



Title: Moving Targets: an agenda for irrigation management modernization in East Asia and the Pacific

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Abstract – The rapidly changing demands for agricultural products in East Asia and the Pacific (EAP) region are prompting a rethink on how transition economies in the region are positioning the irrigated sub-sector. Lessons can be learned from post-industrial countries in the region and the current state of irrigation in transition countries can be informed with a view to the future. An approach for taking stock of national and regional prospects for modernization is evaluated from some preliminary assessments. Conclusions over the probable evolution of irrigation management modernization in the regional are presented.

Keywords – Irrigation, Modernization, Prospects, East Asia

Introduction – The structural role of irrigation in East Asia and the constraints it faces in meeting current and future demand for irrigated products is often not factored into macro-economic accounts of regional development. Recent accounts of rice production in the East Asia region (e.g. Pandey et. al. 2012, Reardon, 2012) describe the economic transformation that is occurring but do not focus on the detail of water service delivery to irrigated agriculture. The ‘future-watch’ analysis for countries the region (e.g. Christiaensen, 2012) may presume an elasticity of supply which is in fact highly constrained by hydrology and hydraulics. But such also point to the “farm income problem” (Christiaensen, 2013) noting that land consolidation/rental and mechanization will have to play a role in boosting farmer productivity and farm income. These broader water resource implications of agricultural transitions have already been examined in a set of global examples (Molden et al. 2010) pointing to ‘second best’ solutions that may lie outside the standard water resource management domain. These considerations notwithstanding, it is argued here that in order to assess the actual production risk, now and in the future, the structure of the irrigation and drainage sub-sector and the levels of performance have to be ‘unpacked’ and set in the relevant national and regional context. Scheme by scheme diagnostics through tools such as the FAO published RAP and MASSCOTE assessments (FAO, 2007) are necessary, but they are not sufficient to paint a macro-picture across river basins that may be experiencing constructed scarcity, or diagnose the drivers of change at national and regional level that will determine future demand and also the future technical capacity to produce into that demand.

Socio-economic drivers impact both the providers and the consumers of irrigated production. Irrigation and drainage systems are now more likely to be multi-purpose and multi-use and will therefore have multiple performance objectives. If the combination of climatic variability and green growth policies (low carbon) are likely to shape economic transitions, they will also shape irrigation operations. In some cases the energy balances may become more significant than water balances. As these drivers and pressures multiply, production risks are amplified and risk management (whether through avoidance/transfer, mitigation or simply coping) becomes a necessity. Building in hydraulic flexibility through the adoption of service management principles (Box 1) has been at the heart of irrigation modernization (Box 2) attempts in the East Asia region to anticipate such risk management.

Box 1: Service Oriented Management

In the business sector service-oriented management (SOM) is the operational management of service delivery within a service-oriented architecture (SOA). The primary objective of SOM is to provide a differentiated service delivery capability during operation, using business objectives to drive system behaviour. An SOM solution supervises and controls the delivery of a service from a service provider to a service requester. (It can also be seen as supervising and controlling the consumption of services by a requestor from a number of providers.) An SOM solution should be able to manage any service from any technology without requiring code changes, special deployment, or special development environments. SOM solutions are runtime solutions rather than development or deployment solutions.

Source: FAO, 2007.

Box 2: What is modernization?

“Modernization of an irrigation system is defined as the act of upgrading or improving the system capacity to enable it to respond appropriately to the water service demands of the current times, keeping in perspective future needs, or as a process of technical and managerial upgrading (as opposed to mere rehabilitation) of irrigation schemes with the objective to improve resource utilization (labour, water, economics, environment) and water delivery service to farms. This involves institutional, organizational and technological changes and implies changes at all operational levels of irrigation schemes from water supply and conveyance to the farm level. The objective is to improve irrigation services (and minimize associated costs) to farmers, and improvement in canal operation will generally be a critical first step in the process”

Source: Thierry Façon introduction to Plusquellec, 2002.

Given the importance of irrigation production in the EAP region and the regional initiatives in food security (See Box 3) to stabilize production and prices, the EAP region at the World Bank together with ADB and FAO wanted to take a regional view of modernization in order to anticipate lending and technical assistance for irrigation in the region. The prospect of an Asia Economic Community in 2015 can be expected to give a further impulse for increased flexibility in irrigation and drainage to meet enhanced trading opportunities.

