Multiple Uses of Water in Large Irrigation Systems: Conceptual approach & Cost Benefit Analysis for Operation and Management

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Summary
This paper discusses Multiple Uses of Water Services MUS from the perspective of water management on large irrigation systems (LIS) and more specifically addressing the Cost and Benefits Analysis (CBA) pertaining to MUS in irrigation addressing successively the set of questions proposed for the expert meeting.

The conceptualization of MUS in large irrigation system is intrinsically linked to the adoption of a Service Oriented Management approach (SOM). The concept of SOM when introduced in the auditing procedures clearly reveals the existence and importance of MUS practices in irrigation systems.

A FAO survey of 30 irrigation systems shows that "Single Use" is marginal (2 out of 30). Beyond irrigation the services either by design or as a result of practice, are quite diversified: productive and non productive services, this also includes social and cultural functions, ecosystem services etc... The FAO approach considers the command area of large irrigation systems as "agriculture dominated ecosystems" and has adopted the ecosystem services approach which has been formulated by the Millenium Ecosystem Assessment with the following grid:

- provisioning services, e.g. food, fibber, fresh water, energy, wild food, spices, medicinal products.
- regulating services, e.g. carbon sequestration, waste decomposition, purification of water and air, crop pollination, pest and disease control, water retention and regulation
- supporting services, e.g. nutrient dispersal and cycling, seed dispersal,
- cultural services, e.g. cultural intellectual and spiritual inspiration, recreational experiences, scientific discovery.
- and additionally, biodiversity.

Cost and Benefits Analysis (CBA) has critical implications at several levels for MUS which are considered as important for FAO interventions:

1. Water systems: to raise awareness and develop methodologies for management improvement.
2. Nation/State policy: to increase the quality of policy advice and specifically the support to country members
3. Global: global advocacy of the advantages of MUS compare to SU, especially for the most vulnerable.

For the management of irrigation systems, CBA is critical for two types of concern:

- to raise the awareness among local authorities and managers of the impacts of MUS on local population, ecosystem. This recognition can have immediate effect on the way the system is operated and improve its performance.
- to feed a consolidated stakeholder process with robust valuing methods aiming at improving the overall governance of the MUS system.

These two concerns are not addressed in the same way and with the same approach. The first one is addressed as part of the Rapid Appraisal of Performance [Step 1 of the MASSCOTE audit procedure] and thus must be by definition rapid and simple. Obviously Rapid and simple is obtained at the expense of accuracy but still this allows reaching the reasonable objective of alerting the stakeholders on MUS by providing orders of magnitude of its importance. Once this phase realized and MUS clearly recognized and established then a second phase can take place with in depth analysis, detailed survey on what use, what users, what values, what stakeholders, etc. to improve the management and governance of the system.

Looking more globally it is important to document the evidence of superiority of MUS compared to SU, and particularly for nation/state and global levels. This mapping exercise of MUS/SU must be carried out extensively. There are several dimensions to explore:

- Water use: the idea of providing different services with the same water, which is captured in the slogan "More MDGs per drop". However the use and re-use of water drops is no exclusivity of MUS therefore the specificity of MUS needs to be well documented on the basis of reliable water accounting procedures.
- Cost-efficiency: providing numerous services to a greater number of users/stakeholders with the same infrastructure is more cost-effective for investment and management than achieving the same with single use systems.
- Provision of extra services: there are ecosystems services provided by MUS systems for which little or no alternative exists at the scale of the command area, and this needs to be accounted for as added values by irrigation.
- Going beyond the services and talking of externalities, MUS obviously is an externality to the irrigation process. However as such this should not be limited to the positive side. Any process generates positive and negative externalities, therefore "water management" in irrigation systems should look at both side: the additional eco-system services and the negative impacts on natural resource basis.

Practical changes that should be done to accommodate MUS are at both local and policy levels. But the more important initial step is to document properly the MUS dimensions and impacts within command areas of LIS. FAO believes that once the advantage of this practice will be well documented then local actors and state policy makers will start to remove the silo approach that prevails for the moment for water services.

FAO believes that priority research for MUS in large irrigation system should concern the development of robust and simple methodologies to characterize CBA for each service, also to produce locally relevant references (inputs and impacts) for all possible services related to MUS. FAO would support the idea that a large MUS Irrigation system should be taken as a pilot area to investigate all issues related to MUS by a consortium of interested partners.

