IWMI - ACIAR Investing in Water Management to Improve Productivity of Rice-Based Farming Systems in Cambodia Project. **Issue brief #1, June 2013**

Agricultural Water Management Planning in Cambodia

IWMI International Water Management Institute

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AWM planning in Cambodia

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This issue brief is based on a review conducted by the International Water Management Institute (IWMI) on behalf of the Australian Centre for International Agricultural Research (ACIAR). The paper has been supplemented by discussions at a public workshop in Phnom Penh on 19 March 2013. IWMI gratefully acknowledges the input of workshop participants.

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Irrigation is promoted by the Royal Government of Cambodia (RGC) as a major component of poverty reduction and economic development. The question facing RGC is how to target its investment most effectively, given the possibly diverging goals of increasing rice exports at the national level; and improving food security and poverty reduction at local levels. How can RGC best support moving towards a diversified, modern irrigation sector?

Introduction

Agricultural water management (AWM)—particularly irrigation—is promoted by the Royal Government of Cambodia (RGC) as a major component of its poverty reduction and economic development plans. Investment in AWM in Cambodia is driven by two different policy imperatives – increasing rice exports at the national level and improving food security and poverty reduction at local levels. These are not necessarily incompatible but neither are they well aligned in terms of their target groups or methods of achieving them. The former focuses on rice intensification via dry season irrigation and commercialization of farming; the latter focuses on semi-subsistence smallholders[1], securing the wet season rice crop and diversification or crops in the dry season.

The National Strategy for Agriculture and Water (SAW) identifies a range of investments in irrigation, primarily in the development and rehabilitation of large-scale infrastructure at the national level. In 2012, MOWRAM listed over USD 260 million in planned investments in the form of loans and grants for on-going irrigation investments with external partners, with a further USD 868 million committed, mainly for large-scale infrastructure. In addition, commune planning through D&D (Decentralization and De-concentration) identifies AWM priorities at the commune level, although sources of funding for such local initiatives are limited.

Recent investments have targeted rehabilitation of existing systems, mainly gravity-fed canal commands and storages, with a strong focus on improving operation and management using participatory approaches through Farmer Water User Committees. Results have often been disappointing, with significant underperformance of many schemes, lower than expected uptake of dry season irrigation, and failure of FWUCs to effectively manage water delivery, leading ADB (2010) to conclude:

> *A new approach is needed to support water resources management in Cambodia. The scope for identifying conventional large irrigation projects is limited and the low level of past success indicates a range of problems. Other more innovative approaches which more carefully fit the characteristics of the country need to be developed, including smaller scale simple water resource management projects that are easier to implement under the evolving institutional capacity of the country.*

What might these innovative approaches look like?

[1] Only 35% of Cambodian farm households produce a surplus of rice; the rest produce less than or just sufficient for home consumption (CDRI 2008).

Revitalizing Asia's Irrigation

In much of Asia, irrigation is being transformed, as large-scale centrally managed schemes are giving way to individually managed small-scale pumping from canals, rivers, aquifers and on-farm ponds (Mukherji et al 2011). This "water-scavenging" economy is made possible by the availability and affordability of small portable pumps, and has been driven by a need for reliable, flexible access to water so farmers can adapt their agriculture to modern practices and crops. Many of these investments have been undertaken by farmers themselves, which has replaced or leveraged public investments in the agricultural water management sector (Molden, 2007).

Following a major study of trends in Asian agriculture, IWMI and FAO formulated 5 strategies to capitalize and support these trends in order to revitalize irrigation.

Strategy 1: Modernize yesteryear's schemes for tomorrow's needs
Redesign, operate and manage irrigation schemes for a range of uses, e.g. surface irrigation schemes could be used to recharge aquifers or fill intermediate storage structures, such as farm ponds, providing farmers with greater reliability and control. Flexible and responsive management is needed, allocating water to multiple uses and to meet environmental targets.