Box 3: The 34th ASEAN meeting of the Ministers on Agriculture and Forestry, 27 September 2012, Vientiane .

“Meeting Challenges and Opportunities for Food Security

4. We, while noting the good progress in the implementation of the ASEAN Integrated Food Security (AIFS) Framework and the Strategic Plan of Action on ASEAN Food Security (SPA-FS) (2009-2013), including the entry-into force of the ASEAN Plus Three Emergency Rice Reserve (APTERR) Agreement, agreed to remain vigilant on the opportunities and challenges of food security in the region and the world, particularly at a time of high volatility of commodity prices and economic uncertainties. Moreover, we agreed to continue building on existing mechanisms and explore new initiatives that contribute to food security in the region.”

Source: http://www.asean.org/news/asean-statement-communiques/item/the-thirty-fourth-meeting-of-the-asean-ministers-on-agriculture-and-forestry-34th-amaf?category_id=26

A simple framework with the acronym ABCDE+F is used in a 4 step process (Annex 1) to assess the overall state of irrigation and drainage services in 4 participating countries (China, Indonesia, Malaysia, Thailand) and establish a common baseline from which a regional synthesis can be drawn. The method is designed to reveal the state and potential of the irrigated sub-sector to policy makers and particularly finance and planning. An illustration with simplified generic samples is given in Table 1. With this diagnostic in place it is then possible to undertake:

- a short-term analysis to assess, at country level, how well they are likely to be suited to current and near-future conditions (drivers) and improve water delivery services;
- a long term analysis to determine a modernization strategy that is based on new objectives linked to probable futures in which overall performance is maintained or raised.

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Table 1: Basic ABCDE+F framework and service interface (with generic examples)

LEVEL	A: Accounting	B: Bargaining	C: Codification	D: Delegation	E: Engineering	F: Feedback
National	<i>National water audit</i>	<i>National water council</i>	<i>National water law</i>	<i>Regulation policy</i>	<i>Interbasin transfer</i>	<i>Agricultural growth</i>
Basin	<i>Basin audit</i>	<i>Basin planning Board</i>	<i>Basin plan</i>	<i>River basin organization</i>	<i>Hydromet network</i>	
Service Interface Basin – Main Irrigation System	<i>Water account</i>	<i>System representation on Board</i>	<i>Water use rights + bulk allocation and service standards</i>	<i>Bulk delivery payments</i>	<i>Flow management system</i>	
Main Irrigation System		<i>Irrigation Committee</i>	<i>System operation plan</i>	<i>Irrigation system authority</i>	<i>conveyance + drainage system</i>	<i>Annual review and plan setting</i>
Service Interface Main Irrigation – Sub-Irrigation System	<i>System scheduling account</i>	<i>Water use association federation (WUAF)</i>	<i>Scheduling agreement</i>	<i>Service contract and revenue flows</i>		
Sub Irrigation System		<i>Secondary</i>	<i>Cropping schedule</i>	<i>WUAF</i>	<i>Flow control and storage</i>	
Service interface WUAF – WUA		<i>Water user Association (WUA)</i>		<i>Service agreement + payment mechanism</i>	<i>Cross regulation operation</i>	
WUA		<i>Tertiary</i>		<i>WUA</i>	<i>Drainage</i>	<i>performance review</i>
Service interface WUA – Farmer	<i>Water account</i>		<i>Service agreement</i>		<i>Turn out operation</i>	<i>Information flows</i>
Farmer			<i>Water order</i>	<i>Delivery and payment</i>	<i>On-farm technology</i>	<i>Farmer income</i>

Key Issues and Challenges –

Socio-economic prospects

The long term viability of public and private irrigation infrastructure in East Asia should be a concern. Globally, irrigated agriculture produces 44% of crop production on just 16% of cultivated land (Alexandratos & Bruinsma, 2012). In East Asia alone irrigated agriculture dominates production of staples but the annual conversion of irrigated paddy in Indonesia, for example, is now estimated at 100,000 ha as a result of urbanization and oil palm plantations. Agricultural land encroachment, migration of rural labour and progressively scarce and degraded water supplies are threatening current productivity. The scope for pursuing a structural transformation with respect to rice has been noted by Timmer (2010) who points to four “quite relentless and interrelated processes”

- “a declining share of agriculture in gross domestic product (GDP) and employment;
- rural-to-urban migration that stimulates the process of urbanization;
- the rise of a modern industrial and service economy;
- and a demographic transition from high rates of births and deaths (common in backward rural areas) to low rates of births and deaths (associated with better health standards in urban areas)”

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Indeed, accelerating rates of economic transition are now evident in the EAP region. Agriculture has a much lower share of GDP. Commercialization of agriculture and deepening of supply chains to service supermarket chains are aided by information technology and higher levels of education. But new investors and financiers are also entering the fray and under the provisions for the AEC by the end of 2015, the policy space for much more precision agriculture is expected to enlarge as regional trade barriers are removed. All this assumes that national policies in food security, poverty alleviation, rural development, urban, industry and environment are not contradictory.

