

An Assessment of the Spanish National Hydrological Plan

ASIT K. BISWAS & CECILIA TORTAJADA

Third World Centre for Water Management, Avenida Manantial Oriente No. 27, Los Clubes, Atizapan, Estado de Mexico 52958, Mexico.

Email: akbiswas@att.net.mx, thirdworldcentre@att.net.mx

ABSTRACT *The paper is a comprehensive review of the Spanish National Hydrological Plan, which proposes to transfer water from the lower part of the Ebro River up to the Levante basins, around 912 km away. The National Hydrological Plan is a conventional, static plan, which focuses primarily on supply management. The plan is based on the explicit assumption that the world will change only incrementally during its entire economic life of 100–200 years. The analysis indicates that much of the increased water demands forecasted are unlikely to materialize due to increasing emphasis on demand management practices, major structural changes in the agricultural sector that will occur by 2020 and the requirements of the Water Directive of the European Union, which must be fulfilled by 2010. Even now, the cost per cubic metre of water delivered at the end of the transfer is nearly twice the cost of desalinated water. The National Hydrological Plan in its present form cannot be justified for economic, environmental and social reasons. In addition, the plan will not be necessary if demand management practices are implemented.*

Introduction

The assessment in this paper is based on a visit to Spain over the period 19–29 October 2002, during which an extensive and intensive set of discussions were held with appropriate senior officials from several ministries of the government of Spain in Madrid, senior officials of the government of Aragon in Zaragoza and Madrid, leading academics from several Spanish universities, water experts from the private sector and certain selected representatives of major non-governmental organizations. Field visits were undertaken to specific areas which will be affected by the proposed water diversion plan, including the Ebro River estuary, where the adverse environmental and socio-economic impacts due to the implementation of the plan are likely to be greatest. Special attention was given to ensure that the consultations undertaken during this visit to Spain included people who were supporters of the plan, as well as those who opposed the plan, and were neutral on the plan in the sense that they approved certain aspects of the plan but disagreed with its other components. In addition to these discussions, extensive documentation and reports were collected from all the persons who were consulted, and the institutions that were visited. All these reports were subsequently analysed very carefully. The paper is based exclusively on the discussions that were carried out in Spain, field visits to certain special areas of water diversion and in-depth analyses of all the documents collected from the proponents and opponents of the plan, including the governments of Spain and Aragon. The law authorizing the plan, which was approved

by the Cortes Generales and sanctioned by His Majesty Juan Carlos, the King of Spain, on 5 July 2001 can be seen in this special issue of the journal.

Assessment of Act 10/2001 on the National Hydrological Plan

The Act authorizing the Spanish National Hydrological Plan (hereinafter referred to as the National Hydrological Plan) correctly and logically identifies the overall *problematique* of water management in Spain and the process to formulate rational water management for the country. For example, the Act points out that:

- water is a scarce resource in the country, with serious imbalances between different regions in terms of its availability because of differing climatic, hydrological and topographical conditions;
- because of this variation, it is essential to ensure rational use and management of water resources available so that all types of demands can be met cost-effectively and without adversely affecting the ecological and environmental conditions of the existing water bodies (both surface water and groundwater), and associated natural resources such as land, biota and the environment;
- because of these constraints and requirements, a national plan to manage the nation's limited water resources is necessary to ensure that the present and future water requirements of the country can be met in a sustainable, balanced and environmentally sound manner, and also that the economic development of the different regions of the country is not unduly constrained due to the water scarcities that may exist at present, or that are likely to occur in the future.

The Act also correctly identifies many, but not necessarily all, important criteria on the basis of which such a national water resources plan should be formulated. Among the criteria that are specifically identified in the Act that should underpin the plan are the following:

- the planning process should involve all the various appropriate public authorities concerned;
- civil society should be involved directly within an overall framework of a wide-ranging drafting and consultation process;
- the environment should be considered as a "most important component" of the planning process;
- the plan should be "governed by the principles of diligence, rationality, sustainability, protection of water in the public domain, maintenance of good ecological status of water; and protection of environmental flows";
- the principle of cost recovery should be an important requirement of the plan;
- "various alternatives" should be considered, and "exhaustive" cost-benefit analyses should be considered for all the alternatives identified, which should take into account appropriate environmental, social, economic and technical variables;
- the alternatives should be subject to a broad spectrum of social consultation and debate;
- the plan must be justified by "overwhelming" public interest;
- the plan must be "plural and decentralized in its origin, scope and execution";
- the plan must guarantee that the developments in the basins of origin are not compromised in the future because of water withdrawals, and that such basins are compensated "to finance environmental measures linked to water usages";

- the transferred water must not be used to develop new irrigated areas, or to extend existing irrigated areas;
- transferred water should be used “exclusively” for urban water supply, and for consolidating the supply of water to irrigation schemes that are in a precarious state, *provided* rational and effective water management policies are practised, and “maximum effectiveness in resources management” is ensured in the receiving basins;
- wetland conservation is an essential requirement of the plan;
- the plan should contribute to achieving a balance in regional and sector developments;
- the plan should be compatible with European Parliament and Council Directive 2000/60/EC of 23 October on water.