Global perspective on MUS

In 2009 the concept and practice of Multiple Uses of water have received for the first time high attention at global level through the technical and political agenda of the 5th World Water forum. The outputs of the forum recognize the multiple benefits of multiple uses and functions of water services including for the most vulnerable users. It stated that "multiple use systems can provide the more vulnerable users with low cost services for domestic water, water for agriculture (irrigation, rain fed), homestead, garden, water for cattle, habitats for fish and other aquatic resources and rural enterprise water supplies. The same infrastructure may be used for these services as well as for hydroelectric power and, in some cases, to aid inland waterway navigation. Multiple use systems consider also support important cultural values and functions that are essential for local well-being and livelihoods and might provide ecological benefits which include flood control, groundwater recharge, water harvesting, water purification and biodiversity conservation. Diversification of water sources and of productive activities is instrumental in increasing local community resilience and management to global shocks and risks that may result from climate or market crisis (WWF5, 2009).

MUS: a river of multiple contributors

This recognition of MUS results from different approaches which have revealed and underlined the existence and extent of MUS: the livelihood approach, the ecosystem services approach and the service oriented management approach for the most recent approaches which add to the irrigation modernization at field level and the concept of multi-purpose infrastructure.

The livelihood approach revealed how much especially poor people can benefit from using water in multiple ways from the same infrastructure to satisfy basic needs that would cost a fortune to satisfy by other means (van Koppen B. et al, 2006, Renwick M. et al, 2007).

The ecosystem services approach has been historically another source for revealing in various instances the high value of multiple uses (positive externalities) when it is threatened to merely disappear. A good example of such an ecosystem services approach is the paddy cultivation the multiple values of which have been (re)-discovered and documented when this agriculture practice has been seriously jeopardized on the solely basis of rice economic, abundant examples of that exist in Asia but also in other parts of the world. Today the approach of agriculture and wetlands are also another important stream underlining the importance of ecosystem services (Wood A. and van Halsema G., 2008).

The irrigation modernization at field level has also been historically a trigger in enlightening the case for multiple uses of water associated to the traditional surface irrigation techniques. For instance in south of France modernisation of irrigation techniques at field level in the 70s and 80s were mainly based on the shift for sprinkler or drip irrigation, with the consequences of improving dramatically water application efficiency with the consequences of cutting of the recharge of groundwater and the source of water for many other uses during the dry summer period, including domestic supply to towns. This recognition has led in the 80s to specific modernization programs maintaining a high proportion of surface irrigation at field to avoid the depletion of groundwater highly dependant on deep percolation from irrigated fields (Renault D. 1988) and which are the sole source of domestic water to some towns during summer.

Historically the first, the concept of multi-purpose water infrastructures sharing the same reservoir or the same canal have been also another important stream for the practice of MUS.

The concept of "Service Oriented Management" (SOM) is central in the FAO approach of the management modernization of large irrigation systems, it clearly has revealed the importance of the various uses and users "beyond the crop" and beyond the farmers. In medium and large irrigation systems the concept of multiple uses of water which was neglected or even sometimes rejected, has gain momentum during the last decade as the result of SOM. The necessity to improve service to users and to progressively balance the account for operation and management has led managers to cense more carefully uses and users and ultimately the potential payers of the services.

Diversifying services for agricultural uses

Many irrigation systems have been designed to supply the same water service to farmers throughout the entire command area, considering quite uniform needs for water based on assuming uniform conditions of crops, soils, local water access, etc. However, we know much better now that agricultural demands are not homogeneous. Some physical conditions differ from one location to the other; access to alternative source of water varies highly in a command area. Furthermore in most of the irrigation systems diversification of cropping patterns has largely occurred since inception time. The demands of an organic farming community, growing vegetables and flowers, will be very different from uniform rice-based smallholder systems, which are again quite different from large cotton or sugar-cane estates. Their irrigation requirements will not only be different in terms of all performance variables, but their water demands will also be based on considerable differences in irrigation techniques, labour requirements, economic returns, vulnerability to service failures, bargaining power, status, gender divisions, etc. Crop water requirements for the different crops and varieties will be the basis of any irrigation service demand, but they are not the only rationale in farmers' irrigation strategies.

It is important to remember that the demand for irrigation services even for the same type of users (farmers) is heterogeneous in time and space within a command area. The motto for modernization and SOM is then to define the right service at the right cost to each use and with each user.

Part 1 Conceptualization of MUS in large irrigation system

Service-oriented management in irrigation: revealing MUS
Service Oriented Management is a managerial approach that focuses on the supervision and control of the delivery of a service from a service provider to a service requester. In irrigation management, the latter is called a service receiver. The three pillars of SOM are the service itself and the two actors – the provider and the receiver (or user and beneficiary).

The actors of the service
In business language, receivers are considered customers or clients. In an irrigation system, receivers are these but also actors or stakeholders of the management through effective participation in the governance of the scheme. For example, in a Water User Association (WUA), farmers are not only the customers of the service, they also are involved in the decisions about it. In this sense, the farmers are also actors.