The role of irrigation and drainage infrastructure and management in such structural transformations should be of interest given the level of public and private investment in the sub-sector. And the while the magnitude of the challenge in meeting current and future demand for irrigated products has been acknowledged in economic accounts of regional development, evidence of 'quality' solutions is hard to come by. In many instances irrigation institutions have found it difficult to adopt service-oriented management principles and position the sub-sector in relation to changing demands, and changing capacities. This is despite the examples from water supply or energy utilities.

This lack of attention to hydraulic and institutional detail on the region's large irrigation schemes threatens to foreclose opportunities for positive modernization at time when the nature of the supply of inputs is likely to change as much as the demand for other multi-functional services from irrigation and drainage systems (FAO, 2010)

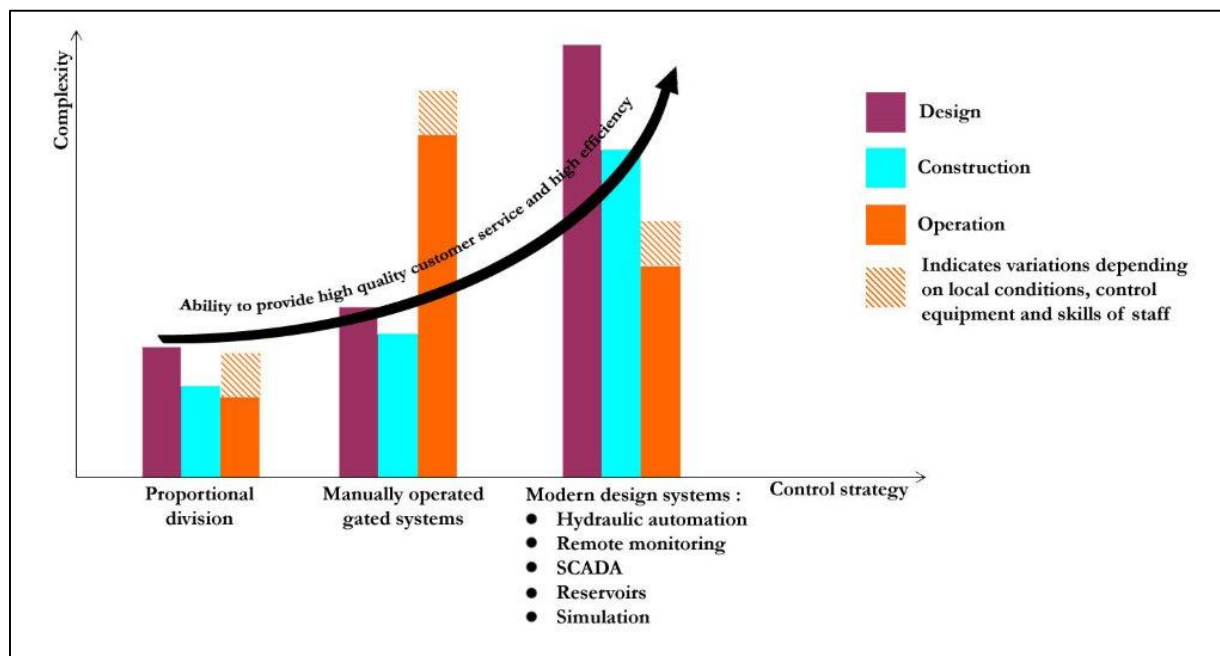
As such urbanization and concentration occurs, what of those left behind? For instance, in the case of Vietnam some recent research at the World Bank (Lanjouw et al. 2013) makes an argument for more targeted transfers to address poverty sees the need to promote growth of poles or zones of intensification

