduced 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, an important fact militating against aid to agriculture, and especially irrigation, has been growing doubt about side effects on health, displaced people, and environmental sustainability. What does this project tell us about

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the validity of such objections (as compared to the anti-poverty benefits), both for existing irrigation and for potential new irrigation, and about ways to build or manage new irrigation that will increase environmental and health gains, reduce costs and risks, and compensate losers?

NOTES

[1]**FSR**: Final Synthesis Report: I. Hussain, *Pro-poor Intervention Strategies in Irrigated Agriculture in Asia: Poverty in Irrigated Agriculture – Issues, Lessons, Options and Guidelines: Bangladesh, China, India, Indonesia, Pakistan, Vietnam*, IWMI-ADB, Colombo, May 2005. For the country summaries, I sometimes cite instead **PPI**: I. Hussain, *Pro-poor Intervention Strategies in Irrigated Agriculture in Asia: Poverty in Irrigated Agriculture – Realities, Issues, and Options with Guidelines: Bangladesh, China, India, Indonesia, Pakistan, Vietnam*, IWMI-ADB, Colombo, April 2004, or **HW**: I. Hussain and D. Wijerathna, *Irrigation and Income-Poverty Alleviation: a Comparative Analysis of Irrigation Systems in Developing Asia,* IWMI, Colombo, Feb. 2004.

[2]Follow-up work on this project might include impact of irrigation/drainage management choices on the poor via drinking water and insect disease vectors (Lipton and de Kadt, 1988; Lipton *et al.*, 2002b).

[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.

[4]PIM is a *modest* illustration that farmer-, or client-plus-operator-, controlled methods need not be confined to micro-irrigation.

[5]Even within the Washington Consensus, this is increasingly questioned for market reform of primary health care or schooling.

[6]Why might largeholders have irrigation when nearby smallholders, often with higher returns to it (because they use less water per ha and operate more labour-intensively) lack it? Both unequal power and market failure must be at work here. Irrigation reform, by addressing water-market failure, should be pro-poor even with high inequality – but much less so than otherwise. Also this abstracts from possible interests of irrigation allocators, private or public, in subverting reform.

[7]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'' (Hussain and Wijerathna, 2004).

[8]These studies do not allow for negative externalities of tubewell use (my new tubewell lowers the water-table and may make your dug well, or shallow tubewell, useless). But externalities affect all irrigation: surface and groundwater, large and small systems, farmer-controlled and managed/allocated. No broad comparison of *social efficiency* among irrigation types appears to exist.

[9]Hussain and Wijerathna (2004) report that ''a recent study by the World Bank (2002) in Pakistan indicates that inequity in land distribution is [among] the causes of low agricultural productivity''. In *developed* countries the productivity advantage switches to larger farms, whose lower transactions costs in capital markets come to outweigh smaller farms' advantages in labour markets (Eastwood *et al.*, 2008).

[10]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 tend to use higher lines. So poverty incidence is artificially raised in irrigated areas, because they are better off and thus tend to use a higher poverty line; this would cut the measured effect of irrigation on poverty, as compared with an absolute poverty line with constant purchasing power across countries, e.g. the (purchasing-power parity) dollar-a-day measure.

[11]Generalisations are dangerous; effects of reforms changing head–tail–middle water distributions depend on local conditions, including political ones. However, the study finding follows the ''middle ground hypothesis'' (Wade, 1982) 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 access, 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 cooperation exceeds the benefit; for middle-grounders, collective action pays.

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[12]CE = proportion of system water reaching cropland; FE = proportion of field water reaching crop root zone; 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 (IFAD, 2001).
[13]WUE of 40–45% is typical for developing countries (IFAD, 2001). However, the Chinese Country Report 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.
[14]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 Siebert (2001).
[15]Lipton *et al.* (2002a) 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. [Probably] 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 utensils, [and with less] access to 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.'
[16]"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" (Lipton *et al.,* 2002, citing Carruthers, Blackman and other data).
[17]Not all seepage from canals is waste; some means more 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; Lipton *et al.*, 2002a). More canal irrigation led *via seepage* to more groundwater irrigation.
[18]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" (Azam and Rinaud, 2000).
[19]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 (2003) and Mustafa Talpur (2000).
[20]"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 significant 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" (Huppert and Wolff, 2002: 99).
[21]Though not necessarily in construction (nor, therefore, rehabilitation).
[22]See (Hussain *et al.*, 2004d: 119) on thokdari group management of rotational irrigation in Uttar Pradesh.
[23]"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).
[24]So are the disaggregations by crop, not discussed here.
[25]They cite in further support (a) Hussain *et al*. (2003); (b) a recent World Bank study of Pakistan.
[26]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.
[27]The two continents contain well over 90% of the world's dollar-poor.