Strategy 2: Go with the flow by supporting farmers' initiatives
Farmers are using locally adapted irrigation technologies to scavenge water from surface sources, wastewater, and groundwater. Identify successful initiatives and direct investment towards schemes emulating farmers' methods.

Strategy 3: Look beyond conventional PIM/IMT recipes
Explore a range of management approaches targeted to specific local contexts and modes of irrigation delivery, including public – private partnerships, private sector management, and farmer cooperatives.

Strategy 4: Expand capacity and knowledge
New approaches need upgraded technical skills; invest in building the capacity of all stakeholders (including the irrigation bureaucracy) with engineering courses in universities, in-depth training workshops for farmers and irrigation officials, or revamping irrigation departments to empower their workforces.

Strategy 5: Invest outside the irrigation sector
Policies and programs that influence agriculture, both directly and indirectly, also drive developments in irrigation. Framing policies to ensure external influences on the water sector are properly understood and planned is one way to indirectly influence irrigation performance.
http://www.iwmi.cgiar.org/Publications/Other/PDF/Revitalizing%20Asia%27s%20Irrigation.pdf

Current situation and trends – what have we learned?

Agriculture in the region is shifting from traditional subsistence to modern commercial farming, and is currently being shaped by a complex mix of factors: population growth, urbanization, economic development, and global trade. Improving management and productivity of water is an essential part of modernizing and intensifying agriculture to meet growing demands while safeguarding the natural ecosystems that underpin production. Given the importance placed on irrigation in government policy, and the amounts committed for investment, there are surprisingly few studies of the effectiveness of irrigation in increasing agricultural productivity and incomes, and even fewer comparing the relative costs and benefits of different modes of irrigation. However, some interesting questions emerge from current trends:

Wet season supplementary irrigation for food security

The wet season rice crop is the main component of Cambodia's food supply, and accounted for 77% of total rice production in Cambodia in 2012 (MAFF 2013). Most farmers produce rice mainly for home supply, but a growing number are producing a surplus for sale. Wet season rice is thus also important as an export crop, particularly some high-value aromatic varieties.

MAFF (2013) estimates that around half (~0.76 m ha) of the total wet season rice crop (~1.45 m ha) has access to supplementary irrigation. The largest areas of existing irrigation in Cambodia are suitable only for wet season irrigation, far exceeding dry season irrigated areas (~0.36 m ha) (MAFF 2012). Proposed new schemes continue this pattern; for example, the first phase of the recently announced Vaico River project will irrigate 108,300 hectares of wet-season rice and 27,100 hectares of dry-season rice, at a cost of USD 100 million (Cambodia Herald 21 Feb 2013).

Studies indicate that wet season irrigation has very little impact on rice yields (Wokker et al 2011; Halcrow 1994). Increases in yield of wet season rice over the last 20 years have come primarily from improved varieties and usage of fertilizer (IRRI 2012). Irrigation of wet season rice is mainly used to reduce the risk of crop loss, providing very low marginal returns. This very modest economic performance discourages investments in infrastructure and maintenance, limiting the feasibility of cost-recovery from irrigation service fees for wet season irrigation (Wokker et al 2011). While drought is undoubtedly a serious issue for farmers in some seasons, losses from flood damage are generally a much larger; for example, flooding damaged over 10% of the wet season crop in 2011 (ADB 2012a; MAFF 2012).

Thus it can be argued that investments in large infrastructure (canals and storages) for wet season irrigation are unlikely to significantly and efficiently address poverty alleviation objectives, or increase the availability of rice for export. In terms of food security, protecting the wet season crop is a high priority, but it is not necessarily clear that formal irrigation systems are the best way to achieve this. Given the high establishment costs of formal schemes, and the on-going problems with operation and maintenance in existing schemes, it is possible that small-scale pumping of surface and/or groundwater, or small on-farm storage facilities, may be more efficient ways to drought-proof wet season crops.