If the criteria and requirements of the Act are followed properly and objectively, the Act should result in a good, rational and logical plan that should be of direct national interest, both for the present and for the future. In other words, the hypothesis, assumptions and logic that are stipulated in the Act should contribute to the formulation of a plan that is technically feasible, economically justifiable, socially acceptable and environmentally desirable.

Assessment of Some Fundamental Assumptions on which the National Hydrological Plan is Formulated

While the factors suggested by the Act for the formulation of the plan are excellent, on the basis of the discussions conducted in Spain and in-depth analyses of the documentation that is currently available it has to be concluded that the formulation of the plan leaves much to be desired because it does not consider many of the fundamental criteria, either seriously or comprehensively, even though they are explicitly stipulated in the Act. Furthermore, many of the important planning criteria that are noted in the Act have been basically ignored, or not adequately considered, as a result of which the very basis of the need for the proposed water transfer, as it is currently proposed, can be seriously questioned. In fact, the main objective of the water transfer, that is, that the coastal areas of the south require additional water from the north, essentially from the Ebro River, can be challenged for three fundamental reasons.

- Forecasts of the water demands for the future are likely to be very significantly less if demand management practices such as full cost recovery, proper levels of water tariffs and more efficient water management in the urban, industrial and agricultural sectors, etc. are considered. These are considered to be necessary requirements under the Act.
- Technological options currently available are already more cost-effective when the costs of transferred water exceed €0.45/m³. In addition, consideration must be given to treat and reuse waste waters generated, which are now mostly discharged to the sea without adequate treatment. Costs of certain alternatives such as desalination or transportation of bulk water through rubber bags are likely to decline even further in the future, especially by 2015, when the water transfer project, if completed, is likely to become fully operational. This is likely to seriously undercut the very logic of diverting water to the Levante basins from the Ebro River for economic reasons alone.
- The European Union (EU) is likely to be very different by 2015, because of the

introduction of new member states and the signing of free trade agreements with other countries. The Common Agricultural Policy, from which Spain is now benefiting significantly, is likely to undergo radical modifications within the next 15 years, and the European agricultural subsidies are likely to be significantly lowered because of the ongoing global negotiations that are being conducted under the aegis of the World Trade Organization (WTO). Because of these changes in agricultural policies, and prices of agricultural products, the structure and economics of agricultural production in Spain are likely to be very different by 2015 and beyond, compared to what they are at present or the projection of the current trends under a business-as-usual scenario, on which the National Hydrological Plan is based. Thus, it can be forecasted with complete certainty that the irrigation water demands by 2015 are likely to be much less in the region receiving transferred water, compared to what is forecasted by the plan.

Thus, the entire *raison d'être* of the water transfer over 912 km is difficult to justify, especially if cost recovery and other demand management practices are seriously considered and implemented in the Levante basins, as noted in the Act and required by the EU Water Directive. Furthermore, whatever additional water demands may occur in the future in the water-receiving regions can be met by other significantly more cost-effective sources of water. In addition, many of these alternatives will have significantly fewer adverse social and environmental impacts compared to the proposed National Hydrological Plan.

The above issues and other associated fundamental issues of the proposed water transfer under the National Hydrological Plan will be discussed in more detail next.

(1) The main focus of the National Hydrological Plan, as it is currently formulated, is on supply management. Demand management has received inadequate attention. If demand management is seriously considered, as noted in the Act and required by the European Directive, much of the forecasted water demand in the Levante basins region will disappear beyond the post-2015 period.

Up until recently, the traditional approach of water management has been to consider supply management, that is, to increase the availability of water supply so that it meets the increasing demand. Logically speaking, the word 'demand' in the context of water planning, especially for the agricultural sector and often for the urban sector, is a misnomer. Demand for any good generally has a price associated with it. Demand may become unlimited, if no price, or a minimal price, is charged for the goods. As the price of any good increases, its demand starts to decline since the consumers become more and more rational in their behaviour, and start practising conservation and more rational use. In the context of water management, the term 'demand', as it was used in the past and is often used at present, could be considered to be more of a 'requirement' because of very low prices charged for water.

In the agricultural water use sector, which is the main user of water in Spain, in most cases the farmers generally pay a minimal amount based on the area irrigated rather than on the volume of water actually consumed. Thus, water management in the agricultural sector has generally been inefficient, not only in Spain, but also in other parts of the world. For countries such as Spain, where water is relatively scarce, and where nearly 80% of the developed water supply

is for irrigation, it is simply no longer a desirable option to consider expansion of water supply by developing new sources, unless these developments can be done cost-effectively and in a socially acceptable and environmentally friendly manner. Most of the economic and easily accessible water sources have already been developed in Spain. For example, Spain has already constructed over 1000 dams, whose reservoirs now cover more than 5% of the country's surface area. Thus, the new sources of water are becoming increasingly complex and unattractive to develop because of increasing economic, social and environmental costs. Accordingly, the old and traditional supply side solution, aimed at increasing the supply of water at whatever demand, is no longer an attractive solution in economic, social and environmental terms, especially for countries such as Spain.