The elements of the service
The first element is the **water** itself: the water quantum or characteristic associated to the service (discharge, volume, quality, water level,...), but it is not the only important component. **Information** is also an important element of the water service. Information flows in both directions, from providers to receivers and vice versa. Users need to have information about the allocation of water, the scheduling of supply, and the measurements of deliveries. **Money** is also a critical element of the service approach. For instance the bill for the irrigation management services has to be paid by someone, now or later, for own use and for someone else. Therefore, it is a major responsibility of the management to organize effectively the flows of money for covering the cost of producing the services. Indeed, the service consists of three main flows: service = water + information + money which are intrinsically linked to each other.

The ecosystem services approach
The approach of Ecosystems services has developed significantly recently through the Millennium Assessment of Ecosystems (MEA 2003). Mankind benefits from multitude of resources and processes that are supplied by natural ecosystems, these benefits are known as ecosystem services which are grouped into four main categories:

- provisioning, e.g. food, fibber, fresh water, energy, wild food, spices, medicinal products.
- regulating, e.g. carbon sequestration, waste decomposition, purification of water and air, crop pollination, pest and disease control
- supporting, e.g. nutrient dispersal and cycling, seed dispersal,
- cultural, e.g. cultural intellectual and spiritual inspiration, recreational experiences, scientific discovery.

The concept of ecosystem services is pertinent for the irrigated command area where water is often critical for and has a strong influence on these services.

The grid provided by MEA is no doubt helpful in ensuring that all functions and roles associated to water management are considered on large scale systems. It does not necessarily define precisely the nature of the said service with the users and beneficiaries, the payers if any. This leads to the next question as to where to place the limit of “water service” from the management point of view.

Table 1. Classification of water services in a command area following the MEA grid.

Provisioning services	Supporting Services
Domestic water Food and fiber (irrigation) Water for cattle Transportation Hydropower Fuel (natural vegetation) Biochemicals and natural medicines Habitat improvements (raw materials for construction, shade,...)	Groundwater recharge Environmental flows Support to fishing Support to natural ecosystems and wildlife (biodiversity) Soil conservation
Regulating Services	**Cultural services**
Sanitation and wastewater treatment Flood protection Cooling effect on habitats. Erosion control	Social functions linked to the infrastructure and management Recreation and Tourism Cultural heritage values and landscape (ex. terrace system)

Note that as mentioned by the authors of the Ecosystems Services in the MEA report, this partition for water is not clear cut many services are relevant to two categories.

Where to put the limits of water service? Lumped *vs* atomistic services?

Looking beyond the initial design service for crop and farmers ecosystem services in a CA can be direct or indirect as conceptualized in figure 1.

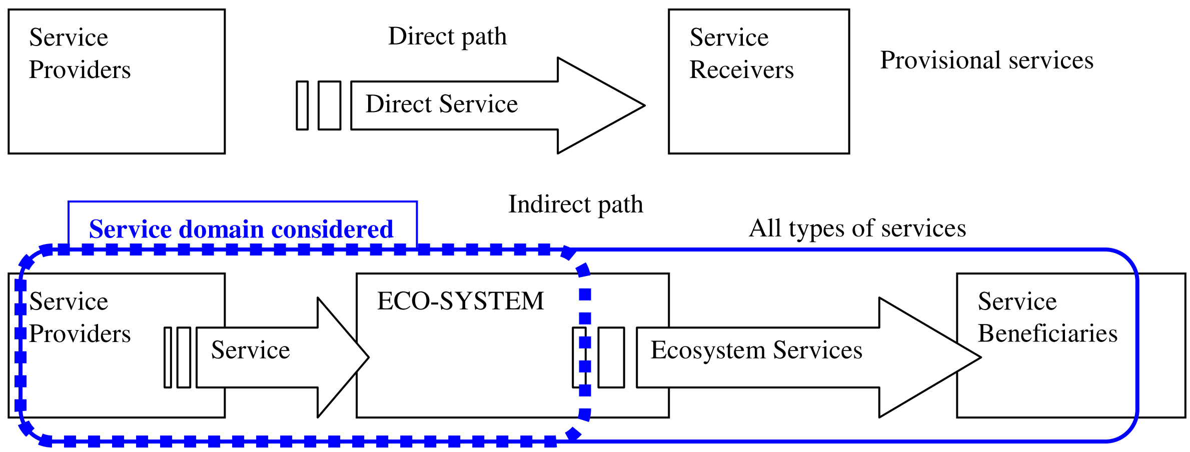

Figure 1. Direct and indirect service relationships in water systems Lumped service (blue dashed) and atomistic service (bold blue.)

