FINANCING IRRIGATION

FRANÇOIS BRELLE[1] ANDETIENNE DRESSAYRE[2]

ABSTRACT

For the last ten years, food security has been coming back on the centre stage as a major challenge for the next decades. Financing irrigation and drainage is really a broad issue, of which each main component requires a specific analysis: investment, operation, maintenance, renewal, rehabilitation and modernization. Questions, and thus answers, differ for funding infrastructures and for paying for water service. Financing setting up, rehabilitation or modernization, operation and maintenance of systems for collective irrigation and drainage are considered.

The present paper aims to highlight the main lessons learnt from the past, to analyse the present constraints and trends, and to propose in which directions to steer for so as to take up the challenge of a sustainable increase in production of more and better food while better preserving ecosystems and natural resources.

It asks the question of what should be the contribution from states or public authorities, in other words from all taxpayers or citizens. What can be the role of private sector, either for financing, building and/or operating, in which cases and under which conditions? What should and can be the contribution of the water end users – and end payers. And which other conditions should be fulfilled for the various financing mechanisms to succeed, like the possible solidarity between usages according to their respective ability to pay?

RESUME

Ces dix dernières années ont vu la question de la sécurité alimentaire revenir au-devant de la scène comme un défi majeur pour les prochaines décades. Financer l'irrigation et le drainage est véritablement un sujet très vaste, dont chaque composante requiert une analyse spécifique: investissement, exploitation et maintenance, renouvellement ou rénovation, modernisation. Les questions, et donc les réponses, varient selon qu'il s'agit du financement des investissements ou du paiement pour le service de l'eau. Ces questions sont abordées pour les systèmes collectifs d'irrigation et de drainage.

Le présent document a pour but de mettre en évidence les principales leçons à retenir du passé, d'analyser les contraintes et tendances actuelles, et de proposer les directions à suivre pour relever le défi d'une amélioration durable de la production alimentaire, tant en qualité qu'en quantité, tout en préservant mieux les ressources naturelles et les écosystèmes.

Il pose la question de savoir quelles doivent être les contributions financières relatives des états – ou de leurs agences ou établissements publics, en d'autres termes des citoyens par l'impôt. Quel peut être le rôle du secteur privé, que ce soit pour financer,

[1] Vice-President ICID - Président, AFEID, Directeur Technique Ingenierie de la Société du Canal de Provence, Le Tholonet, CS 70064, 13182 Aix-en-Provence Cedex 05, France, Tel: +33 4 42 66 70 00. E-mail: afeid@irstea.fr, francois.brelle@canal-de-provence.com

[2]Administrateur AFEID, Directeur de Projets, BRL, 1105, av. Pierre Mendès France, BP 94001, 30001 NÎMES CEDEX 5, France, Tel : +33 4 66 87 50 85. E-mail: etienne.dressayre@brl.

construire ou exploiter, dans quels cas et sous quelles conditions? Quelle doit être la contribution des usagers de l'eau, payeurs in fine? Et quelles autres conditions doivent être remplies pour que les divers dispositifs de financement réussissent, comme par exemple la solidarité entre les usages en fonction de leurs capacités financières respectives?

INTRODUCTION

After having not been considered as a top priority during last two decades of 20th century, compared for instance to access to water and sanitation, food security has been coming back on the centre stage as a major challenge for the next decades.The high level panel on the post-2015 development agenda, in his report sent to the Secretary General of the United Nations on May 30th, 2013, stated that ensuring food security and good nutrition be considered among major goals (ranked 5th), along with ending poverty and achieving universal access to water and sanitation. The panel suggested that 'increase agricultural productivity with a focus on sustainably increasing small holder yields and access to irrigation' be considered as a target.

Even if, by improving its yields, rainfed agriculture should largely contributeto increase food production, irrigation remains undoubtedly among the main ways to achieve this goal.By allowing farmers to master how and when giving water to the plants, irrigation is indeed the best tool for securing the production against hazards of climate, and as such for guaranteeing not only quantity but also quality, which is essential for good nutrition. But other uses must be considered as well:water needs forenvironment have to be better satisfied;water for drinking and for hygiene must be made more available for more people. And climate changes will result in many regions in lower or more irregular rainfalls, and thus river flows. Every usage will be compulsorily thriftier, and thus farmers will have to make 'more crops with fewer drops'.

On the other hand, increasing food production requires good quality land. Maintaining such a quality may require drainage, either for preventing excess in salinity or for gaining arable land, taking care, of course, of aquatic ecosystems, essentials to preserve biodiversity.

It remains strategic to extend irrigated areas and thus to create new irrigationsystems – and drainage if necessary – to restore or improve existing schemes so that they will offer a better service than at their origin when water resource was more available. It will be necessary to set up means and methods for ensure efficient and reliable water service.Farmers have to be given knowledge and proposed affordable tools for being more water efficient at farm level. Researchers must intensify their works on how produce more, more sustainably and with less water.In other words, irrigated agriculture involves large and long term investments, of which it must bear the corresponding costs, including water resources.

Financing irrigation and drainage is a reallybroad issue, of which each main component requires a specific analysis: investment, operation, maintenance, renewal, rehabilitation and modernization, ancillary services like training… Questions, and thus answers, differ for financing infrastructures and for paying for water service. Less costly infrastructures often generate more current operation and maintenance expenses. Technology costs more in investment, but allows significant savings of water.

The present paper will tryto highlight the main lessons learnt from the past, to analyse the present constraints and trends, and to propose in which directions to steer for so as to take up the challenge of a sustainable increase in production of more and better food while better preserving ecosystems and natural resources.