Because of this situation, increasingly, all over the world, demand management practices are receiving a higher degree of attention from policy makers and water professionals. The need for demand management and cost recovery is noted in the Act. The main focus of the demand management is to target the water users and the water institutions in order that they modify their behaviours so as to achieve more desirable allocations of water, and promote its efficient use. In contrast to supply management, where infrastructural developments are essential, demand management strategies consist primarily of non-structural measures such as economic and legal incentives to change the behaviours of the water users, along with the formulation and implementation of appropriate policies and the creation of an appropriate institutional environment that can actively promote such an approach.

Globally, the shift to demand management has been receiving increased attention. If it is considered that water is an economic good, and water has an economic value, the issue of water pricing becomes a very important component of demand management. The National Hydrological Plan accepts the overall philosophy that underlies the concept of demand management. The Act explicitly refers to the "principle of cost recovery" and to achieving "maximum efficiency" in managing water in the recipient basins. The Act further notes explicitly that water will be available in the recipient basins "provided that rational and effective water management is practised" in this region.

The need for and the urgency of appropriate water pricing are now universally recognized. Thus, the Water Framework Directive of the EU, which is noted in the National Hydrological Plan, very specifically states in item 38 of the preamble that:

The use of economic instruments by Member States may be appropriate as part of a programme of measures. The principle of recovery of the costs of water services, including environmental and resources costs associated with damage or negative impact on the aquatic environment should be taken into account in accordance with, in particular, the polluter-pays principle. An economic analysis of water services based on long-term forecasts of supply and demand for water in the river basin district will be necessary for this purpose.

The Directive further stipulates, in article 9, that:

Member States shall take account of the principle of recovery of the costs of water services, including environmental and resources costs,

having regard to the economic analysis conducted... and in accordance in particular with the polluter pays principle.

Article 9 then states categorically that:

Member States shall ensure by 2010

- that water-pricing policies provide adequate incentives for users to use water resources efficiently ...
- an adequate contribution of the different water uses, disaggregated into at least industry, households and agriculture, to the recovery of the costs of water services, based on economic analyses conducted ... and taking account of the polluter pays principle.

The parts of the Directive quoted above are of absolutely paramount importance for any objective assessment of the plan, since it will be necessary for Spain to comply with the cost recovery principle for water services by 2010. This is because even under the most optimistic scenario, the construction of the proposed diversion plan cannot be completed before 2010, when Spain and all other members of the EU must ensure that costs are recovered for all water services provided to households and industrial and agricultural users.

Because of the importance of this principle, and the deadline for its implementation by 2010, it will be useful to consider what are likely to be the implications of the application of the cost recovery principle in terms of the proposed water transfer to the Levante basins.

The Directive stipulates that cost recovery should include environmental and resource costs, and must take into account the polluter pays principle. Furthermore, cost recovery should be applicable equally to the domestic, industrial and agricultural sectors.

Currently, only domestic and industrial consumers pay much higher prices for water, compared to agricultural users. Even then, if the cost recovery principle is to be used properly, in most cases the water prices for the urban and the industrial consumers will have to be increased. In some parts of Spain, the increases are likely to be quite significant for domestic and industrial water users, which in all probability will reduce the present and the future total water requirements substantially. Cost recovery for the agriculture sector will mean that agricultural water rates will have to be increased by several hundred percentage points within a decade, which will undoubtedly result in significant savings in water use, as farmers become conscious of the value of this resource, and marginal and uneconomic agricultural production disappears.

The adoption of the cost recovery principle in Spain will mean that during the post-2010 period, all water users in the region where water is to be diverted will have to pay prices that reflect the scarcity value of water available in the area. Conceptually at least, when this scarcity price equals or exceeds the long-run marginal cost of bringing new water into the area (currently likely to be around €0.45–0.50/m³), new sources could be added so that the market price can be maintained at this level. New capacity can be added when it is confirmed that additional demand for water exists at this pricing level.

On the basis of the currently available information, it appears that the price of water for agricultural uses does not exceed €0.04/m³ in almost all the counties of Júcar, and in some of the Segura counties. The price increases to €0.15/m³ in some of the southern basin counties of Almería province, where the water

scarcity is more severe. If these low prices are increased moderately, say by €0.20/m³, it is highly likely that the inefficient farmers and the production of uneconomic crops such as irrigated cereals will disappear almost completely over a short time period. This means that even if agricultural water uses continue to be subsidized at this higher price level, during the post-2010 period, it would not be necessary to transfer 820 hm³ from the Ebro River to the Levante basins, as proposed at present, because of very significant reductions in agricultural demands in the future due to higher water prices. If the full cost of providing irrigation water to the farmers is recovered from 2010, a significant part of the current agricultural water demand will disappear, let alone as much additional water being needed in the future as is currently forecasted in the plan. More studies will be necessary to forecast reliably what are likely to be the agricultural water demands under both modest and higher water price increases. However, an intelligent guess, based on experiences from other parts of the world, indicates that price increases are likely to reduce agricultural water demands within the 30–60% range, depending upon the actual price charged.

