Improving irrigated agricultural productivity in an age of food and water scarcity[1]

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Introduction

This short essay describes the pivotal position that irrigated agriculture plays within a globalised food system. It explains the scale of water use and food production linked to irrigated agriculture and highlights the underlying complexities and challenges that society faces as we consider how to increase food security through improved water management.

Putting the numbers into perspective

To put water and crops – or water scarcity and food security - in perspective, we can start by observing that most crops require, per hectare, approximately 150 kilograms of potassium and 150 kilograms nitrogen in one growing season, but about 5,000 to 8,000 tonnes of water. This water (which passes from roots to transpire from plant leaves) must be provided either by rainfall, by shallow groundwater, by irrigation, or by a combination of all three. The numbers quickly add up. Ten thousand hectares of rice require about 120 million cubic metres of water for one four month season (equivalent to a storage body of about 50 metres depth by 1.5 km squared.) Moreover, we can use a simple rule of thumb; the amount of water required for one hectare of irrigation in hot climates is about one litre per second every second of the day. This means an area of 10,000 hectares requires about 10,000 litres per second during the peak requirement period. And to put this in perspective, the larger urban area of Bristol with about 10,000 hectares (10 km squared) and 1 million inhabitants uses about 20 per cent of the irrigation demand for an equivalent area (using a per capita use of 170 litres per day.)

Worldwide, agriculture evapotranspires approximately 20-25 cubic kilometres per day and the 270 million hectare irrigated component of this evaporates daily about 6-8 km^3 per day of water globally (global withdrawals for urban and domestic use are approximately a tenth of this[2].) In abstracting water from rivers or aquifers, the presence of irrigation depletes about 70-80 per cent of freshwater in most developing countries – as a result of the areas involved situated in hot, semi-arid or semi-humid climate (in cooler temperate Britain only 2-3 per cent of freshwater is consumed in irrigation.) We can now see why irrigation places stress on tropical or sub-tropical river basins more than climate change and why uneven consumption within river basins can be a source of water conflict. Temporary or long term water shortages concern many communities and countries that share rivers: from the local scale where irrigators attempt to close down neighbouring irrigation intakes, to the national scale where the 10 countries that share the Nile Basin attempt to table discussions on new volumetric apportionments.

Food security and food productivity

Irrigated agriculture provides about 40 per cent of the world's food[3], including nearly all rice which is a key grain crop for billions of people living in Asia. Other key foodstuffs include fruit and vegetables and increasing amounts of meat via irrigated pasture. Irrigation thus underpins many agro-industrial economies and provides livelihoods for millions of farmers and secondary producers.

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[1] This may be cited as Lankford, B.A. 2010. Improving irrigated agricultural productivity in an age of food and water scarcity. In J. Osikena and D. Tickner (eds) Tackling the Worldwater Crisis: Reshaping the Future of Foreign Policy. Foreign Policy Centre, London, pp 35-40.

[2] CAWMA (Comprehensive Assessment of Water Management in Agriculture). 2007. Water for Food, Water for Life: A Comprehensive Assessment of Water Management in Agriculture. London: Earthscan, and Colombo: International Water Management Institute and see FAO Aquastat website'.

[3] Schultz, B, Thatte, C.D. and Labhsetwar, V.K. 2005. Irrigation and drainage. Main contributors to global food production. Irrigation and Drainage 54 (3).

Furthermore, irrigation is believed to 'waste' significant amounts of water that might otherwise be used to extend agricultural lands or be allocated to other uses – for example, wetlands and other environmental flows. Although there are significant misunderstandings about the science of water waste and savings (often 'waste' water is not 'lost' as it is collected for downstream use), most scientists agree that productivity can be significantly boosted by using water in a more careful and timely manner. The author estimates that productivity can also be increased by 25 to 30 per cent by refining existing technologies and practices including better irrigation scheduling.