Financing setting up, rehabilitation or modernization, operation and maintenance of systems for collective irrigation and drainage are only considered. Properly financing know-how and equipment at field level, especially as regards small and very small farms, is a condition for success for collective systems and is therefore a key issue. But mechanisms for individual investments, especially in case of large estates, are more likely comparable to those found in any economic activity. Training issue could be addressed without being necessarily linked to infrastructures. These are major issuesin themselves and thus should be addressed separately.

I & D WORLDWIDE: TECHNICAL AND FINANCIAL FIGURES

To properly setup the frame, the main figures that characterize irrigation and the related challenges are given in the tables below.

Table 1. Areas cultivated,irrigated and drained in the world(million ha)

Region	Total arable area	Irrigated area	Sprinkler irrigation	Drip irrigation	Drained area
Europe	280	22.3	3.50	0.59	49.2
Middle-East & North Africa	109	29.9	0.64	0.11	11.2
Sub-Saharan Africa	178	5.5	0.92	0.37	0.26
North America	253	32.1	13.40	1.85	62.2
Central & South America & Caribbean	123	12.4	2.00	0.15	2.62
North&Central Asia	34	11.3	8.20	0.07	5.4
South & South-East Asia	137	63.9	0.01	0.01	25.9
East Asia	311	114	6.60	4.00	29. 9
Oceania	45	3.2	0.52	0.19	2.2

Source:ICID Database

Table 2. Investments in irrigation infrastructures (billion US$ – 2005 value)

Region	1950-1960	1961-1970	1971-1990	1991-2000	2001-2010
Europe	n.a.	n.a.	n.a.	n.a.	n.a.
Middle-East & North Africa	3.11	4.72	2.76	2.81	1.31
Sub-Saharan Africa	1.33	3.82	2.38	1.53	0.53
North America	n.a.	n.a.	n.a.	n.a.	n.a.
Central & South America & Caribbean	n.a.	n.a.	n.a.	n.a.	n.a.
North & Central Asia	n.a.	n.a.	n.a.	n.a.	n.a.
South & South-East Asia	9.26	11.69	16.84	6.33	1.25
East Asia	5.8	22.53	10.91	9.11	1.32
Oceania	n.a.	n.a.	n.a.	n.a.	n.a.

Source: FAO: http://www.fao.org/fileadmin/templates/solaw/files/thematic_reports/TR_17_web.pdf

Table 3. Added valueof agricultural production (billion US$ – 2005 value)

Region	2006	2007	2008	2009	2010
Europe	339	392	442	386	338
Middle-East & North Africa	139	157	145	146	155
Sub-Saharan Africa	122	142	99	97	94
North America	197	210	216	174	186
Central & South America & Caribbean	133	178	219	208	243
North & Central Asia	14	18	22	21	23
South & South-East Asia	331	417	455	486	600
East Asia	371	459	574	574	678
Oceania	32	20	25	22	27
TOTAL	1677	1993	2195	2116	2344

Source: The World Bank: http://data.worldbank.org/indicator/AG.LND.IRIG.AG.ZS

Table 4. Average unit costs or irrigation projects (US$/ha – 2000 value)

Region	New projects	Rehabilitation projects
Middle-East & North Africa	8 780	8233
Sub-Saharan Africa	14 455	4582
South Asia	3 393	1008
South-East Asia	9 709	1840
East Asia	8 221	1990
Central & South America	4 903	3432
All regions	8 213	1993

Source: FAO, 2005

SOME GUIDELINES FOR ADDRESSING THE ISSUE

Stakes of an efficientand sustainable irrigation are not only properly feeding the world, but also contributing to economy, and financing it must be considered accordingly. On the other hand, irrigated agriculture is not industry and what has to be taken into account is that infrastructures are very long term investment, most often contributing to land development. They benefit far wider than to farmers only as they boost economy at larger scale. In South Africa for instance, *'the National water Policy (NWP) recognizes the importance of agricultural water use for rural economic growth and development'*(Backeberg, 2006). It is therefore necessary to set up appropriate long term funding mechanisms, involving stakeholders beyond agricultural sector limits.

Moreover, what has to be taken into consideration is that:

- *'economic risk is pervasive in agriculture due to climatic variability and irrigated agriculture is no exception'* (Shahbaz Khan et al., 2009);
- investing in irrigation infrastructures requires such a huge amount of money that they should be maintained as long as possible, so as to prevent the owner – government, public authority, water user association – from having to re-invest for rehabilitation. It is therefore necessary to include a long term renewal in the initial financial equation;
- head structures are most of time not delivering any individual service. Their amortization depends therefore on development of distribution network which only allows billing the water service. Moreover, amortizing the whole investment requires that developing the irrigation system is accompanied by an appropriate agricultural development;
- there is a link between capital expenses, efficiency, and maintenance costs. There is a link between technology and financing (Van Bentum, 1993): concrete lined canals cost more than earth canals, but their current maintenance is easier and less expensive. Fixed speed pumping stations are cheaper than variable speed ones, but consume more energy. Water meters make the network cost higher, but they contribute to better service billing and encourage water savings;
- irrigation schemes and water allocation must be adapted to the needs of the farmers, which aresubject to evolutions according to the context and the market. Collective water may be suffer the competition from other available water resources. All these issues make variable the part of financing which can be expected from the users;
- what is billed is mainly the water service and the wording 'water pricing' or 'water tariff' is not actually relevant, with the exception of what should be paid for the resource itself (conservation, prevention from pollution);
- most of water users are ready to pay for good quality water service, i.e. providing water in required quantity, at the right time, sometimes with enough pressure and with the appropriate quality. Such a good service requires that systems are well operated and kept in good condition trough proper current maintenance. Furthermore, efforts for agricultural development would be useless if water service is not thoroughly efficient;

- getting money back from the water users, i.e. farmers, presupposes that their income allow them to pay. But market prices fluctuations are a major thread on farming economy. Covering real full cost from irrigation water users may therefore be not sustainable, with the exception of small scale systems serving high added values productions;
- hydraulic systems and water services are often designed and developed for a single usage, i.e. irrigation, although people in the command area need and use water for different purposes, or the system configuration could allow producing for instance hydro-electricity. Recognize the reality of multiple uses at design stage and for organizing the service would prevent from misusing of the system(Renault, 2009), and could even improve the sustainability through the financial solidarity which can be set up between low and high added value uses.