If the European Directive is to be applied fully in Spain by 2010 for all water use sectors, and if users are expected to pay the full cost of water, it would unquestionably mean that a very significant percentage, if not all, of the total forecasted water demands in the Levante basins, which will receive water from the water diversion project, may not materialize. The maximum reduction of demand due to the application of the cost recovery principle will occur in the agricultural sector, followed by the domestic and industrial sectors. The inclusion of social and environmental costs in the water pricing structure after 2010, as required under the EU Directive, will unquestionably make water use in the entire region extremely efficient in all the three above-mentioned sectors. For the agricultural sector, which is at present a very large consumer of water, and also a sector where water is supplied at a very highly subsidized price, it will mean that the high water prices will force the producers of low-value crops to go out of production: only crops of high economic values can be grown. This restructuring of agricultural production due to the radically changed economic considerations because of cost recovery from water services will undoubtedly reduce agricultural water demand very significantly. The National Hydrological Plan, as it is currently formulated, does not adequately consider the reduction in water demand that will occur in the post-2010 period because of the higher water prices.

The concept and application of full cost pricing are likely to revolutionize water management practices not only in Spain but also in the rest of Europe. The disappearance of the provision of low-cost water, which is now heavily subsidized by the taxpayers of Spain, especially for the agricultural sector, will mean that all the existing forecasts of future water demands beyond the 2010 period have to be scaled back very significantly due to radically changed economic and institutional (mainly EU) requirements.

Additional research and analyses in the Levante basins under the expected new economic regimes will be essential for forecasting future water demands reliably. If the National Hydrological Plan is used to divert water, it will require, first, to estimate with some degree of accuracy the cost of economic, social and environmental externalities that must be added to the price of water after 2010. It will then be necessary to construct fairly sophisticated models that will forecast what are likely to be the expected water demands, when water prices

have to be increased very significantly, and progressively. Currently, the real costs of economic, social and environmental externalities of the water diversion plan are not known, except in a somewhat general and superficial manner. In fact, even a realistic cost estimate of direct investments required for all the necessary infrastructural developments is not available at present, let alone estimates of the costs of economic, social and environmental externalities that would result from the water diversion plan.

Only after all these costs are objectively and reliably estimated can a realistic model be built to forecast future water demands in the Levante basins. Once these demands are known, the next logical step would be to decide how best to meet these additional water demands cost-effectively, and with the least possible social and environmental disruptions.

The existing forecasts of demands for water in the more southerly parts of the region, such as Almeria, Segura and Murcia, where water will be transferred, will unquestionably prove to be far too high for the post-2010 period, if the principle of cost recovery is to be applied for domestic, industrial and agricultural water use sectors. Thus, the National Hydrological Plan, as it is formulated now, significantly overestimates the future water demands in the Levante basins.

(2) *Economics of water diversion and possible alternative sources of water.* It is axiomatic that for any water diversion project, the cost of water will be at its lowest nearest to the source from where water is diverted. The cost will steadily increase with distance from the source, and it will be at its highest at the tail end of the diversion project. It is now estimated that the cost of transferred water will range from a low of €0.19/m³ in Baix Maestart county, to a high of €0.75/m³ in Campo county.

It should be noted that the reliable costing of the entire water diversion plan is not available at present. This is not surprising since the plan is still in its initial phases. Considerably more studies and analyses have to be made of technical factors, and of social and environmental costs, before a reasonably reliable estimate of the total diversion cost can be made. Currently, the estimates that are available range from €4 billion to €7 billion.

On the basis of analyses and experiences of similar water diversion projects from different parts of the world, it is almost certain that by the time all the costs of infrastructural developments of the National Hydrological Plan are included, the final cost is likely to be much higher than what is anticipated at present. For example, the plan will require considerable energy for pumping water. The cost of power stations that have to be constructed to provide this additional electricity, and then the construction of the high-voltage lines necessary to transmit this electricity, do not appear to be costed in the project at present. Yet, these are direct costs which must be attributed to the project. All similar other costs, which still have not been computed, and reliable estimates of the costs that have already been included, are necessary before a reasonable total cost of the plan can be arrived at.

As yet, no comprehensive social and environmental impacts assessment of the project has been carried out. Without such in-depth impact analyses it is not possible to put any monetary value on the social and environmental costs that are likely to accrue due to the entire project. Only when such impact studies are completed will it be possible to estimate the costs of:

- ameliorative measures that must be undertaken to ensure that the environmental impacts on the lower part of the Ebro River and its estuary are reduced to the minimum possible, so that such costs can be accepted by the society as a whole in Spain, and also to ensure that such developments do not violate the various environmental directives of the EU;
- also, the people who now depend upon the water of the Ebro River downstream of the water transfer and in the delta area to earn their living are likely to be one of the main groups who will suffer economic hardships because of the proposed transfer. At present, it is not known how many people will be economically affected by the diversion, the types of hardship they will suffer and over what time periods, so that the level of financial compensation that has to be provided to them can be estimated.

Addition of the above direct and indirect costs associated with the adverse environmental and social impacts which are likely to occur due to the implementation of the National Hydrological Plan will undoubtedly further increase the real cost of the plan. Based on experience of similar water transfer projects in other parts of the world, and depending upon the final engineering and technical plans and proper estimates of the social and environmental costs, *a more realistic guesstimate of the real cost of implementing the plan is likely to be in the range of €6.5 billion to €9.5 billion in today's money.* Viewed from any direction, even the lower estimate of €6.5 billion transforms the National Hydrological Plan to the level of a mega-construction project.