Irrigation familiarity and complexity

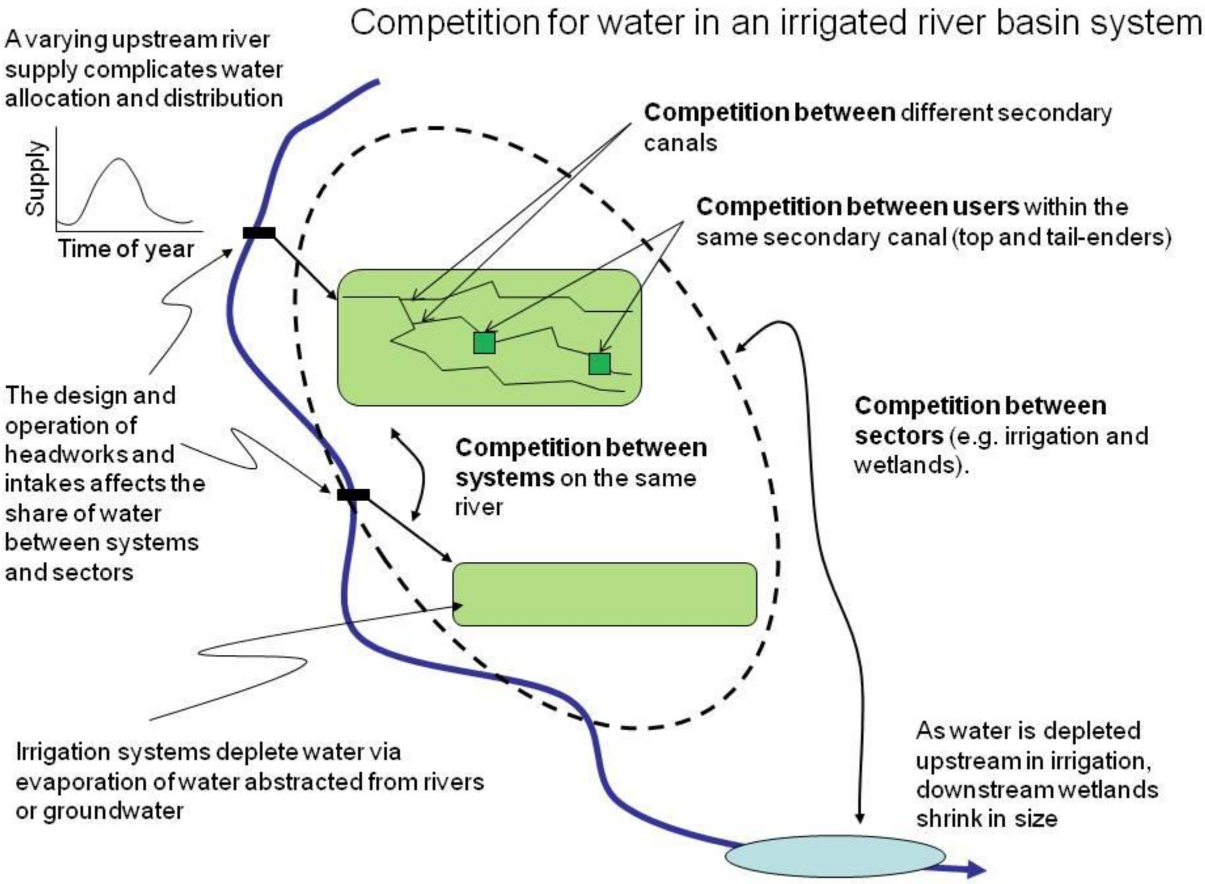
The great policy risk is to oversimplify our approach to irrigation by relying on an incomplete perspective. Some see irrigation as an agronomic act of bringing water to crops (rather like adding fertiliser.) Others view it as a cultural landscape (think of the terraces of Bali.) Others perceive it to be 'infrastructure' (canalisation, not too dissimilar to rural roads), whereas others view it as part of precision agriculture (akin to computer-aided seed drilling.) To others, irrigation is a social undertaking with user associations and rules of use but where the engineering side, being 'technical' is of no interest. Frequently, it is an arena where inefficiencies are commonly invoked, but in response, small is deemed beautiful (farmer-managed systems), smaller is even more beautiful (e.g. bucket kits) and a switch to new technology fixes everything (e.g. replacing furrow irrigation by sprinkler or drip.) Perhaps irrigation has become too familiar because it is an 'encompassing environment' for farmers and engineers. Rather as city dwellers navigate urban landscapes without complaint, we learn to accept and accommodate its foibles and eccentricities. In this way, it becomes difficult to discern alternatives except through comparative experiences.