All issues developed hereafter will therefore consider:

- what should be the contribution from states or public authorities, in other words from all taxpayers or citizens;
- what can be the role of private sector, either for financing, building and/or operating, in which cases and under which conditions;
- what should and can be the contribution of the water users;
- how to address the issue of financing water resource conservation;
- which other conditions should be fulfilled for the financing mechanisms to succeed.

FINANCING INFRASTRUCTURES & LONG TERM MAINTENANCE

Economic and social backgrounds of investments in irrigation infrastructures

Irrigation infrastructures, like other large hydraulic systems, are generally contributing to land development, and as such depend upon national policies and development strategies. They are therefore usually financed by governments, acting in their own name or giving public institutions the responsibility for planning, design, construction and operation.

Furthermore, many infrastructures are actually multipurpose. More upstream are the structures, more uses may benefit from them: dams are most often equipped so as to produce hydropower, and the water resource they contain is as far as possible considered for several usages like urban supply, irrigation and industry as well. Transfer aqueducts are also sized so that water they convey could be given to arable land, cities and industries.It is only at 'production'level (distribution networks, pumping stations, treatment plants), that each use is served separately. It is therefore not easy to identify which share of the costs should actually be bared by each usage.

The question may be raised whether every usage must pay the same price for water service from a same hydraulic system. As a matter of fact,service constraints vary according the usages, making different for each of them the costs for infrastructure, operation and maintenance. On the other hand, water, as an input, has a different added value according the process it is used for, and therefore the price for the service could vary accordingly.

As far as irrigation infrastructures are concerned, a major question must be raised:'*Who benefits from irrigation development and who should pay the cost?*'(Bhattarai et al., 2007). In India, the answer, according the referenced paper authors, is that '*about two thirds or more of the benefits from irrigation development have been accrued to the non-farm sector*'. One thus could conclude, like the said authors, that this '*should be considered in developing a rational cost recovery and*

irrigation financing policy'. This would result in mechanisms which allow irrigators not paying the full costs of irrigation, by mobilizing solidarityfrom the society at proper level, as for instance '*benefits and costs measured from a national perspective are often misunderstood by […] local interests, which can adversely affect project support*'. (Knapp and Summers, 2002)

Irrigation projects do more than bringing water to farmers. They may be the major way to maintain – or re-settle – people in rural areas, giving them an economic activity.They therefore contribute to livelihood and prevent the rural populations from poverty, and thus from flying towards big cities suburbs, along with well-known increase of poverty, unemployment and criminality. Furthermore, what must be recalled is that these rural areas will supply food to these cities only if they are enough populated to provide the necessary farming manpower.

What also must be kept in mind, even if often not given a high priority, is that infrastructures are getting old more or less, whatever current maintenance level is carried out, and therefore lose efficiency with time. The question could thus be, after 50 years or more, either how to refurbish or renew them or whether it would better give them up and build something else adapted to new needs. Whatever option is chosen, financing it should result from appropriate asset management policy, which should be defined from the origin of the projects.

Therefore, initial investment and physical asset management financing should not be considered separately. This will result in solutions which include both bearing the cost of initial installation of the project and necessary amortization / renewal costs. Irrigation projects, especially head works, have among the longest lifetime.Short term solutions are therefore not relevant.

Usual involvement of states and/or Public Authorities, usual support from donors

As stated above, setting up new irrigation projects, or rehabilitating / modernizing of schemes is actually a component of economic policy, and there is a long history of financing such projects within national or state budget, in numerous countries all over the world. Improving agricultural production, especially food, is in most cases a national issue, which justifies that governments are drivers as regards investments in hydro agricultural infrastructure projects. The challenge may be to increase the gross national product or to improve the self-sufficiency in food production.

Often, other reasons invoked for investing with public money are the needs for preserving rural territories andfor helping farmers to face uncertainties of food market (Ward, 2010). Another factor can justify – or at least explain – that public funding is now mobilized for irrigation project modernization: old systems have not been designed for maximizing the added value of the volumes of water withdrawn from rivers or aquifers. Current and expected resource scarcity due to climate changes, increase in competition between usages, and ecosystems conservation for biodiversity are leading public authorities to improve efficiency of hydraulic systems. In France[3], for instance, Water Agencies currently finance old irrigation infrastructure modernization projects aiming at improving their efficiency and thus reducing the withdrawn water volumes.

[3] French water policy is defined and coordinated at the national level but is decentralized at scale of large river basins, where six water agencies, as public agencies depending on the Ministry for Sustainable Development, are entrusted with the tasks of helping protecting water resources, in both terms of quality and quantity, and aquatic ecosystems. They collect taxes on withdrawn volumes and finance measures and projects aiming at efficient management of water and aquatic environment.

But above all is the need for coordination, planning and financing collective systems. Whatever the size, from small project for irrigating less than one hundred hectares to large schemes with command areas of several tens of thousands of hectares, these tasks can be achieved only with the help of public authorities, or by the said authorities themselves for the largest projects.