Without accurate estimates of the cost of water delivered at different locations along the water transfer route, it is difficult to consider alternative sources of water which could be used to meet the demands identified. This does not mean that the demands projected by the National Hydrological Plan should be considered to be reliable and thus should be met, but rather, assuming that the water demands projected by the National Hydrological Plan should be met, do new, alternative sources of water exist which could satisfy the projected demands satisfactorily, but more cost-effectively and with significantly fewer adverse social and environmental impacts? This fundamental question has yet to be answered definitively.

As noted earlier, as a general rule, the cost of transfer of water will increase as the distance from the source, that is, the Ebro River, increases. Social and environmental impacts of the water transfer project will depend on many factors, among which will be the quantity of water that will be transferred; the exact locations from which the water will be diverted; technical, physical, social and environmental characteristics of the water diversion route; and ecological conditions of the areas from which water will be diverted, and the areas that will receive the water.

In the absence of detailed and reliable analyses of all the parameters that are associated with the proposed water diversion scheme, only some general comments can be made. For a complex, large and expensive mega-project like the National Hydrological Plan, the concept of average cost per cubic metre of transferred water, which is estimated at €0.50/m³, does not have much meaning. Thus, it is necessary to review the diversion scheme in terms of specific locations, and the actual costs of water at those locations, so that appropriate alternative sources of water can be considered for specific locations.

It is probably reasonably safe to say that based exclusively on economic

considerations, the transfer of water for the first 300 km of the diversion route, perhaps up to Tous, can most probably be justified. The cost of transferred water is likely to be around €0.40/m³ at Tous, and less in urban centres such as Castellón (North, Mijares and South) and Barcelona, which are much nearer to the Ebro River, from where water will be diverted, compared to the areas of the Levante basins.

However, economic considerations alone may most probably make the transfer of water beyond Tous unattractive and inadvisable. This is because by the time the construction of the water transfer scheme is completed, which is unlikely to be before 2015, several trends can be predicted with complete certainty. Among these major trends will be the following.

- Costs of conventional water development schemes requiring major infrastructural development projects will steadily increase in real terms:
 - (1) because the technical, social and environmental complexities of new projects are much greater than for the earlier generation of water projects;
 - (2) social and environmental costs associated with the new projects will have to be incorporated in the costs of water because of the will of the societal paradigm shift as well as due to the requirements of the EU. These costs can no longer be ignored.
- By 2010, satisfaction of the environmental and ecological water needs is likely to be made mandatory, and thus a significant percentage of water flow will have to be left in a river to satisfy its environmental and ecological needs.
- Demand management policies will be widely implemented by the post-2010 period, including extensive use of full cost recovery, which in turn will reduce water demands very considerably for the urban, industrial and agricultural sectors.
- Waste waters will have to be properly treated for health and environmental reasons, and treated waste waters will be reused extensively for the agricultural, industrial (especially process cooling) and certain recreational (that is, parks and golf courses) sectors, as a result of which the anticipated need for fresh water for these sectors will be much less than what is forecasted in the plan at present.
- Technological developments during the next 10–15 years are expected to:
 - (1) reduce even further the exiting costs of desalination of brackish water and sea water;
 - (2) reduce further the cost of transportation of fresh water over seas and rivers by the use of water bags and other such proprietary rubber bag technologies;
 - (3) include the development of more efficient wastewater treatment processes, which will mean that the quality of treated waste waters will become progressively better. This will mean that treated waste water can be used directly for most purposes, except for direct human use. It should be noted that the EU has steadily tightened the wastewater treatment requirements over the past 20 years because of human health and environmental considerations and technological developments. This trend is likely to continue at least over the next decade, which will mean that more and more treated waste water of increasingly better quality will be available for reuse in the future.

Because of these and other associated technological developments, it is likely that beyond 2010 the cost of desalinated sea water, and the cost of transporting fresh water through bags over the sea for use in coastal areas, will be in the €0.40/m³ range, or possibly even lower. Such costs are significantly lower than the currently projected costs for supplying water to the Levante basins through the National Hydrological Plan, even though the National Hydrological Plan costs are serious underestimates at present.

Consideration of all the above and other associated development will mean that it would be difficult to justify any cost of water beyond a maximum of €0.40/m³ for the post-2010 period.

If the costs of desalinated sea water and other usable alternatives are reduced to around the €0.40/m³ range by 2010, which is highly likely, the cost of transferring water beyond Tous may not make any economic sense.

Desalination

Overall, the National Hydrological Plan does not give adequate emphasis to the use of desalination of sea water and brackish water as a new, alternative source of water, except for Almería. For water diversion areas in the Segura and the Júcar basins, desalination is mostly considered to be a 'bridging option' which can be used as a reserve and for emergency requirements. *Análisis de Sistemas Hidráulicos* (Ministerio del Medio Ambiente, 2000) further considers that desalination is not economically justifiable because of its high costs, when compared to other alternative sources. These assertions are incorrect at present, and will become increasingly irrelevant after 2010.