Then in some cases the manager is confronted to a choice, he has to decide whether the service that his management provides is a form of lumped service to the ecosystem or goes much beyond to target each single service to users and beneficiaries. It is a question of where is the limit of the service. For instance irrigation managers can consider that they support the whole eco-system during the dry period, without looking at any specific use by users. In that case this is the overall function of support that they do consider. It is like providing coverage of water supply similarly to what the rainfall performs without looking at the disaggregated uses of water. This can be called as is **the Lumped Raw Water service concept**. This concept is discuss within the realm of irrigation itself where atomistic irrigation practices through individuals pumping have changed in practice the nature of the services that should be provided throughout the CA. This lumped raw water service that is considered as one future pathway for modernization would target servicing local units (of several hundreds of hectares) on the basis of a reliable assessment of the water balance, considering all sources of water.

More disaggregated than previous would be **the atomistic services** which would be set to serve each and every use/user within the CA. The expression “atomistic” is used in irrigation to qualify the wide spread practice of individual irrigation from tube wells or agrowells which has bloom recently throughout the CA of irrigation systems. This option considers all potential users for each service and is a much more demanding sophisticated SOM technique.

An example illustrates this point: water supply to vulnerable people within the CA who have can be seen in the following ways:

- to sustain water streams from surface canal water allowing people to have a reasonable access to water (within a 400 meters reach of their dwelling for example)
- to ensure that identified group of users have a physical and safe access to water at preset points of the canal.

The case shown in Plate 1 illustrates a limitation of the first approach in some cases. Not considering the atomistic services as access to domestic water for the near by population who have no alternative source of freshwater generates practices with high risk for the population, as shown on the left picture women washing their clothes along the steep slope of concrete banks are at risk compare to these having a fair access to raw water through steps built along the bank (right picture). In arid environment where vulnerable people leaves no one can justify himself by saying that access along the main canal is forbidden.

Another example is the access to canal water by animals with the creation of ramp to avoid accident as well as degradation of the canal banks.

Probably the future practices of MUS on Large Irrigation System will be an intermediate between lumped and atomistic. The first option although pertinent as a service to the ecosystem may not be sufficient for legal, social and managerial considerations and specific services to specific users more likely will have to be incorporated into the management, operation and governance of the system.

Plate 1. Limit of raw water service without consideration to the specific service: (left) lack of provision for accessing the canal along a very large canal in Karnataka endangering people life; (right) same command area along secondary equipped with stairs.

Conceptual approach of Multiple Services

Building upon the previous definition of services, FAO approach to MUS in irrigation systems is laid as follows:

1. First, irrigation system are taken as a Bio-Physical system and for this reason we consider them as a specific ecosystem providing ecosystem services supported by a structured intervention on water management.
2. Second the social and economical set up determines the way people use the bio-physical system. Access to natural resources such as land and water is critical for many to fulfill basic human needs. Therefore it is recognized that supplying large quantum of water in arid areas is likely to generate numerous uses of water beyond that of included by design.
3. Third an organic service relationship is considered as the core of the irrigation business with service providers and services receivers.
4. Fourth, there is the need to define clear cut physical, legal and managerial boundaries to shift away from irrigation management into water services management.

Finally the FAO approach based on the Services Oriented Management (SOM) in irrigation system management considers that:

Water management activity within the limits of their managerial boundaries takes place and impacts a command area considered from a bio-physical perspective as an agro-ecosystem providing critical ecosystem services to people, and centred on a dynamic organic relationship between provider and users of services.

<u>In short a business service model intervening on a large ecosystem serving multiple uses</u>

With this organic relationship in mind we considers that water management activities are providing services directly to users (farmers, villages, etc..) for the main provisional services or are indirectly serving beneficiaries by acting on the ecosystem processes which in turns influence the ecosystem services.

Part 2 Cost and Benefits Analysis in Large Irrigation Systems

From the FAO perspective the implications of CBA are at several levels:

1. Water systems: to develop methodologies for improving management of water systems
2. Nation/State policy: to increase the quality of policy advice and support to country members
3. Global: global advocacy of the advantages of MUS compare to SU, especially for the most vulnerable.

Specifically for the management of irrigation systems, FAO considers CBA critical for two types of concern:

- to raise the awareness among local authorities and managers of the existence and impacts of MUS on local population, and that can have immediate effect on the way the system is operated to improve its performance.
- to feed a consolidated stakeholder process with robust valuing methods aiming at improving the governance of the MUS system, water allocation and cost sharing.

This section elaborates on how FAO sees the **CBA approaches for management** and what are the methodologies used to develop further audit tools for MUS. The selection and use of specific "valuing techniques" are only briefly addressed here.

The CBA approach is part of a more comprehensive performance auditing procedure called MASSCOTE composed of 10 STEPS of analysis, in which the first Step is a Rapid Appraisal of Procedure (RAP). It addresses key steps of the process.

MASSMUS is a stepwise MASSCOTE module dedicated to multiple uses [MASSMUS= Mapping System and Services for Multiple Uses of Water Services].