As far as donors are concerned, which occurs in most cases in developing countries, their contribution is subject to the economic impact of the investment / rehabilitation project.According to Pr. Franck A. Ward (2010), *'Sustainable economic and financial performance for irrigation infrastructure investment ultimately comes from additional incomes earned (by farmers) or from added net national economic benefits resulting from that investment'.* The question may be which should be the extent of this impact. This question is similar to the one presented above. This criterion may vary according funding institutions' policy, but the following requirements are usually to be fulfilled:

- planning phase through collaborative processes;
- project compliant to regionally agreed approaches for sustainable water management;
- direct and indirect net economic benefits to the country(or to the region);
- broader net benefits to environmental, social, recreational and cultural values.

Possible role of private sector

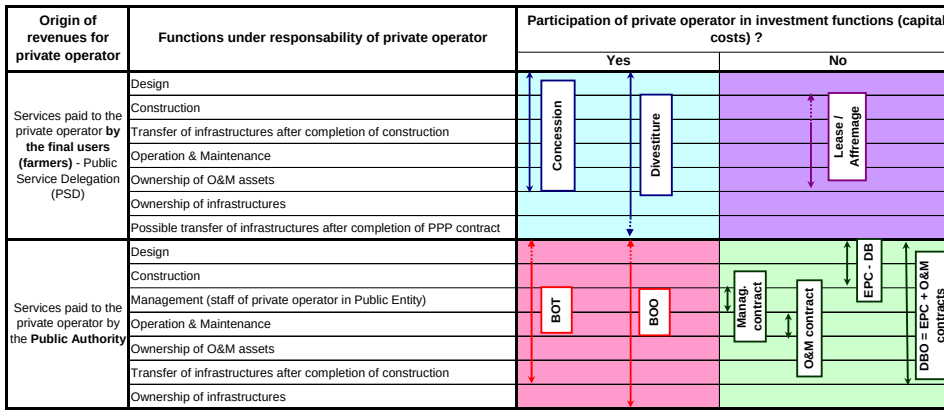
The recent development for irrigation services brings obvious opportunities but also challenges that have to be understood and tackled for involving the private sector in financing irrigation development and/or management. A potential does exist, but investing is risky, and private sector involvement in irrigation may be sought only under the following conditions:

- economic viability of the project and limited unforeseen: actual agronomic potential and land availability, good access to market (transport infrastructure, agroindustry…),sufficient water resource;
- appropriate legal framework as well as favourable political and financial context.

Private sector involvement in investment can be a way to facilitate achieving funding patterns, as seen in Guerdane Project in Morocco where the project could not be done with public funds only. Furthermore,obligations made by the contract as well as operator's business objectives may result ina 'virtuous cycle': better collection of irrigation service fees, which relies on good quality of water services through better management of operation, and which contributes tomore sustainable running of the scheme through better management of maintenance.

Generic terminology 'Public Private Partnership' (PPP) actually covers a broad typology of private involvement patterns. Figure 1 illustrates the diversity of arrangements that can be made according to three main criteria:

- origin of the income for the private operator,paid by the final users or by the contracting public authority / agency;
- different functions – and related risks – thatprivate partner will take responsibility for through the contract (design, construction, etc.);
- the share of contribution of the private partner to the capital expenditures (CAPEX).



Legend:
Differences between lease and affermage is in the rent paid to the Contracting Authority (lease fees: fixed rent / Affermage fees : varying on revenues collected from users)
BOT : Build Operate Transfer
BOO: Buid Operate Own
Manag. Contract : Management contract
O&M Contract : Operation & Maintenance contract
EPC / DB : Engineering Procurement Construction (also called Design Build)
DBO : Design Build Operate (contract with EPC + O&M together)

Figure 1. Main Public-Private transaction models according origin of Operator's income

Most common transaction models involving private stakeholders in investment are as follows:

- concession (public service delegation): the private operator is required to contribute to CAPEX, to carry out operation and current maintenance and to fund long term maintenance and renewal. Its revenues come from fees billed to from final users (farmers). This is the most risky arrangement for the private partner. Concession is by itself a performance based contract which is probably the best way to achieve sustainability in investment as well as in physical asset management. French Regional Development companies, set up in 1950s, Guerdane Project in Morocco and initiatives in Brazil, Peru and Egypt are grounded on this model. According to the functions transferred to contractor, this kind of contract may be called DBOT (Design Build Operate Transfer), or DBTO (Design Buid Transfer Operate), or any other acronyms that will indicate the functions transferred to the private contractor;
- PFI British model (Private Finance Initiative): The public authority / agency signs a contract with a private consortium (knows as Special Purpose Vehicle - SPV), formed for the specific purpose of providing the PFI, whose funding is used to build the facility. SPV is responsible for operation and maintenance and is paid a performance based rent over the course of the contract, i.e 20 to 30 years. Thiskind of contract, very controversial, has often been used for public facilities and services such as hospitals and highways, but not actually for water service.

Giving a private company / consortium the most significant responsibility (trough concession for instance) should be a good way towards sustainability, as the contractor in interested in the financial results of the contract, and therefore in the performance of the service, on which the farmers' willingness to pay relies. But this is also the most risky for the contractor.

These four major issues must be considered in PPPs(European Commission, 2004):

i. The variable duration of the relationship, mainly depending on the contribution of the contractor for investment, and thus often fairly long (more than 10 years, possibly up to 20 or 25 years)involving cooperation between the public partner and the private partner on different aspects of a planned project;

ii. The method of funding the project, in part from the private sector, sometimes by means of complex arrangements between the various players. Nonetheless, especially for irrigation projects, public funds - in some cases rather substantial - must be added to the private funds;
iii. The important role of the economic operator, who participates at different stages in the project (design, completion, implementation, funding). The public partner concentrates primarily on defining the objectives to be attained in terms of public interest, quality of services provided and pricing policy, and it takes responsibility for monitoring compliance with these objectives;
iv. The distribution of risks between the public partner and the private partner, to whom the risks generally borne by the public sector are transferred. However, a PPP does not necessarily mean that the private partner assumes all the risks, or even the major share of the risks linked to the project. The precise distribution of risk is determined case by case, according to the respective ability of the parties concerned to assess, control and cope with this risk.