Promoting double cropping for poverty alleviation

Moving from single to double cropping has very significant benefits in terms of both food supply and farm family income (Thuon, this study; Chea et al 2004). In many cases, double cropping involves cultivation of short period crops (rice or non-rice) in the early or late wet season, along with the traditional wet season rice crop. The second crop is at least partially rainfed, but generally requires supplementary irrigation. Availability of supplementary irrigation even for limited, strategic irrigation reduces the risk of crop loss and increases the practice of double cropping (Phaloeun et al 2004).

Double cropping has been successfully established outside of formal irrigation systems by using small scale pumping from groundwater (tube wells) or small surface storage reservoirs (natural or man-made). However, within some of the larger systems, uptake of double cropping has been very limited (e.g. in Stung Chinit ((Thuon, this study)). The reasons for this are complex, but are due at least in part to unreliable and inflexible water delivery within large schemes, which are designed primarily for rice irrigation and do not adapt well for other crops, nor allow flexibility in planting dates and watering schedules. Even within formal schemes, private pumping is emerging as a mode of securing water supply (Phallika 2012).

Enabling farmers to grow two crops a year is critical for both poverty alleviation and rice export goals, but requires flexibility for crop diversification. This may require significant change in the way formal schemes are operated, and/or a shift to individually managed irrigation. However, provision of access to water is only one part of the solution. The drivers for adoption of double cropping are complex, including market opportunities, availability of inputs, and agronomic information about new crops or farming methods. Requirements to support adoption of new practices are specific in terms of geographic location, farming system, and crop types: there is no single approach that suits every situation.

Dry season irrigation for commercial rice production

In general, dry season irrigated rice cropping does not benefit the poor, since poorer farmers are less able to afford the inputs, and less willing to take the associated risk. Full irrigation of dry season rice provides high yields, but requires high levels of inputs (improved seeds, fertilizer, and pesticides); Thuon (this study) estimated the cost of inputs for dry season crops at around USD 800/ha to stabilize yields at 5-6 t/ha. Returns from irrigation are much higher than in the wet season (Yu and Fan 2009; Wokker et al 2011), but risk of insect damage is high, resulting in the use (and sometimes overuse) of pesticides. Reliable water is a relatively small component of total cost. Irrigation thus becomes an essential insurance protecting the farmer’s investment. Dry season rice production is trending towards commercial production; most farmers growing dry season rice have larger holdings, and mechanization is increasingly common.

Three successful models for dry season intensification were identified: reservoir schemes in the Tonle Sap basin; large canal systems such as those in Takeo; and individual pumping of groundwater in Svay Rieng and Prey Veng. In each of these contexts, cultivation of two or even three crops a year is possible, and yields of 6 t/ha are not uncommon. However, each faces different constraints.

Reservoir capacity limits irrigation potential in some Tonle Sap sub-basins. The physical limits to viable reservoir volume in the Tonle Sap sub-basins need to be carefully defined before large investments are made. This is particularly important in the context of proposed multi-use (hydropower / irrigation) schemes for Pursat, Kampong Thom, and Kampong Speu, with Chinese and Korean investment.

Canal systems in the south benefit from the large volumes of water in the rivers. However, while availability of river water in the canals is not usually an issue, transferring the water from the canals to the fields necessarily limits the overall productiveness of the system. There is an increase in the number of operating private pumps, either individually owned or operated commercially by middlemen water sellers; as such, maintenance, particularly of secondary canals, is an issue. Potential solutions include lining of canals or even replacing canals with pipes, but these solutions require significant investment.

MOWRAM has adopted a precautionary approach to groundwater use because of the risks of depletion and endangering domestic groundwater supplies. However, groundwater use is widespread in the Mekong Delta where other sources of water are not available. In general, groundwater is best used for supplementary irrigation, rather than full dry season irrigation, but regulating use is very difficult.