"We show that poverty rates have become more concentrated in Vietnam between 1999 and 2009. This phenomenon is likely not unique to Vietnam and may be widespread in developing countries. Economic activity and growth are becoming more spatially concentrated, due to agglomeration benefits related to network, technology and human capital externalities. This suggests that spatially targeted re-distribution policy executed alongside the development of high-potential areas may offer one means for a country to maintain growth while also maintaining an equitable distribution of wealth. As poverty becomes more spatially concentrated, the effectiveness of geographic targeting is likely to improve"

So in this case the intensification offered by irrigation will be called upon to service a more sophisticated urban population and agricultural productivity (on basis of Total Factor Productivity) will need to improve to underpin a successful structural transformation as pointed to by Timmer (op. cit.). But how? In the case of China, a calculation has been made that to maintain rural wage levels just growing a single commodity, harvested areas per farmer would need to increase from 0.6 ha to 3.6 ha (Christiaensen, 2013). No doubt progressive mechanization and commercialization of agriculture will be combined with land consolidation (where possible) and off-farm income to keep rural wage levels buoyed up. But this begs many questions over the current and future design of large irrigation systems that will be experiencing higher levels of water scarcity and higher frequency of flood damage. Figure 1 gives an indication of the progression of control strategies that can be anticipated as more flexibility and resilience is factored in.

A recent World Bank study (2012) on the Water Security of the densely populated and rapidly urbanizing Island of Java not only shows the need for better irrigation service provision, but also the associated need to address the issues around conservation and protection of land and water resources, water quality management and pollution prevention controls for 'green' agriculture to remain competitive in the higher quality segments of agriculture in Indonesia. Spatial planning that incorporates 'water' tests for hydro-environmental quality will significantly change the use of water and land resources and enhance resilience of agriculture systems if properly enforced.

Figure 1 Irrigation control strategies for flexibility and resilience.



Source: Plusquellec, 2002.

Hydrological Futures

If the socio-economic prospects are “relentless”, then the water resource futures look precarious at best. Basin planning/negotiation processes in the region are now more pluralistic than ‘integrated’, but a general disconnect between water resource management and agriculture persists. In East Asia region agriculture withdraws 775 km³/yr (FAO AQUASAT on-line data) but this allocation can be expected to decline as demand from industrial use (currently 208 km³/yr and municipal use (currently 89 km³/yr) increase.

Further agricultural intensification in already developed basins will force higher water productivity with existing irrigation assets and while basin storage can be maximised to cope with extreme events, smart management required to optimize actual operation. But the range of hydrological uncertainty under climate change could paralyse institutional transformation and public investment precisely when risk management strategies for regional food security need to be activated. For this it is important to identify who takes the production risk, at what level, and how? The transfer of risks through indexed crop insurance will be an option for producers dealing with high frequency and low loss events (periods of stress during flowering), but operators of hydraulic infrastructure may be more vulnerable to low frequency events with severe system wide losses. Beyond these levels, the macro-economic management of food security risks may extend to wholesale purchase of natural resources and production capacity beyond national borders.

Institutional Trajectories

The governance environment and the institutional arrangements for irrigation may also be uncertain and it has proved - easy to deflate irrigation institutions, rather more difficult to re-build them. Indeed certain approaches to transfer of liabilities and risks (IMT/PIM) have had a patchy record. But certain things can be factored in. De-centralization is a political reality. The informal private sector is vibrant, and mixed pluralistic arrangements of users, operators and regulators is progressively forcing ‘polycentric’ decision-making. Beyond this it can be anticipated that that requirements for environmental compliance will become more stringent.

Even if irrigation has been used as a system of political patronage, irrigation and drainage schemes are much more ‘open’ to environmental stress, inter-sectoral allocations than ever before. Trying to manage them as self-organizing complex systems is bound to fail but building a strong service oriented backbone should pay dividends in the future –

leaving the system open to service new demands. This has traditionally been seen as a threat when in fact it is more likely to be an opportunity. Taken with the future ‘threat’ of increased environmental regulation, irrigation institutions that are able to move away from monolithic infrastructure ‘silos’ and address increasing complex markets and social change could see such challenges turn into opportunities. For instance, such fundamental concerns as food security will continue to have a cost that is not borne by the market and the sheer scale of the irrigation and drainage asset base may still need strong public institutions. But the role of government may not need to be restricted to traditional supply ‘fixes’. For instance, smarter regulation of water use rights could spread risks and enable more stable engagement with natural resources in the long term. But whatever the policy and institutional preferences, there should be no excuse to move toward transparent service oriented systems.