This clear risk sharing depends on to the context and may associate farmers, for instance through the water service contracts. This sharing must make the project attractive for each party, in a win/win perspective.

The authors want to point out another relevant issue: the private partner is submitted to incentive remuneration, either directly through the irrigation service fee or through the achievement of performance indicators. Both of them insure the willingness of the partner to achieve the highest level of quality of water service.

Last but not least, it has to be stressed that it must be set out how to securing the operator's source of income, by guaranteeing for instance that no competing service – either public or private – would significantly change the economic balance of the project.

Contribution of the water users to investment

Referring to usually put forwardprinciple of 'full cost recovery', water users should be billed their contribution to investment. But is such a principle reallyrelevant? What can be asserted is that food prices may not be high enough for farmers – especially small holders in developing countries – to make a minimum profit after having paid all the expenses necessary for their production. Prof. Anthony Allan (2011), at World Water Week in Stockholm in 2011, pointed out that common *'cheap prices food policies'* combined with present *'rules and organizations in the food supply chain'* are major obstacles to sustainable increase in food production to meet the needs for feeding the world.Irrigation water service is often priced below its marginal cost (5), or at 'sustainability cost' only (1), what does not allow recovering any capital cost.

Some mechanisms have been designed so as to make the water users contributing to the capital expenditure. In Morocco, for instance, irrigators in large scale irrigation systems are subject to payment of such a contribution called *'participation directe'*, the purpose of which is recovering 40% of the cost of the infrastructures from water users. This contribution, calculated according to the farm area, was first fixed by law in 1969. But updating the legal amount to take into account inflation has always been very sensitive and politically difficult, and the collection rate of this fee remains fairly poor (El Alaoui, 2006).

In France, within the concession contract given to SCP, regional development company owned by local authorities,the tarifftakes into account capital and O&M costs and is subject to yearly escalation. But farmers do not bear the total costs as their tariff is partially subsidized.

Financially autonomous institutions or companies, acting as owner of the infrastructure, are charging a price for water service which aims at recovering capital costs other than the subsidized part of the investment. But in most cases, investments are made by governments or public agencies and irrigation tariff does not pay for capital.

Scale effects and solidarity in multipurpose projects

As stated above, head structures amortization depends on development of distribution network.. But their weight on investment unit cost (per hectare) benefits obviously from scale effect. However, small projects may be safer as regards sustainability as water users are more easily involved at planning, design and construction stages, which may result in a better involvement in operation and maintenance (see hereafter).

On the other hand, identifying and recognizing multiple uses of water may be very helpful to mobilize the necessary funds for financing projects. Most of large scale hydraulic schemes depend on water resource constituted thanks to large dams, which are often economically feasible in themselves because of their hydropower capacity. The whole projects are therefore more bankable due to the benefit expected from energy production.

Relevant land planning and economy policies often lead to combine irrigation and urban water supply. Numerous examples of such multipurpose infrastructures can be found all over the world, either in northern or in southern countries. All concerned sectors are thus ready to bring their financial contribution, making effective the solidarity between usages, as whole economic benefit is taken into consideration, generally at country level, sometimes beyond borders in case of trans-boundary projects.

At stage of launching and constructing large scale project, financing multiple use projects by mobilizing cross solidarity is not a real challenge. But long-term management of the corresponding asset may not be as easy as setting it up. And solidarity may thus no longer exist. This issue is dealt with in next chapter.

FINANCING WATER MANAGEMENT, OPERATION & MAINTENANCE THROUGH WATER SERVICE FEE(S)

'Governments and donor organizations rarely assign high priorities or large budgets to irrigation infrastructure maintenance (Ward, 2010)'. As a matter of fact, covering the cost of operation and maintenance is usually ensured by setting up and enforcing appropriate pricing of water service. This is economically sound as O&M are partof water service. End user has therefore to pay for. According to Henri Tardieu and Bernard Préfol (Tardieu and Prefol, 2002), there is a 'sustainability cost' (SC) of irrigation schemes, including water resource conservation. SC is less than full cost, as it does not include financial cost of initial investment, but allows long-term asset management as it include operating costs, routine corrective (repairs) and preventive maintenance and sustainable modernization and renewal costs.

Covering the SC is essential because, as stated above, water users will be ready to pay for water service only if the said service comes up to their expectations. And how could the service be good if operation is poor or canals, pipes and pumps in bad condition or out of order due to lack of maintenance?

Irrigation infrastructures are long lasting works. Is it relevant to consider that their life time is finite, and that re-investing is necessary after 50 or 100 years? Managing this

asset considering a quasi-infinite life duration (Tardieu and Prefol, 2002) is probably a better choice. It is therefore necessary to constitute provisions for carrying out in due time the necessary renewal and modernization works.

Last but not least, it should also be borne in mind that water resource management and conservation has a cost. But who should pay? Water users are indeed concerned and should thus contribute.

What does Sustainability Cost (SC) include?

At least, SC includes:

- current operation expenses: salaries of staff, expenses for transportation and eventually housing, daily upkeep, consumables;
- routine maintenance: repairs (spare parts, materials and works) and related temporary works, work survey and preventive maintenance;
- energy in case of pumping;
- other charges (taxes, water right, engineering services and technical assistance...).