Access to credit in order to afford inputs can be a constraint for dry season farming. While contract farming is one way around this, it is not widespread, except close to the border with Vietnam where Vietnamese middlemen provide informal credit by administering seeds and fertilizer. The financial risks in dry season farming could be reduced or offset through farmer cooperatives, government subsidies, and guaranteed markets.

Successful DS farming requires technical advice on suitable varieties, fertilizer and pesticide use, and water use efficiency. Approaches to reduce water use could increase the viability of dry season irrigation. SRI and alternate wetting and drying approaches are used in some areas, but are not widespread.

Is a focus on rehabilitation of existing schemes impeding progress?

An inventory reported by CEDAC (2009) found that of 2525 schemes, only 6% were functioning well and 62% were not functioning. MOWRAM disputes these figures, and claims that the proportion of operating schemes is much higher; however, the Ministry acknowledges that maintenance of schemes is a significant problem, and that funds for maintenance are rarely sufficient. Large investment has gone into repair and rehabilitation from both government and donor programs, but outcomes have been very mixed; there are reports of widespread failure of rehabilitated schemes after 1-2 years, attributed to lack of regular maintenance, flood damage, and poor operational practices. The government's policy reliance on Farmer Water User Communities (FWUC) as the main source of routine maintenance and system operations is questionable.

Around 80% of the irrigation schemes extant after 1978 were built during 1975-8 as part of a Khmer Rouge plan to build a nationwide chessboard of leveled 1 ha plots fed by canals in a 1x1 km grid. Himmel (2007) reports that these irrigation works were often built without consideration of overall water requirements or availability, soil suitability, or siting of structures, and that as a result, many existing schemes suffer from flawed design, poor construction, and inappropriate siting, making it possible that they may never be feasible. MOWRAM disputes this view, and considers the basic design of most of the major canal systems to be sound, although gates and other structures need to be modernized.

It is possible that the presence of this pre-existing infrastructure has resulted in unrealistic expectations of what can be achieved with irrigation in Cambodia, and has distracted from rational planning and design for specific conditions and locations. Not only does it engender an expectation that irrigation can and should be extended to all the major rice areas, it has also entrenched the model of gravity-fed canal command irrigation as the norm.

Cambodia's geography and hydrology limit the areas where irrigation is feasible and effective. The very flat topography of the lowland plains allows widespread use of gravity-fed canal systems, but means there is an almost total absence of suitable locations for construction of reservoirs to supply them; Halcrow (1994) estimated that <15% of major rice areas are capable of controlled irrigation based on reservoirs. Annual inundation of the floodplain means that any irrigation infrastructure is also flooded, with resulting damage and silting up of canals, gates, and storages, adding very significantly to O&M costs. Poor soils (sandy, low in nutrients and with low potential for yield improvement) characterize almost half of Cambodia's agricultural areas (White et al 1997) making it unlikely that expanding irrigation in these areas will be economically sound (MOE 2011, McKenney and Prom 2002).

In addition to adapting to the physical constraints of the system, successful irrigation development should be carefully targeted to the requirements of irrigation users. Gravity-fed canal command irrigation is suitable for rice monoculture, but is not easily adapted for a diversity of crops. RGC's agricultural policies encourage diversification of irrigation into high value vegetables, fruit trees, and industrial crops, but existing infrastructure does not support this.

Is built infrastructure the only option?

Future plans for irrigation in Cambodia are dominated by three types of development (Young 2009; MOWRAM 2012): canal systems diverting water from the major rivers (pumped or gravity fed); systems fed by storage reservoirs in the Tonle Sap basin (some multi-purpose hydropower and irrigation dams); and large scale flood protection schemes in the Delta south of Phnom Penh. All require major built infrastructure. As with other countries in Asia and Africa, opportunities for public investments in smaller scale, farmer based solutions have, until recently, been largely ignored (Giordano et al, 2012).