Sizing the services

Three elements that one needs to have in mind to estimate the importance of a specific use and the corresponding services are (see Figure 2):

- WATER: Quantum or Share of Water Use (or Magnitude of the use) considering both water quantity and water quality
- BENEFIT: Share of the total benefits that are generated by this use.
- COST: Share of MOM cost coverage to sustain the water services.

One critical issue is how do stakeholders value the various uses of water. This question goes beyond the strict approach of benefits to include the preference of users among alternatives. Approaching the values of water uses is important but requires more in depth survey, user interviews to understand on what ground comparison among uses should be made, decision should be taken and conflict resolution proposed. Therefore there is no attempt in MASSMUS to address the values; however MASSMUS application is likely to recommend that an assessment of how stakeholder values water should be properly carried out.

ASSESSING WATER SHARES

Before going into the detailed process of accounting and evaluating the share of each specific use, it is important to gather critical information of the system under consideration. Most of the "consumptive use" of water occurs through either evaporation of land surface (soil, stream and water body) or transpiration of the canopy. It is therefore critical to start the process of evaluation with an accurate map the gross command area. Also external watersheds contributing to the runoff into the GCA need to be delineated to account for precipitation contributions. Activities that are localized (not associated to a large area) need also to be identified on the GCA map.

One difficulty: mapping the groundwater system

Probably the more difficult task is to map the groundwater system to which the GCA is associated. What and where are the boundaries of the aquifers? What lateral transfer should be considered? Physical properties and water fluxes at boundaries are often not accurately known. What is often known is the water table elevation over time. It gives clear indication of the long term changes and sustainability of water resources in the area but this is not enough to calculate the water balance.

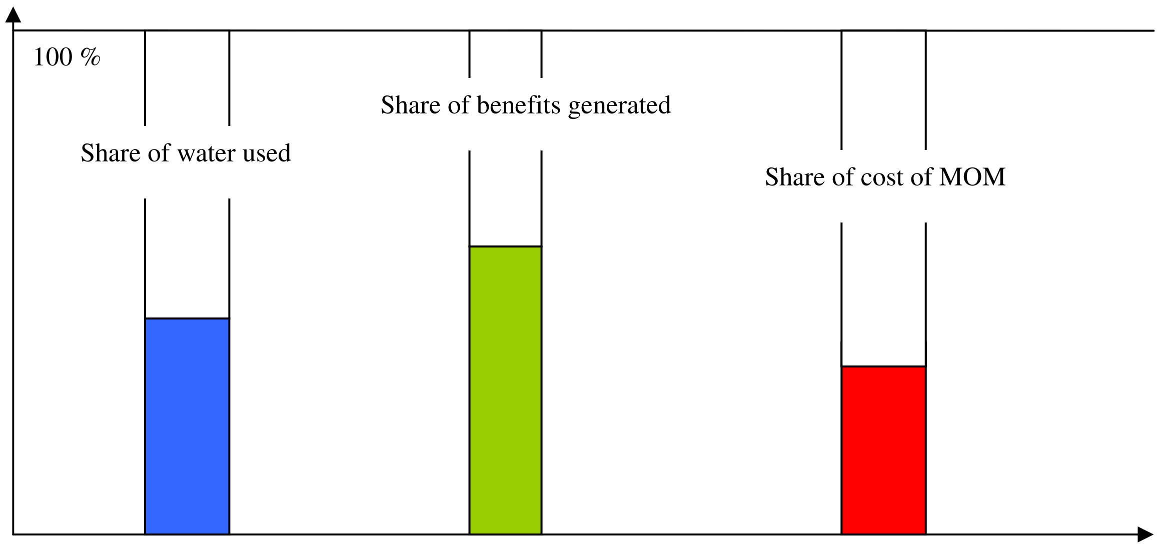

Figure 2. The 3 main dimensions of a Water Use in a MUS irrigation system.

One issue: shares from water bodies with multiple services/benefits

Some consumptive uses are unambiguously associated to one single use like crop production, or homestead garden, natural vegetation, although they might yield to several beneficial outputs.

Some consumption corresponds to several uses or function of water and it is not straightforward to partition the consumption according to these various associated uses. This is in particular the case of water bodies such reservoirs, lakes, tanks etc... They may serve several purposes: storage of water for the dry season, fisheries, recreational activities, tourism, wild life, flood protection, etc... There are no simple rules to partition the water evapotranspired from a reservoir. Criteria that can be used to weigh the consumption are:

- numbers of beneficiaries, households, jobs
- monetary value generated per use
- environmental values.

Impact of water quality

The return of water into the system after some use may occur with deteriorated quality (pollutant, thermal change...) and that has to be considered when water accounting is processed as a whole.