It should be emphasized that preventive maintenance is too often neglected, although not really costly.But it is essential for service continuity, which is a main factor so that the water users trust the system and its management, and thus are ready to pay for the service.

Long-term maintenance, renewal and/or modernization

It is to be emphasized that sustainable agriculture relies on sustainable management of land, of water resource, but also of the physical asset constituted by irrigation collective infrastructures. Sustainably managing these infrastructures means that care is taken for them to ensure irrigation service durably, that is to say (i) ensuring long term maintenance, (ii) adapting the structures to changes in water demand (cropping patterns and climate, thus irrigation requirements) (iii) improving the efficiency so as to face environmental increasing obligations, rising competition between usages and water resource getting scarcer in many cases. This implies that what is usually called ‘renewal’ encompasses technological progress and functional adaptations necessary for the schemes to keep ensuring a good quality service taking into account developments in economic, social and environmental requirements and regulations.

In spite nobody willdeny that long-term maintenance and renewalareamong main conditions for sustainability, governments and donor organizations rarely assign high priorities – and thus significant budgets – to this component of the projects (Ward, 2010). From the point of view of asset management, provisions for long-term maintenance, modernization and renewal should thus be included within SC. The question remains of how much should be provided for.

In France, Regional Development companies have obligation, through their concession contract, to maintain the conceded asset so as it will be in full capacity and in good condition at the end of the contract, i.e. after 75 years. They have subsequently to make ad hoc provisions, of which annual amount ranging from 0.1 to 10% of the current value of structures and equipment (lowest rate for heavy civil works, highest for electronics and automation). Actually, these provisions were amounting between 0.1 and 3%.Presently, SCP’s annual provision is about 1% of the current value of the physical asset. According to a Ministerial Direction issued in February 2008, these provisions are now subject to five-year renewal-modernization programs.

Tariff versus costs

Cost is not price: expenses are not directly making tariffs, even if water service pricing must allow covering the above described costs and must take them into account. Water service pricing in collective irrigation systems is a matter of policy, which must comply with objectives of equity (or equality?), affordability by farmers (i.e. proportionate to farm gross revenue), incentive to thrifty use of water. Furthermore, simpler is the tariff, more efficient the collection may be.

Equity or equality?Equality would mean that every user pays the same unit price, wherever he is, whenever he takes water and whatever is the discharge he takes, whatever the usage. Such equality does not take into account any O & M constraints, highly variable with each of these parameters. Equity means that everyone pays proportionately to the impacts of his consumption on resource, system functioning and operation costs. For instance, serving water far from the system intake cost more and thus should be invoiced more than close to it. If water service is required continuously, it has an impact on operation and maintenance, as no water cut is possible for maintenance, and thus the price should be higher.

Volumetric or non-volumetric pricing, binomial pricing?Making the system as simple as possible may require just invoicing a lump sum price, per hectare for instance. It is easy to apply, as regards both methodology and technology, but may lead to wasting water. Volumetric pricing aims at encouraging water saving. Binomial pricing allows taking into account the impact of the served user on the system functioning. Parameter to characterize this impact may be the served area or asubscribed discharge at delivery point. In that case, the price is calculated through binomial formulae with fixed fee (proportional to area or to discharge) and variable part, proportional to delivered volume. A variant of volumetric pricing is time-pricing, a method applied for instance in Australia. The delivery point is equipped with flow rate measuring device (calibrated weir in case of surface delivery) and the farmer pays for the time he receives water. Fixed step pricing is also used to regulate demand, for instance with a current allocated quota price and a discouraging overconsumption price (Tardieu and Prefol, 2002).

Encouraging water saving requires volume (or time) measuring, which requires technology. This is costly at installation stage, but also requires control and regular maintenance of measuring devices. In any case anyway, five main conditions must be fulfilled, the irrigation system either being publicly owned or operated by private company:

i. whatever the tariff is, delivery of water must be controlled, the operator being given police power so as to be able to sanction misconducts andfraudsof any kind;
ii. measuring equipment, if any, must be mastered and carefully managed by the operator;
iii. attention must be paid to collection of fees, as any weakness in this respect may lead to lack of credibility for the operator;
iv. total of invoiced amount must be more than Sustainability Cost of the system;
v. it is imperative for the tariff to include escalation formula, rigorously – and courageously – applied, so as not to have quickly a gap between actual SC and collected funds.

Possible role of private sector

The typology of private involvement patterns and the diversity of arrangements that can be made for contracting with private companies or consortia for involving private stakeholders in irrigation has been presented above. As regards operation and

maintenance only, the most common transaction models are the following:

- the lease (French 'affermage') will consist in contracting with private company / consortium for operation and current maintenance without any significant involvement in financing neither initial capital expenditure nor renewal. Among operator's responsibilities is billing the service to water users. He collects the fees, a part of invoiced amount making its remuneration, the balance being paid back to the owner. This form of delegation is common for urban water service, and can be found for irrigation service as well;
- O&M contract (or management contract) or any other arrangements on the right bottom part of the figure where the private partner will limit its risks, as the contractor has no financing role and is paid a rent by the contracting public authority / agency and not from the users. This kind of contract is also found for irrigation purpose.

Second option is ordinary service delivery. Attention must be paid in the contract to how will the service be accepted and the contractor be paid. Success fees, at least for a part of the operator's remuneration, are often anappropriate incentive tool.

In the first case, giving the operator the responsibility for billing the service and collecting the fees and is an incentive in itself. Better is the quality of irrigation and drainage services, better will be the collection of irrigation service fees, and thus more will be the money available for good management of maintenance.