Recent trends indicate, however, that a significant proportion of irrigation in Cambodia occurs within the informal sector, with widespread small-scale pumping by individual farmers from both surface and groundwater, using a range of sources – a pattern very common in other parts of Asia, and described by Mukherji et al (2010) as "water-scavenging". This is made possible by the availability and affordability of small portable pumps, and relies on the existence of natural surface and subsurface storage reservoirs: streams, lakes, wetlands, and aquifers.

Although Cambodia's geography poses significant challenges for irrigation, it also offers some unique opportunities in terms of "natural infrastructure" for water management (Smith 2010). The most obvious example is Tonle Sap Lake, which functions as a giant retention pond, holding floodwaters and releasing them to Southern Cambodia during the dry season, thus extending the season during which water is available in downstream areas by several months. The floodplain contains a large number of natural lakes, swamps, and wetlands, which retain water during the dry season; these act as small storage reservoirs. They are important sources of water for informal pumping during the dry season, offsetting to some degree the lack of suitable sites for constructed storage. The colmatage systems constructed in the Delta in the early 20th century used a network of canals and dykes to capitalize on floodplain structures, providing flood protection and access to river water in areas that are inundated seasonally for long periods. As such, restoring systems that incorporate flood protection and drainage as well as irrigation is an important priority for the floodplain.

Natural storage is also provided by the extensive shallow aquifers that underlie the floodplain and lowlands. These are annually recharged by floodwaters (Rickman and Sinath 2004), although the volume, spatial pattern, and rate of recharge are not well characterized. Groundwater storage has the significant advantage of minimal evaporative losses. Techniques exist to increase recharge and enhance groundwater storage (managed aquifer recharge, MAR – IWMI 2010). Since groundwater is usually accessed directly by tube-wells at the point of use, aquifers also act as transmission systems, reducing the need for surface canals.

Conclusions

Government policies on AWM and investments by government and development partners have focused almost entirely on formal irrigation schemes (at a range of scales), but a shift towards informal, water-scavenging irrigation is already underway, driven by individual farmer investments. AWM planning in Cambodia needs to support these new modes, as an adjunct to traditional formal schemes. Small-scale water stores and pumping, with conjunctive use of surface and groundwater, can improve water delivery both within and outside formal schemes. There are significant advantages in terms of flexibility and individual control over water access, resulting in a reliable, timely, and adequate supply of irrigation water, but these techniques pose a new set of challenges in terms of managing water resources.

Questions for further research

What are the relative productivity, economic costs, and livelihood benefits of different modes of irrigation in different contexts in Cambodia?

Very few analyses have been made of the outcomes from irrigation in Cambodia. Acknowledging that the importance of wet season supplementary irrigation may be in reduction of risk rather than increase in yield, can expenditure on large infrastructure for wet season irrigation be justified in terms of economic or other livelihood benefits? Are there more efficient ways to reduce drought risk? Are formal irrigation schemes sufficiently flexible to support widespread adoption of double cropping using supplementary irrigation, or are other approaches needed? Do the regulated water regimes of gravity fed irrigation schemes reduce flexibility of crop choice, thus trading a reduction in short term drought risk for reduced adaptive capacity in the longer term? How does access to irrigation affect other components of livelihoods (fisheries, livestock, off-farm income)? What investments would be most effective to support the development of commercial dry season rice production?

These questions could be addressed through a comprehensive comparative econometric analysis of different modes of irrigation (wet season supplementary irrigation; supplementary irrigation for diversified double cropping; full dry season irrigation of rice and other crops) in different contexts (canal command, small and large reservoirs, on-farm storages, colmatage, groundwater). Such an analysis would encompass broadly based livelihood surveys during different seasons over multiple years (similar to the current ACIAR project assessing the impact of community fish ponds), as well as an analysis of overall water productivity in different contexts (taking into account other uses of water, including fisheries and livestock). This analysis would need to use a water accounting approach and remotely sensed data to improve information on the extent, location, timing, and water use of irrigated cropping in different seasons and contexts, building on current programs in IRRI (http://bit.ly/12cBFI6) and IWMI (http://ccafs.cgiar.org/node/1751).

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