ASSESSING the BENEFITS

There are some hurdles along a benefit analysis. Several points are to be considered. First, decide about the criteria reflecting the benefits of water use:

- o Product generated by the activity supported by this water service
- o Jobs/employees
- o Number of households served
- o Monetary and non monetary values (social, culture, etc..)
- o Health impacts
- o Environmental values
- o Frequentation of a particular spot for cultural, social or recreational purpose

One issue is to address the benefits associated to the non-provisioning services in a way they can be compared to the provisioning services.

Another issue here is to use as much as possible comparable criteria to allow estimating the "share" of the service. When this is not possible then we have to resort to qualitative comparison (important- medium-low important).

Second decide about the evaluation method to be used for estimating actual:

- Gross production supported by the service (Crops Fish)
- Additional benefit generated by the service (ex. irrigated vs rainfed, Or with/without)
- Cost of a technical substitution to produce the same service and impacts.

Third consider the availability and accuracy of data for the selected criteria.

Fourth consider that references for units of benefits are often lacking (value of homestead garden, raw water in situ, raw domestic water supply, environment,..).

As part of a rapid appraisal method, time constraints, pragmatism and data availability are the elements to decide on the methodology to evaluate the benefits.

Valuing techniques

The economic sphere provides us several valuing techniques which are relevant for estimating the benefits of any particular services. A list of the main techniques is presented in Table 2, with examples and comments relevant to MUS.

An example of the kind of question related to the method to be used for benefit analysis: How to estimate the value provided by the shade of the trees as shown in Plate 2? A substitute cost method would partially work for estimating the value of house cooling through air conditioning but won't work for the homestead garden itself. Probably the best option would be the Hedonic Pricing Method which would estimate the difference of real estate value between two similar houses, one with the other without big trees.

Table 2. Valuing Techniques and applicability for CBA in MUS systems (After Pendse, 2009).

Method	EXAMPLES	Comments
Market Price Method Estimates economic value for environmental goods/services that are bought and sold in commercial markets	Value of raw materials, such as rope, we can look at the economic benefit generated to producers and consumers from the sale of the rope.	Values are well defined but this is only valid for market goods.
Productivity Method Estimates economic values for environmental goods/services that contribute to the production of goods/services that are bought and sold in commercial markets.	To estimate the value of water in irrigated crop production, we look at the productivity of water in regards to the profit made from the crops.	Relatively basic data are often available. Limited to goods /services related to commercial goods. Production costs can be uneasy to evaluate.
Hedonic Pricing Method Estimates economic values for environmental services that directly affect market prices of some other good.	To estimate the value of a homestead garden we can look at variation on housing/real estate prices that reflect the value of specific attributes.	Actual consumer behavior and property values are usually good indicators. Limited to places where real estate market exist.
Travel Cost Method Estimates economic values for environmental goods/services associated with environmental sites by assuming the value is reflected in willingness to pay to travel to visit the site.	To estimate the value of a water body (lake, tank), which has a tourist value.	Maybe difficult to collect required data.
Cost Avoided Substitute Cost Method Estimates economic values for environmental goods/services based on costs of damages avoided, cost of replacing goods/services, or costs of providing substitute services.	To estimate the value of flood control of an irrigation canal, one could use the amount it would cost for a substitute-building a reservoir or levee. One could also estimate the value by calculating the value of property protected. This can be found in property value data, or for a simpler version, lost profits from crop yields from flooded land.	Less data needed. Work best when there is an exact substitute.
Contingent Valuation Method Estimates economic values for environmental goods/services by asking people to directly state their willingness to pay based on hypothetical situations.	To estimate the value of animal habitat, people can be surveyed to see their willingness to pay for land conservation in a specific hypothetical scenario.	Widely accepted method but cumbersome and sometimes imprecise.
Benefit Transfer Method Estimates economic values for environmental goods/services by using benefit estimates from previous studies.	To estimate the economic value of water quality in a stream, you can use values determined in other studies from similar locations, context	Depend on the availability and quality of other studies.

The issue of References: building up a database

A pragmatic standpoint has been adopted by FAO considering the issue of references data. MASSMUS audit method is initially provided with a database of references extracted from the compilation made by Renwick et al and from other sources. Users are also given the choice to insert their own data and decide about which one to be considered in the analysis. The RAP-MUS worksheet database will be progressively enriched as far as MUS studies will be carried out on irrigation systems. Therefore an update of the worksheet will be performed regularly to incorporate more contextualized references.

MASSMUS rapid methodology for mapping benefits

Bearing the above in mind FAO considers that a benefit analysis should be split into two separate approaches. A comprehensive and congruent benefit analysis of the various water services is beyond the scope of MASSMUS rapid exercise. Therefore what should be the objective for MASSMUS is to map down the order of magnitude of the benefits and produce some useful recommendations for further refined investigations.

1. Initial mapping of the order of magnitude of the benefits.
2. Recommendation to carry out in depth survey of benefits, beneficiaries and values associated to the main identified services as part of the modernization program.
3. Thorough analysis of the benefits per services and the values for the stakeholders.
4. Indications on how the governance of the MUS system should be based.