Farmers' capacity and willingness to pay; organization of water users

A key element in project development is the concept that long-run sustainability can be achieved only with the active participation of the major stakeholders, i.e. the farmers. It is strongly believed that only by directly charging beneficiaries for the water they use will enhance their sense of responsibility and ensure their eventual partnership in the irrigation scheme. Irrigation service fee rate has a significant impact on the farmer's acceptation, then to their contribution of the system financing. So it must be fair and attractive, i.e. it must not jeopardize farmers' operating income.

According to Tardieu and Prefol (2002), sustainability requires that price of water service is kept below strategic value of water for farmers, i.e., the added value per of irrigated crops vs. non-irrigated crops.

What must be emphasized is that, provided the fee is affordable, farmers are generally ready to pay for having water. But this willingness to pay is largely depending on the quality of the water service and on the farmers' faith in the capacity of the one who bills the service to provide the said service with the required quality.

One of the best ways to involve water users and make the responsible for sustainable management of irrigation schemes is to empower them through training and extension, as recommended by Backeberg(2006). Constitution of Water User Associations (WUA), which can be given responsibilities – at appropriate level – for operation, maintenance and fee collection, should often be considered as a relevant way towards sustainability. In the above referenced paper, the author points out that WUAs may be innovative, thinking for instance about volumetric charging tariff, the Administration remaining reluctant.

Empowering Water User Association in management is an attractive alternative to public management and delegation to private company. As a matter of fact, in spite WUAs may have public entity status (ASA in France for instance, are bodies governed by public law), they are representing farmers'interests, i.e. private ones. The contract they conclude with government, through which they are entrusted operation, maintenance, water service and related invoicing and collection,

sometimes ownership (Arcahaie Irrigant Association, Haiti) and water resource management, may thus be considered a kind of PPP; discussion is open…

But optimizing water service costs could be achieved through an adequate combination of public private and end users respective skills and capacities. One can imagine a large scale irrigation project owned – and initially funded - by the State, or a Public Authority (PA) responsible for water resource management and allocation. State or PAwill then be contracting with a private company or consortium for operating headworks, including for instance a big pumping station (maybe after having built them). The private operator obligation is todeliver bulk water toWUAs,responsiblefor managing distributions network and invoicing individuals for water service. Institutions and organizations could complement each other, thus putting together the conditions for the irrigation water service to be fully and sustainably financed.

Cross subsidies ormultiple use / scale –solidarity?

'A cross subsidy occurs when losses incurred by pricing one service below its recoverable cost are offset by charging a price above recoverable cost for a related service supplied by the same organization. A common cross subsidy occurs between power buyers and irrigators who benefit from the same reservoir and dam.'(Ward, 2010) Is this an actual and appropriate way for financing irrigation? As a matter of fact, this situation can be found in many countries, from both North and South. At early stage of feasibility, as stated above, there is a common approach considering all usages of large scale hydraulic scheme. As a result, power pays for dams, the most expensive infrastructure, even if the stored volume will be used for irrigation. As noticed buy Pr. Ward (2010), *'U.S. Congress […] authorized the difference between the cost of development and repayment charges received from farmers to be paid from cross subsidies paid by hydroelectric power revenues.'*

At operation stage, revenues from hydropower, urban water supply if any, and irrigation are rarely put together to cover the whole cost of sustainable operation and maintenance of the whole system. In most cases, institutions in charge of energy manage dams and power plants, others are in charge of urban water supply, and irrigation does its best with its infrastructures and what can be billed to farmers.

Many examples of such situations are found all around the world. In Senegal basin, Diama dam and related dikes suffer a lack of maintenance. Their role is to prevent the river from salt intrusion and to protect surrounding areas – most cultivated – against floods. There is not direct revenue to the institution managing these works allowing it to maintain them. On the other hand, the power generation at Manantali, the other dam upstream of the river, is operated by another company who makes a big turnover selling electricity. Both structures cannot work without each other, and the whole system should be considered economically, as it is technically. Recently, in several cases in southern France, making irrigation schemes economically sustainable was the subject of investigations. The solution found in many cases consisted in equipping the system for generating hydropower. In Haiti, large scale (30 000 ha) Artibonite irrigation system is equipped with one hydropower plant, but the facility is (fairly badly) operated by National Electricity Board. As main structure maintenance costs are too much for being invoiced to farmers, these are government tax-financed. Would it not be better to give the irrigation system operator – a public body contracting with WUAs – the responsibility for operating the power plant and selling the electricity for funding head work maintenance? Probably yes, and global efficiency would be better, because the same body would be interested in both energy and hydraulic efficiency.

These examples may lead to conclude that 'solidarity' should be preferred to 'cross

subsidy', as electricity buyer is not paying for irrigation but actually contributing to funding a global water service. In any kind of business, a good way towards robustness is to diversify the goods or services sold as well as the customers. Why irrigation should be compelled to be economically autonomous when 'related water service' can contribute to equilibrate its operating account? Same solidarity may exist between different uses of water, or between big and small customers of irrigation service.

Payment for water resource conservation; Water Market mechanism

According to traditional, cultural and religious point of views, water must be considered as a common good which cannot be sold, and the major part of what is commonly called 'water bill' is relating to funding hydraulic structure capital expenses and O&M costs.However, monetary transactions can be helpful to regulate the equitable use of this common good. Furthermore, water resource conservation has a cost, and thus someone has to pay for it. Because we all need water, 'Someone' means 'Everyone'.Buthow muchshouldirrigation water users pay?