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REFERENCES

Azam JP, Rinaud JD. 2000. Encroached entitlements: corruption and appropriation of irrigation water in Southern Punjab (Pakistan), Development Studies Working Papers No. 144, Nov. 2000, www.dagliano.uni-bocconi.it.

Berry A, Cline W. 1973. *Agrarian Structure and Productivity in Developing Countries*. Johns Hopkins: Baltimore.

Binswanger H, Deininger K, Feder G. 1995. Power, distortions, revolt and reform in agricultural land relations. In *Handbook of Development Economics*, vol. 3b, Behrman J, Srinivasan TN (eds). North-Holland: Amsterdam.

Biltonen E, Hussain I, Tuan DD, Van Quy N, The Phong D, Hung LN, The Hung D, Tiep NX, Ban PV, Dung LQ, Minh ND, Chinh LV, Dung TA, Vu NM. 2004. *Vietnam Country Report: Pro-poor Intervention Studies in Irrigated Agriculture in Asia*. IWMI-ADB: Colombo.

Blackman R. *Irrigation: notes for IFAD Rural Poverty Report 2000*. Mimeo. Poverty Research Unit, University of Sussex.

Cernea M. 1991. Involuntary resettlement: social research, policy and planning. In *Putting People First. Sociological Variables in Development Projects*, 2nd edn. Oxford University Press: New York.

Chambers R, Saxena NC, Shah T. 1989. *To the Hands of the Poor: Water and Trees*. ITDG: London; 18.

Dhawan BD. 1988. *Irrigation in India's Agricultural Development: Productivity, Stability, Equity*. Sage: Delhi.

Eastwood R, Lipton M. 2000a. Pro-poor growth and pro-growth poverty reduction. *Asian Development Review* **18**: 22–58.

Eastwood R, Lipton M. 2000b. *Rural-urban dimensions of inequality change*. Working Paper No.200, World Institute for Development Economics Research, June.

Eastwood RK, Lipton M, Newell S. 2008. Farm size. In *Handbook of Agricultural Economics*, vol. 4, Evenson R, Pingali P (eds). North-Holland: Amsterdam.

Fan S, Hazell P, Thorat S. 2000a. Targeting public investment by agro-ecological zone to achieve growth and poverty alleviation goals in rural India. *Food Policy* **25**: 411–428.

Fan S, Linxiu Z, Zhang X. 2000b. *Growth and Poverty in Rural China: the Role of Public Investments*. International Food Policy Research Institute: Washington, DC.

FAO. 1996. *Implementation Completion Report, Pakistan. Second Irrigation Systems Rehabilitation Project, Pakistan*. Report No. 96/028 CP-PAK. Cr.1888-PAK; 7 August.

Fisman R, Gatti R. 2002. Decentralization and corruption: evidence across countries. *Journal of Public Economics* **83**: 325–345.

Hazell P, Ramasamy C. 1991. *The Green Revolution Reconsidered: the Impact of High-yielding Rice Varieties in South India*. Johns Hopkins: Baltimore.

Hooja R. 2000. Participatory irrigation management efforts in Rajasthan. In *Participatory Irrigation Management Paradigm for the 21st Century*. Jaipur; Rawat.

Howes M. 1984. *Whose Water?*: Croom Helm: Chichester; 114.

Huppert B, Wolff W. 2002. Principal–agent problems in irrigation – inviting rent seeking and corruption. *Quarterly Journal of International Agriculture* **41**(1–2): 99.

Hussain I. 2004. *Pro-poor Intervention Strategies in Irrigated Agriculture in Asia: Poverty in Irrigated Agriculture – realities, issues, and options with guidelines: Bangladesh, China, India, Indonesia, Pakistan, Vietnam'*, IWMI-ADB, Colombo, 2004.

Hussain I. 2005. *Pro-poor Intervention Strategies in Irrigated Agriculture in Asia: Poverty in Irrigated Agriculture – Issues, Lessons, Options and Guidelines: Bangladesh, China, India, Indonesia, Pakistan, Vietnam*. IWMI-ADB: Colombo.

Hussain I, Wijerathna D. 2004. *Irrigation and Income-Poverty Alleviation: a Comparative Analysis of Irrigation Systems in Developing Asia*. IWMI: Colombo, Feb.