On the contrary, irrigation is highly complex - comprising nested (and competing) network systems that have individual command areas that range from a fraction of a hectare to a million hectares or more (see figure). Recognising irrigation means coming at it simultaneously from both a systems, water, technological, societal and policy points of view. Irrigation poses significant policy dilemmas when society seeks to apportion limited amounts of a varying water supply using gravity to many thousands of farmers and small plots – mindful of quantity, quality, timing and the need to minimise waste – in the face of changes in supply, land, soil, ownership, climate, weather, culture, economics and claims and counter-claims for water to be used in other sectors such as for urban supply or for the environment.

As irrigation systems grow, either individually or coalescing at the basin scale, their complexity grows geometrically. In other words, evapotranspiration solves local water needs but leads to shortages many kilometres away. Such is the diversity of circumstances that policies for improving irrigation efficiency and productivity need to be continuously adjusted according to the specific mix of stakeholders, characteristics and trajectories of the systems and their contexts.

This complexity is behind scholars' beliefs that irrigation incubated the organisational strengths of ancient civilisations in Egypt, Mesopotamia and the Indus. And it was 2010 Nobel Laureate Elinor Ostrom's research on irrigation that contributed to our ideas on collective co-management of 'the commons[4].' Yet, despite irrigation being so central to society, there are surprisingly few bespoke postgraduate degrees or training courses in the world. Furthermore, its study has so thoroughly contracted that only a handful of research and policy programmes amount to current global effort. No single Research Council in Britain 'owns' and fosters irrigation research, often for the reasons given above, choosing to see only its social or engineering dimensions.

[4] Ostrom, E. 1990. Governing the Commons. The Evolution of Institutions for Collective Action. Cambridge University Press.



Excessive costs
We need to find less expensive ways of supporting irrigation. Surface irrigation is costly to build from new or to rehabilitate; the track record of donors shows that US$10-20,000 per hectare is spent on irrigation programmes. This is excessive and would translate to a rehabilitation bill of US$65 billion if, say, half of Africa's 13 million hectares of irrigation were to be improved[5]. High costs are currently a feature of such programmes regardless of whether canal, drip or farmer micro-irrigation is the selected technology. This expense cannot be sustained in the future.

Ways forward
If we accept that irrigation is complex and challenging, it is not surprising that a comprehensive policy framework should be considered. Its aim would be cautious and careful water management nested at all levels of river catchments, giving farmers a more predictable and timely supply of water against which they may also invest in seeds and fertilisers to raise yields. Briefly, this might require:

1. A new postgraduate qualification in irrigation systems management.
2. New financial support for the scientific organisations involved in irrigation, e.g. International Water Management Institution (IWMI) and International Commission for Irrigation and Drainage (ICID), at global, regional and UK levels, including investments in research programmes.
3. Support programmes that emphasise gravity/canal systems, constituting 90 per cent of all global irrigation by area.
4. Projects and programmes that promulgate ownership of systems by their users yet in close partnership with service and science providers (see next point.)

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[5] Lankford, B.A. 2009. The right irrigation? Policy directions for agricultural water management in sub-Saharan Africa. Water Alternatives 2(3): 476-480.

5. The fostering of non-governmental organisations (an irrigation equivalent of WaterAid) and of commercial stewardship, offering a new emphasis on system monitoring and mentoring and the water management equivalent of 'FairTrade'.
6. On-going institutional reform of government irrigation bureaucracies to orient them towards service provision to water users, setting out professional expectations of government engineers.

Success will be defined by widespread performance improvements at a cost of less than US$5,000/per hectare.

Conclusion

Given the scale of the contribution of irrigation, its nature and its impact on surrounding area, society can legitimately ask whether irrigation should perform better; to produce more food with less water. Through its once historic position, Britain led the way in addressing the challenges of irrigated food security, for example by providing water engineers in India. Currently, by any measure, Britain has lost nearly all capacity to offer expertise in contemporary irrigation science and management – the kind of knowledge that would aim, not to develop new lands, but to sustainably and cost-effectively rehabilitate existing systems. The fruits of this work would be considerable – enhanced water security and performance; increased food production; and opportunities to allocate water to other sectors.