Opportunities

Irrigation systems that have stagnated elsewhere in the world are now showing signs of re-emergence (East Europe) where post-industrial concerns with stabilizing agricultural production and attenuating short-term volatility in cereal supply has been seen as a global ‘good’. In fact irrigation has been taking up a lot of slack in global supply when rainfed production of cereals has been ‘shocked’ by extreme periods of drought. However, this opportunity needs to be informed by look into the future to avoid old-style investment patterns and position remaining institutional capacities and public investment to positive long-run effect

It should be possible to re-calibrate the sub-sector to allow it to adapt to changing demands on irrigated agriculture. These include the progressive urbanization of the region and the deepening of food retail value chains. But the factors of supply are also changing dramatically as the economic transitions proceed. Changing labour availability and rising rural wage levels are prompting land consolidation and adoption of mechanization to maintain acceptable levels of land productivity. The change will be triggered by the overall productivity of farm operations of which water is just one input. However by looking at the detail of water services, it may be apparent that many irrigation problems need to be addressed outside the realm of the irrigation and drainage sub-sector. To a degree this work has already started through the sub-sector (including the RAP and MASCOTTE tools). But while these are very useful tools to assess service levels and propose interventions to achieve or improve agreed levels of service, the application of these tools needs to be iterated with reference to the national and regional economic frames as they transition.

It is argued here that the irrigation and drainage sub-sector has not paid enough attention to the rapidly changing boundary conditions in which those services are to be delivered. When used in an iterative frame, modernization tools such as RAP and MASCOTTE exercises should also provide essential insights for the formulation of development policy. To this extent they are able to unpack the sub-sector under present operational framework and also provide inputs in the formulation of strategies to address the transformation challenges in agriculture as a whole. For instance, bulk supply within irrigation schemes might evolve towards multi-use provision including recharge, low-head hydropower generation, municipal and amenity use. In this sense, any future should present opportunities and even if threats persist, at least they can be anticipated and avoided, mitigated or coped with in an orderly manner. But all this assumes that gravity canal operations can be modernized adequately to meet this more complex set of hydraulic demands and avoid deviations from target flows. Basic measurement and allocation procedures have to be in place as a minimum.

Degrees of Freedom

Given the pace of economic transitions in EAP, institutional tests of resilience and sustainability have to become dynamic notions. To this extent, adaptability and responsiveness needs to become a design criterion in full recognition of a service-oriented management approach. And although maximum change related farming will happen at lower levels, such change may need to be triggered and facilitated by higher level interventions, including basic allocation to first improve reliability of service provision.

Other design criteria for irrigation institutions could include

- ability to remove constraints
- ability to scale practice across irrigation systems & natural resource units
- capacity development – not just engineers, social entrepreneurs environmentalists, lawyers are also relevant
- ability to track performance – economic, social and environmental

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As such, building flexibility in service provision will be key to resilience and sustainability. Regional market connections are likely to improve under ASEAN and AEC agreements so that the production risk can be spread beyond national boundaries. At basin level, even if there is no perfect integrated water resource management, then linking farmer interests to basin planning and operation through more effective institutional collaboration will loosen up formerly rigid planning processes. At irrigation scheme and sub-scheme level a review of basic competencies and professionalism in delivering services and making operational adjustments will remain essential. And at field level, more transparency and information ‘push’ on water services will give farmers more agronomic options if they can anticipate reliable deliveries.

Recommendations/Findings/Options/Questions *This section is intended to provoke discussion of the recommendations three or four recommendations that can be considered by MDBs and DMCs*

The past in no guide to the future: The scope for irrigation sector (and agriculture) to significantly contribute to poverty reduction in the future (as it did in the past) is limited. Policy targets move on and a continuing regime of smallholder protection and subsidy cannot be taken as a given as policy reduction instruments such as direct transfers replace. The economies in transition are still be concerned with food security, but self-sufficiency in key staples unlikely to be a policy priority. Diets are changing along with supply chains that demand high specification, just-in-time delivery of agricultural produce. It is important to avoid policy choices that result in dead-ends and appreciate what ‘second best’ solutions can achieve - but with close attention to the structural evolution of the sub-sector.