Within the past five years, the cost of desalination has come down dramatically. Some 20 years ago, the cost of desalination was often around the €2.00–2.10/m³ level, which meant that this option could be seriously considered for only some very special situations, and under certain specific conditions.

Technological developments have consistently reduced the cost of desalinated sea water in recent years to a level that would not have been considered possible by the most ardent proponents of desalination technology even 10 years ago. Three sets of technological developments have been responsible for this dramatic reduction in costs.

- *Development of better and more reliable membranes for reverse osmosis (RO).* The earlier RO plants required two sets of membranes to reduce the salinity of sea water to the standards specified by the World Health Organization. By 1985, improved thin films, such as hollow fine-fibre membranes, meant that potable water could be produced through a single membrane pass. The technology has further improved so that the cost of membranes has now dropped by over 65% during the past two decades in real terms. The economic lives of membranes have also increased. At present, with proper care, a membrane can last five years or even longer, and it represents around 5% of the cost of the desalinated water.
- *Pre-treatment.* Major advances have been made in designing pre-treatment facilities for large open seawater intakes. Use of advanced alloys such as titanium has meant that highly corrosive acidified brines can be handled effectively at high pressures.
- *Advances in energy recovery technologies.* Probably the most important break-

through that has reduced dramatically the cost of seawater desalination during the past decade has been the advances in energy recovery devices that have been very specifically developed for seawater desalination plants using the RO process. Rapid commercialization of these isobaric chamber devices has meant that efficiencies of the order of 95% are not unusual, and energy consumption of 2.0–2.8 kWh/m³ of desalinated water is now possible under a wide range of operating pressures.

As a result of these technological advances, it is now possible for the private sector to build and operate seawater desalination plants, and deliver desalinated fresh water to clients at the €0.45–0.50/m³ range, profitably. Thus, for the latest major desalination contract that has been awarded in Singapore, the Public Utilities Board will buy 136 000 m³ of desalinated sea water each day from the SingSpring consortium for a period of 20 years starting from 2005, at US\$0.45/m³ of water.

For reasons of water security, Singapore has decided not to renew one of its two agreements to import water from Malaysia when it expires in 2011. Water that is imported at present will be replaced mostly by desalinated sea water.

As the demand for desalinated sea water increases (current annual global growth is of the order of 15–20%), more technological and management changes are likely to occur within the next decade, which in all likelihood will ensure the continuation of the current trend of steadily declining costs.

Unfortunately, the National Hydrological Plan has basically ignored these new developments. In one sense this neglect is not surprising. These reductions in desalination costs have been very recent, and thus the water professionals are mostly unaware of these new developments. The water profession as a whole continues to believe that the cost of desalinated sea water is still around US\$1.00/m³, which makes it a usable alternative only under certain special conditions.

Since Spain has a large coastline, and is also the most advanced country in Europe in terms of using seawater desalination, desalination could be an important new source of water. Accordingly, any transfer cost of water at the level of €0.45/m³ and over, for the post-2010 period, cannot be justified economically.

The desalination option will also be attractive over the water diversion alternative for several other reasons, in addition to the economic considerations. Among these advantages are the following.

- A massive amount of water will not have to be withdrawn from the Ebro River. This will mean that the anticipated adverse social and environmental impacts downstream of the withdrawal area will not occur. If a water diversion plan of reduced magnitude is considered for only the areas where water can be delivered economically, the adverse social and environmental impacts are likely to be significantly less. This will be an especially important consideration for the Ebro delta, which is likely to be affected most severely under the proposed plan.
- The National Hydrological Plan requires extensive construction of water-retaining and conveyance structures, with attendant social, economic and environmental implications. Consideration of a truncated diversion plan will reduce these implications very significantly.
- If water is needed in the Levante basins, many of the consumers (especially

urban and profitable agricultural producers) are unlikely to wait over a decade for the National Hydrological Plan to bring additional water to the area, because many uncertainties are associated with the implementation of the plan. If water is essential for urban, industrial and agricultural uses, and if the present and the future costs of desalination of sea water can prove to be economically attractive, both the public and private sectors will begin the construction of desalination plants. This development in terms of the construction of new desalination plants can already be noted in some parts of this region. The trend of construction of new desalination plants is likely to accelerate further in the future. It should also be noted that the cost of desalination of brackish water is significantly less than that of sea water. Depending upon the salinity contents of the brackish water, the cost per cubic metre could be within the €0.15–0.35 range, with the latest technology, and management techniques.

- Water demands can be satisfied as and when they surface, in terms of both area and time. This would give more flexibility in terms of demand management, which is not possible with any large-scale water transfer plan.
- The National Hydrological Plan, once it is constructed, will have a very high fixed capital investment cost, and the structures are likely to be present for two or more centuries. Once constructed, necessary or not, Spain will have to live with the National Hydrological Plan: there will simply be no alternative. In contrast, the costs of producing water through each new generation of desalination plants will be progressively lower. These plants generally have economic life spans of 15–25 years, after which they can be totally reconstructed, taking advantage of the latest technological developments. Existing desalination plants are now being retrofitted in many different parts of the world to reduce the production costs very significantly, some by as much as 60%. Such options are not available for the National Hydrological Plan.
- Because of the short gestation periods for the planning and construction of the desalination plants (typically two to three years), and low investment costs, the private sector can finance and operate such plants, thus making public sector financing unnecessary, or, at the very least, reducing it significantly. Because of the economics of the National Hydrological Plan, the very high level of investments needed and the long payback time for return on the investment (even if this is feasible), the private sector will not have any interest to provide the capital investment necessary for its construction and operation.