Hussain I, Sakthivadivel R, Amarasinghe U, Mudasser M, Molden D. 2003. *Land and Water Productivity of Wheat in the Western Indo-Gangetic Plains of India and Pakistan: a Comparative Analysis*. Research Report 65. IWMI: Colombo.

Hussain I, Ahmad QK, Karim Z, Haq KA, Quasem A, Rahman K, Chakravorty N, Ali N, Akhter R, Zubair M, Younus AF, Hossain A, Karim,Hossain SM, Ahmed NK. 2004a. *Bangladesh Country Report: Pro-poor Intervention Strategies in Irrigated Countries in Asia*. IWMI–Bangladesh Unnayuan Parishad– ADB: Colombo.

Hussain I, Biltonen E, (eds), Wang J, Huang J, Xu Z, Rozelle S, Huang Q, Msangi S. 2004b. *Pro-poor Intervention Strategies in Irrigated Agriculture in Asia: China*. IWMI, Chinese Academy of Sciences, ADB: Colombo.

Hussain I, Jehangir WA, Ashfaq M, Mudasser M, Nazir A. 2004c. *Pakistan Country Report: Pro-poor Intervention Strategies in Irrigated Agriculture in Asia: Issues and Options*. IWMI-ADB: Colombo.

Hussain I, Sivamoha MVK, Scott C, Jetske B, Wijerathne D, Thrikawala S. 2004d. *India Country Report: Poverty in Irrigated Agriculture*. IWMI/ADB: Colombo.

IFAD. 2001. *Rural Poverty Report*. Rome, Italy.

Kerr J, Kohlavalli S. 1999. *Impact of Agricultural Research on Poverty Alleviation*. International Food Policy Research Institute: Washington, DC.

Lipton M. 1993. Land reform as commenced business: the evidence against stopping. *World Development* **21**: 641–657.

Lipton M, de Kadt E. 1988. *Agriculture–Health Linkages*. Offset Publication No. 104. WHO: Geneva; 33-35.

Lipton M, Longhurst R. 1999. *New Seeds and Poor People*. Routledge: London.

Lipton M, Ravallion M., 1995. Poverty and policy. In *Handbook of Development Economics*, vol. IIIB, Berhman J, Srinivasan TN. (eds,). North-Holland, Amsterdam.

Lipton M, Litchfield J, Blackman R, De Zoysa D, Qureshy L, Waddington H. 2002a. *The Impact of Irrigation on Poverty*, FAO and Sussex Poverty Research Unit.

Lipton M, Sinha S, Blackman R. 2002b. Reconnecting agricultural technology to human development. *Journal of Human Development* **3**[1]: 123–152.

DOI: 10.1002/ird

Narain D, Roy S. 1980. *Impact of Irrigation and Labour Availability on Multiple Cropping: a Case Study of India*. Research Report No. 20. International Food Policy Research Institute: Washington, DC.

Polak P, Adhikari D, Nanes R, Salter D, Surywanshi S. 2003. Transforming rural water access into profitable business opportunities. sec. 2: International Symposium on Water, Poverty and Productive Uses of Water at Household Level, 21-23.1.2003, Muldersdrift, S. Africa, sec. 2: www.wca-infonet.org/cds_upload/1061190612743_WDWP98.pdf.

Ray SK, Hanumantha CHR, Subbarao K. 1988. *Unstable Agriculture and Droughts: Implications for Policy*. Studies in Economic Development and Planning, 47. Institute of Economic Growth: New Delhi.

Siebert R. 2001. No chance for participation. Dam building on the Mekong River. Deutsche Stiftung für internationale Entwicklung. *Development and Cooperation* **4**: 201.

Talpur M. 2000. *Corruption, mismanagement in irrigation water distribution*. *DAWN* 20-3-2000.

The Hindu. 21.7.2003 http://www.hinduonnet.com/thehindu/2003/07/21/stories.

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? *Economic and Political Weekly*, (Bombay) 20 Oct: 1606.

Wade R. 1988. *Village Republics*. Cambridge University Press.

Wallingford Hydraulic Research Laboratory. 1997. *Priorities for Irrigated Agriculture*. Water Resources Occasional Paper No. 1. Department for International Development: London.

Wolff P, Stein TN. 1998. Water efficiency and conservation in agriculture: opportunities and limitations. *Agriculture and Rural Development* **2**: 2–20.

World Bank. 2001. *World Development Report 2000/2001*, Oxford University Press, New York; ch. 8.

DOI: 10.1002/ird