Take account of changing drivers – the short-term analysis: Irrigation schemes in the EAP region are now much more open but will have to respond aggressively to attenuate hydraulic ‘noise’ in stressed basins, reduce environmental impacts and accommodate patterns of production with higher levels of mechanization (not just to substitute labour). The results of the national assessments indicate that a more orderly re-allocation of water resources will need to be combined with exit strategies in place and ‘dead-ends’ avoided.

Be prepared to revise objectives – the long-term analysis: It is argued here that investment that simply steers the sub-sector toward ‘dead-ends’ can be avoided if ‘future-watch’ is incorporated into investment planning and monitoring (public and private). Such ‘enlightened’ investment is likely to focus on transforming hydraulic and institutional performance to allow a re-structured sub-sector to emerge. Current modes of planning and financing are simply too lazy to do this and threaten to reinforce poverty (Timmer, op. cit.) In this sense, future-watch analysis would be a way to transform public assistance of short-term nature (e.g. 5-year self-sufficiency plans, rice mortgage schemes etc.) into a progressive build-up of service oriented management.

Finally, since agricultural water withdrawals will continue to dominate, as the role of water quantity and quality becomes recognized as instrumental in much more sophisticated urban development, the irrigation and drainage sub-sector has a broader responsibility, and opportunity, to articulate the consequences of agricultural water management for spatial and economic planning. These checks on sustainability cannot occur without a full knowledge of the level and dependency of irrigation and drainage services now and their projected evolution in the future.

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ANNEX 1 : Country Assessment Methodology

1. The Assessment Framework

Water resources are managed in a tiered format¹ – basins, administrative units, sectors, users (e.g. towns, industries, irrigation projects). Within an irrigation system the government may operate the main system, water user associations operate distributaries, and individual farmers operate their holdings. In this tiered approach, the interface at each level specifies the service provided by one level to the next – thus nationally, urban usage may be prioritised over agricultural usage; domestic use may be reserved at some minimum level before all other uses; within an irrigation scheme, orchard crops may get priority over field crops, etc.

Present management practices in some irrigation schemes contain a high degree of social accord among the users expressed in non-formal management rules taking many social, physical and multi-use factors in consideration. In other cases rules are absent or unobserved, so that favored farmers take what they want while others are left with whatever is excess.

The service standard will be used to capture and present the national and regional differences in a common framework. The service standard describes the transactions between the managers and users at successive interfaces. The ABCDE+F² framework described below identifies the components required for the service standard to be fully defined. The framework is normative (it does not “promote” one approach over any other), and it will often be the case that the components of the service standard are different for different interfaces (for example, the government may define priorities among regions and sectors, but a private company may set standards for local domestic water supply, or a water user association might administer and operate allocations within an irrigation project). These variations can productively co-exist provided the service standards at the interfaces are fully defined.

Components of the ABCDE+F framework

- A. ACCOUNTING – the process of knowing how much water of which quality is available at a management unit (country, basin, city, irrigation system, WUA) and how it is used.
- B. BARGAINING – the political process of setting priorities for the allocation of water among competing uses, including the environment at the various levels of the system (basin, irrigation system and sub systems).
- C. CODIFICATION — formalizing the outcome of the bargaining process as rules, regulations and procedures. While step 'B' may establish some quantitative elements of the service at each interface, specific rules and decision variables will involve additional details.
- D. DELEGATION — the institutional arrangements for implementation of rules and procedures related to the provision of services, the management of assets which includes investments, the sharing of costs and associated administration. The ultimate financial arrangements, funding mechanisms and availability of funds are essentially result of the negotiation process (in B).
- E. ENGINEERING — the infrastructure: storage, conveyance, flow control, groundwater/surface water conjunctive use and irrigation application technology necessary to provide and monitor the provision of the agreed levels of service.

Finally, this framework is completed by:

- F. FEEDBACK – the process of monitoring and corrective action taken by the parties involved within the ABCDE interactions, including monitoring of investments and results, and responding to new situations such as construction of a new storage facility that changes water availability, or exogenous factors such as climate change.

The ABCDE+F framework is designed to be objective comparison tool. It allows for comparison by focusing on explicit irrigation management functions each system is using to different degrees and in different intensities..

¹ In the case of water, the principle of subsidiarity – delegating management responsibility to the lowest appropriate level – is constrained by the dependence of downstream users on the actions of upstream users.

² The ABCDE framework was developed by Chris Perry, and has been elaborated in “Water in the Arab World Management Challenges”, Vijay Jagannathan, Ahmed Shawky and Alexander Kramer, eds., World Bank 2009.