Thus, it is desirable to review the desalination of sea water and brackish water much more carefully than has been considered thus far. *Prima facie*, the desalination option appears to be a more attractive option for most of the Levante basins, compared to the proposed National Hydrological Plan.

Other Options

It is necessary to consider other options that may prove economically attractive and less socio-environmentally disruptive compared to the National Hydrological Plan, especially during the post-2010 period. One of these options is the transfer of fresh water over the sea in very large sealed rubber and fabric bags. Research on these water bags was started in the early 1980s, and by the late

1990s, these options were being used commercially, though to a somewhat limited extent.

The advantage of the water bag technology is that it does not have the very high capital investment costs needed for mega-projects such as the National Hydrological Plan, or the construction of pipelines. Fresh water can be transported from one coastal area to another, as and when necessary, and in the quantities needed, through these bags. Since fresh water floats over the saline sea water, the bags can be towed from one coastal area where water is in surplus to another coastal region where water is scarce.

The concept of water transfer through water bags is no longer in the realm of theory. For example, in October 1997, the government of Turkey signed a contract with the Nordic Water Supply Company (NWSC) of Oslo, Norway, for transferring at least 7 million m³ of fresh water annually from Manavgat River in central Turkey to northern Cyprus. The contracted price for this transfer is US\$0.55/m³. The water from the Manavgat River is transferred through its delta and then over the sea to northern Cyprus.

On the basis of the results of the experiences of the water transfer between Turkey and northern Cyprus, NWSC has improved the technology of water bags very significantly. The second generation of water bags are much more efficient and economically attractive, compared to the technology that was available in 1997.

In addition to NWSC, other UK, Japanese and US companies have now developed their own water bag technologies, some of which are already in commercial operation. For example, Aquarius Water Trading and Transportation Ltd, of the UK, currently has a contract to supply fresh water from the Greek mainland (Piraeus) to the island of Aegina by using such rubber bags.

As technology improves steadily, the cost of water transfer by bags over the sea will decline significantly within the next 10 years, which will further encourage the use of this option in the coastal areas of different countries.

Conceptually at least, water from the Ebro River and other rivers of the north could be considered for transfer to the coastal areas of the Levante basins through such bags. Because of the flexibility of this option, it will not be necessary to abstract all the water from the Ebro River itself: other rivers from the region can also be considered, provided they have extra water to transfer. A combination of abstraction of water from several rivers will ensure that the environmental stress on the Ebro River and its delta could be significantly reduced. A similar alternative of using water from several rivers is simply not feasible under the current National Hydrological Plan because of economic and technological considerations.

(3) *Forecasts of urban water demands.* According to the National Hydrological Plan, one of the main objectives of the water diversion plan is to meet the future water demands of the urban areas. The following important factors need to be considered to forecast future urban water demands.

Population

In order to estimate the future needs, it is essential to forecast the future likely populations of the areas where water will be transferred. The future population level will depend on natural birth and death rates of the regions, net in-

migration and out-migration from the regions and the seasonal population due to tourism and people who may live in the coastal regions for part of the year. It is possible to make these projections with a reasonable degree of accuracy over the next 15–20 years, especially as independent projections are available from the Instituto Nacional de Estadística. These forecasts are probably the best and the most authoritative projections available, which are somewhat less controversial compared to most other components of the plan.

Per Capita Water Demand

The existing daily per capita water demand per permanent inhabitant is estimated at 377 l for the Jucar basin, 336 l for the inland basins of Catalonia and 289 l for Almería.

The per capita water uses are primarily dependent on two factors: current prices charged to the residents per cubic metre of water consumed; and the efficiency of the management of the water supply systems.

For the domestic urban sector, it can be predicted with considerable certainty that the consumers will have to pay for the full cost of water supply and proper wastewater disposal during the post-2010 period. At present, there are wide variations in the water prices charged in various major cities of the water transfer region, ranging from a high of €1.33/m³ in Barcelona to €0.72/m³ for Almería, where water scarcity is greatest, and the even lower figure of €0.58/m³ for Castellón. As the cost recovery principle is applied, the unit water prices charged in different urban centres are likely to converge.

It is now generally accepted that there are considerable demand elasticities for water use, depending upon the pricing structures used. As water prices increase, water conservation increases as well, since consumers become more careful in terms of their water use practices.

In order to make some reliable forecasts of per capita water use, it is necessary to estimate the full cost of water beyond the 2010 period, as required by the EU Directive, which should also include environmental costs. These costs are not known at present. Prices charged for water will determine the average per capita water use.

It should also be noted that the standard European practice is to consider two components to determine water price. The first is the cost of the amount of water consumed. The second is a wastewater collection, treatment and disposal levy. This levy is based on the fact that in the final analysis, the same quantity of the water that enters a household is also discharged as waste water from the same household. This means that if a household consumes less water, its wastewater management levy will also decline. In other words, a household will pay less water tariff because of not only reduced consumption of water, but also the subsequent reduced discharge of wastewater. In other words, the economic incentives to consume less water in the first place become more and more attractive as the water prices increase in the future, due to the implementation of the full cost recovery principle.