Plate 2. Perennial vegetation supported by irrigation from adjacent fields KOISP Sri Lanka

ASSESSING THE COSTS per service

In order to produce the service that has been decided/agreed upon with users, managers need to mobilize a set of various resources or inputs (water, staff, energy, office, communication and transport). These resources/inputs all have a cost. This section attempt to clarify the issue of inputs/costs for operation *vs* outputs/services as part of the overall management activities and as a fundamental element of the elaboration of a modernization process.

Investigating inputs and costs is important for:

- setting the service levels, in particular in exploring options for different types of services and associated costs;
- water pricing to users, in order to propose a set of charging procedures that takes into account the real cost of service production;
- improving performance and cost-effectiveness, by investigating technical options for maximizing operation effectiveness (better allocation of existing resources, automation, etc.).

The services along an irrigation infrastructure for which costing need to be carry out are:

- irrigation services which may include several level of services if needs be.
- other services concomitant to irrigation
- and the special operation for services during off irrigation period of the year.

Cost to provide raw water service

A good example of raw water provision is given by the Neste System of the Compagnie d'Aménagement des Côteaux de Gascogne (CACG) in France. The Neste canal is a very peculiar trans-basin feeder aiming at supplying on a very short reach the head of many radiating rivers (see Plate 3) in the near by watershed which, due to a geological uplift, is disconnect from the high Pyreneans mountains and as such very dry during summer period The cost to provide raw water service and the specific services of the CACG are to a large extent reflected in the water pricing which is shown in table 3. The charging for raw water services in the river varies from 0.015 Euros/m3 for irrigation to 0.023 and 0.024 Euros/m3 respectively for urban and industrial raw water. The specific service for irrigation pressurized water at field level is charge to farmers at 0.15 Euros/m3.

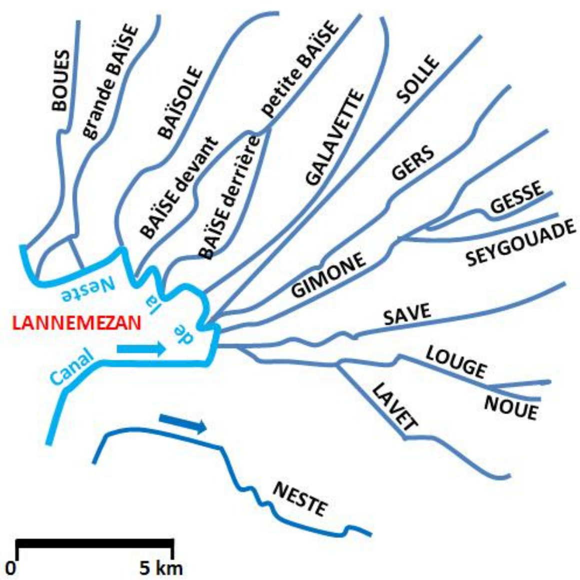

Plate 3. A sketch of the Canal de la Neste, withdrawing water from the Neste river to supply nearby dry watershed.

USERS and SERVICES for MUS

The task of the manager in dealing with all these uses of water is basically to move from informal practices into formal services provision activity with well identified users. The push here is thus in two complimentary directions:

1. Identify the users of water services and their possible representatives
2. Characterise with the users the services to be provided and the means to contribute to the associated cost.

Table 3: Water Pricing Levels in Euro per cubic meter charged by the CACG (after J. Guerrin 2009 citing H. Tardieu, 2009)

Services - Uses	Price (€/m3)
Irrigation (raw water available in the river)	0,015
Irrigation (pressurized raw water brought to the field)	0,15
Urban raw water	0,023
Industrial raw water	0,024

Feedbacks from field survey on MUS in LIS

Single Use Systems are marginal

A set of 30 medium to large irrigation systems mostly in Asia, totaling a Gross Command Area (CGA) of 4.2 Million ha, probably hosting more than 15 millions of inhabitants is considered. 28 of these irrigation systems have been directly investigated by FAO since 2004 through auditing procedures RAP and MASSCOTE.

Out of 30 systems 18 are considered Multiple Purpose Reservoir while 6 systems are Multiple Purpose Network. Only 2 systems are classified as Single Use of Water, 2 Systems are in transition after their recent construction and 26 are true MUS systems. The services reported are shown in Table 4.