Designing an irrigation modernization program involves iterations of ABCDE at project level. Investment and transaction costs can be expected to rise with increasing service levels. An optimum can be found through an iterative negotiation process between service provider/investor and client/payer for service cost.

This framework can be applied to describe the current situation at successive levels – basin, sector, project, WUA. For each successive level, ABCDEF defines the service at the interface with the lower level.

The national assessments should contain information about the present situation for at least three levels at which there is an interface between a larger and a smaller management unit, to capture the environment in which irrigation management modernization is taking place: (i) Basin; (ii) Irrigation System ; (iii) Water User Association System.

2. Short term analysis

By using the ABCDE framework we plan to address the following types of issue:

- What is working well now, and what is not working well – for example, if we look at the agreed priorities and rules (B and C) for allocating water to an irrigation project, does this conform to what actually happens for a specified level of water availability (A), or are “ad hoc” interventions made in response to events? Does ABCDE at the WUA level result in a specified service to an individual farmer? Should this (and does this) result in equitable distribution? The simplest test of the coherence of ABCDE is that the service that a farmer *should* be receiving can be determined from a review of the service definition, and that service can be *observed* in a field visit.
- What (if anything) needs to be done now at each level to improve the definition of the service at each interface, and specifically to farmers? Are rules absent (C), or in place but not enforced (D)? Is the infrastructure fit for purpose (E)? Are financial and staffing levels adequate to ensure sustained service delivery (D)? This analysis will no doubt raise a variety of issues, and should provide the basis for an initial set of short-term (0-5 year horizon) plans to improve the performance of irrigated agriculture (F).

3. Long term analysis

To define the desired modernization concept and finalize short-term plans to improve the performance of irrigated agriculture, the ABCDE framework will again be applied to a vision that has addressed the key questions and the different policy dilemmas. In the longer term (10-20 years), and particularly for the large-scale irrigation sector, how does government perceive the nature of agriculture? What farm sizes will be required if “typical” returns to agricultural labor are to approximate typical returns in the non-agricultural sector? How far can improvements in irrigation service (and related improvements in farm incomes) bridge the gap? What cropping patterns are anticipated in the large scale irrigation sector to meet future food security needs? What are the potential impacts of climate change and perspectives for future water and energy supply for agriculture and other users and environmental performance?

The anticipated future scenarios – assuming there are significant differences to today's irrigation – will probably entail delivery of a better service to a smaller number of operational holdings and stringent environmental performance targets. The interface between operators and farmers will likely be more formal, with measurement structures, recording devices and regular recording of volumes and flow rates. What are the implications of these new scenarios for:

- Institutions – Role of Government, Users and Private Sector
- Human Resources – Capacity – Outsourcing
- Management objectives of irrigation systems and information requirements
- Resource use efficiency – water, energy and other resources
- Service provision – levels and cost of service for irrigation and other users/uses and agricultural support
- Infrastructure – flow control, Operation and Maintenance arrangements and Cost Recovery
- Financing investment and management, Operation and Maintenance
- Who invests?

4. Finalizing short-term modernization plans

Irrigation facilities, if constructed to good standards and properly maintained operate for decades. It is thus necessary for short-term irrigation modernization plans to be compatible with and support long-term evolution scenarios while avoiding evolutionary dead-ends for both infrastructure and institutional assets. In practice, short-term modernization plans would represent the initial steps of a phased longer-term plan, concentrate expenditure on those physical and organizational improvements that will contribute most to the long-term vision of the sector, with all details of both hardware and software changes carefully selected in a longer-term perspective, and include improvements on information systems and complementary research and policy actions on adaptation to climate change and green growth to prepare future modernization steps.

Meeting the irrigation needs of small farmers attempting to diversify into higher value crops is an attractive short-term proposition to ameliorate rural poverty, but within the time frame that such improvements can be achieved at any scale in the rapidly evolving economies of the region, one of the strategic questions to arise will be: how many farmers will still be there when that transformation is complete?

On the other hand, the improvements to the information base, more responsive and servicer-oriented irrigation management with better defined service and other management objectives, enhanced institutional capacity and general stewardship of water resources at larger scales will certainly strengthen governments' capacity to face today's critical problems of over-abstraction, pollution, and climate-change impacts. None of these areas of progress will in any way detract from services to the existing farmer population.