In Europe, the water framework directive provides that Member States must take into account the principle of recovery of the costs of water services, including environmental and resource costs. Many Northern European industrial countries have set up taxes on water abstractions by all usages domestic, industrial and agriculture as well. But Mediterranean States, where irrigated agriculture is the main water usage, are reluctant to impose such eco-tax, which would add up to the costs of irrigation water service, itself not affordable by many irrigators. France has enforced such a regulation, and thetax varies depending on the irrigation method (pressurized or surface), farmer organization(individuals vs.collective systems, WUAs for instance), and the area concerned (water scarce or not). But the amount remains very low, ranging from 2 to 7 cents per cubic meter for pressurized irrigation and from 0.1 to 1 cent for surface irrigation.

Managing water resource and regulating withdrawals may also be achieved through water markets, as *'market mechanisms can encourage economic value of scarce water supplies in the face of growing scarcities […] by addressing allocation inefficiencies found in the traditional irrigation institutions.'* (Ward, 2010). Australia, land of water-scarce environment, has a long history of water markets, and markets for seasonal trade are well established in southern states. Water markets are strictly regulated, as regards trading zones and price mechanisms. They ideally should enhance water resource allocation efficiency without impacting on the environment or social equity (Shahbaz Khan et al., 2009). Transactions are facilitated by traders, who are paid by sellers, while buyers pay duties and taxes on the said transaction.

In South Africa, riparian water rights have been replaced by a system of water licenses which are, according to law, 'designed to allocate water equitably in the public interest'. A license is a particular property, valid for a specified duration, which may be temporarily or permanently traded. The related *transactions are subject to maintaining a balance between the interest of water users participation in the trade and the general public interest. […] The resulting water markets have facilitated transfer of water use to relative higher-value crops and achieved efficiency and flexibility* (Backeberg, 2006). But attention must be paid to the risks that water license trading be used for short-term gains, or that wealthy farmers take advantage of this mechanism at the expenses of poor farmers.'*Water markets without regulations to protect the resource, third parties and environment, and to prevent monopolization, will result in uncontrolled private appropriation of a scarce resource and problems in related markets rather than in efficient resource allocation'*(S0lanes and Jouravlev, 2006*).*

Water markets are a way an option to reallocate authorized water use. Moreover, like any other financial constraint on water resource withdrawals, they may establish the incentives to support maintenance of infrastructures, as highlighted by Pr. Ward (2010):*'When an economic value is secured for water that would be saved by repaired infrastructure, the that value signals the marginal cost of leaving the infrastructure unrepaired'*. But they are far from universal solution, especially when the conditions of fair trade are not fulfilled, for instance when the situation is unbalanced: for instance, how farmers could fairly compete against oil sand or shale gas industries?

CONCLUSION

Collective irrigation infrastructures, like other large hydraulic systems, are generally part of land development, and as such depend upon national policies and development strategies, and collective projects require coordination, planning and financing.They are therefore usually financed by governments, acting in their own name or giving public institutions the responsibility for planning, design, construction and operation.

A potential for involving private sector in financing irrigation schemes through so called PPPs does exist, but investing is risky, and private sector involvement in irrigation may be sought only under conditions, especially as regards risks, which must be fairly distributed between public and private partners. Contracting with a private company / consortium trough long term concession, although risky for the operator, should be a good way towards sustainability, as the contractor in interested in the financial results of the contract, and therefore in the performance of the service, on which the farmers' willingness to pay relies.

Because food prices are rarely high enough for farmers – especially small holders in developing countries – to make a minimum profit after having paid all the expenses necessary for their production, water service is often priced below its marginal cost, or at 'Sustainability Cost' (SC) only, what does not allow recovering full capital cost, and even not at all.

Identifying and recognizing multiple uses of water may be very helpful to mobilize the necessary funds for financing projects, at both construction and running stage. Initial investment and physical asset management financing should therefore not be considered separately. Financing investment in irrigation collective schemes must therefore (i) be significantly public, (ii) trans-sectorial and (iii) include both bearing the cost of initial installation of the project and necessary amortization / renewal costs.

Sustainable managementof these infrastructures means that care is taken for them to ensure irrigation service durably, that is to say (i) ensuring long term maintenance, (ii) adapting the systems to changes in water demand, (iii) improving efficiency. What is usually called 'renewal' must thus encompass necessary technological progress and functional adaptations. The corresponding costs are part of SC.

Provided the fee is affordable, farmers are generally ready to pay for having water. But this willingness to pay is largely depending on the quality of the water service and on the farmers' faith in the capacity of the one who bills the service to provide the said service with the required quality. Empowering Water User Associations (WUA) for operation, maintenance and fee collection is an attractive alternative to public management and delegation to private company. Optimizing water service costs could be achieved through an adequate combination of public, private and end users respective skills and capacities.

Many examples may lead to conclude that solidarity between usages may help

achieving sustainability, as irrigation is not compelled to be economically autonomous when 'related water service' can contribute to equilibrate its operating account. Such solidarityshould exist between different uses of water, or between big and small customers of irrigation service.

Last but not least, water resource conservation has a cost, and thus someone has to pay for it. Monetary transactions can be helpful to regulate the equitable use of the said common good. Many countries, especially in Northern Europe, have set up taxes on water abstractions. South Africa and Australia have made the choice of water markets, which may establish the incentives to refrain from over-consumption and to support improving infrastructure efficiency. In both cases, strong regulation is the only way for equitable sharing of the resource.

What was not addressed in this paper is whether farmers are or not entitled to claim for being remunerated for the ecosystem services they produce. Who should pay, for instance, when treated waste water is used for irrigation? The farmer, as non-conventional water resource end user? Or the polluter, i.e. people who produce waste water, the farmer providing a part of the treatment process? Or simpler: agriculture is indeed often contributing to land management et landscape preservation. Is this something like public service, citizens should pay for? Answering these questions may give solutions for financing irrigation, provided that famers take care of the water resource.

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