Table 4. Multiple services reported on the 30 systems' survey

Type of service	Service	Number out of 26 MUS
Provisioning	Irrigation	30
	Domestic water	24
	Animals	12
	Habitat improvements	9
	Homestead garden	3
Supporting services	Environmental flows	12
	Fishing	9
Regulating services	Flood protection	10
Cultural services	Cultural sites - Recreation	4

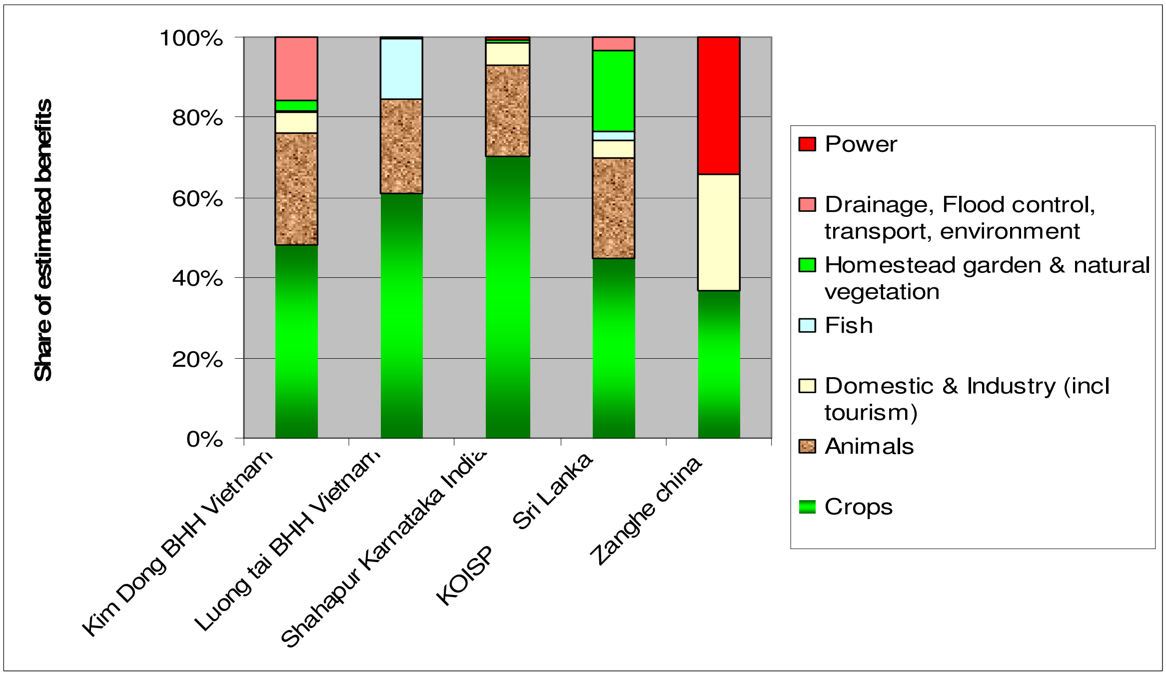

Figure 3. Partition of benefit shares of the provisioning services for 4 MUS systems

It is noteworthy to underline that the extra value generated by MUS compare to crop production ranges from 42 % for Shahapur up to 271 % for Zanghe, also to notice the importance of animal production in 4 systems out of 5 (animal representing a rather constant share of 25 % of the total value generated).

Part 3 Comparative advantage of MUS

Looking more globally it is important to document the evidence of superiority of MUS compare to SU, and particularly for nation/state and global levels. This mapping exercise of MUS/SU must be carried out extensively. There are several dimensions to explore:

- Water use: the idea of providing different services with the same water, which is captured in the slogan "More MDGs per drop". However the use and re-use of water drops is no exclusivity of MUS therefore the specificity of MUS needs to be well documented on the basis of reliable water accounting procedures.
- Cost-efficiency: providing numerous services to a greater number of users/stakeholders with the same infrastructure is more cost-effective for investment and management than achieving the same with single use systems.
- Provision of extra services: there are ecosystems services provided by MUS systems for which little or no alternative exist at the scale of the command area, and this needs to be accounted for as added values by irrigation.
- Going beyond the services and talking of externalities, MUS obviously is an externality to the irrigation process. However as such this should not be limited to the positive side. Any process generates positive and negative externalities, therefore "water management" in irrigation systems should look at both side: the additional eco-system services and the negative impacts on natural resource basis.

Part 4 Practical changes and research needed

Practical changes that should be done to accommodate MUS are at local levels and policy levels. But the more important one and the urgency is to document properly the importance of MUS in serving people especially the more vulnerable, ultimately addressing more MDGs. FAO believes that once the advantage of this practice will be well documented and disseminated among the irrigation community, the state departments and the politicians, then the changes for MUS will be progressively implemented. Local studies reinforced by a set of world wide case studies on the importance of MUS on irrigation systems and on the ways to operate a MUS system based on the analysis of existing experiences are the key for changes.

FAO believes that priority research for MUS in large irrigation system should concern the development of robust and simple methodologies and produce references for all the possible services related to MUS. FAO suggests that a large MUS Irrigation system should be selected as a pilot to investigate all issues related to MUS by a consortium of interested partners.

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