It is highly likely that as the price of water increases by 2010 to meet the EU requirements of full cost recovery, the per capita water demand will decline. This will probably be most noticeable in Castellón, Tarragona, Valencia, Almería and Alicante, where water prices are currently low.

The implications of water pricing for urban water demand have still not been

Table 1. Average water cost in European countries in 1999 (€/m³)

Country	Average cost (€/m ³)
Germany	1.69
Denmark	1.51
Belgium	1.13
Netherlands	1.10
France	1.09
UK	1.07
Italy	0.68
Finland	0.59
Ireland	0.57
Sweden	0.52
Spain	0.50

fully appreciated by the water professionals in Spain, and this lack of awareness is shared by the National Hydrological Plan. On the basis of the existing data available, Spain had one of the lowest water prices in the EU, in 1999, the latest year for which such data are available. This is shown in Table 1. The average domestic water price will have to be increased in Spain to comply with the EU Water Directive, and also to catch up with the water prices charged in other EU countries.

This means that in 1999, the average water price in Germany and Denmark was more than three times that of Spain, and in Belgium, the Netherlands, France and the UK, more than two times.

Thus, within the next decade, water prices in cities such as Castellón, Terragona, Valencia, Almería and Alicante may double, and in Murcia they may increase by more than 50%. Even in Barcelona, which now probably has the highest water price in the region, the cost may increase by another 30–60% by 2010 in real terms. These increases will dampen water demands significantly.

One of the reasons as to why the cost of water will increase in the coastal cities of the Levante basins is the higher levels of wastewater treatments and disposal practices that will be necessary, since discharge of inadequately treated waste waters to the sea will no longer be an acceptable option. Water prices in the post-2010 period will have to consider recovery of all these types of increased treatment costs under the EU Directive.

Such rapid increases in water prices will unquestionably reduce per capita demand, which is not reflected in the current water demand forecasts in the National Hydrological Plan. To what extent the average demand will decrease will depend on the prices charged for water by 2010 and beyond, the level of economic activities and socio- environmental conditions. Thus, additional studies are needed: first, to estimate the likely water charges by 2010 and beyond; and then to estimate the impacts such increases may have on the per capita water demands. Such studies are yet to be conducted.

Realistically, it can be expected that the per capita water demands may decline by around 15–30% in most urban areas, compared to what they are at present, because of increasing costs to consumers.

According to the Asociación Española de Abastecimiento de Agua y

Saneamiento (AEAS-AGA, 2001), the per capita water use in Spain, in spite of the current low water prices, is already showing a downward trend, from 307 l in 1987 to 284 l by 1998. The significant increase in water prices during the next decade is likely to further accelerate this declining trend.

Another important issue of per capita water use figures that has not received adequate attention in the National Hydrological Plan is the extent of unaccounted for water that exists in the current water supply systems. It is estimated that the current level of unaccounted for water in the regions, where water will be transferred, ranges between 20% and 35%, with the higher losses for the smaller urban centres of between 20 000 and 50 000 population.

These unaccounted for losses can be reduced significantly and cost-effectively within a very short time period. The technology for reducing such losses and the management practices needed have been known for many years. However, not only in Spain, but also in most other parts of the world, the mindset of the water professionals has generally been to construct new infrastructures to expand available water supply, instead of making the existing management practices more efficient. Unquestionably, the cheapest new, alternative source of water will be to reduce these losses so that the water thus saved can be used for various productive purposes. An additional advantage will be that water that will be saved has already been collected and treated, unlike any other new sources of water.

In order to see what may be possible in terms of reducing the current level of unaccounted for water, a comparison with the situation in Singapore and Tokyo can be an indication of the direction in which the water management practices in the Levante basins must move in the future. The figures available for 2001 indicate that the unaccounted for water for Singapore is around 6%, and for Tokyo, 6.5%.

Assuming that the unaccounted for water is reduced in the urban areas of the Levante basins to 10% by 2010, and per capita use is reduced by another 15% due to the expected price increases by 2010 (a conservative estimate), it means that *the existing and forecasted per capita demands can be reduced by at least 25%, without having any perceptible impact on the lifestyle of the people, and without any disruptions to the environment and the ecosystems.* The National Hydrological Plan, unfortunately, gives inadequate attention to this type of 'soft' policy option, which is likely to produce optimal results for all parties concerned, including the environment.

(4) *Forecasts of industrial demands.* Except for the inland basins of Catalonia, industrial water demand is not a significant consideration for the Levante basins. If cost recovery increases water prices for industry significantly by 2010, as is expected at present, experiences from other parts of the world indicate that water requirements will be drastically reduced by industry through extensive reuse and recycling.

It can be conservatively estimated that the higher water prices will reduce the industrial water demands in the inland basins of Catalonia within a range of 25–35%, which is likely to reduce the projected water requirements under the National Hydrological Plan in this region by 74–100 hm³ per year, not an insignificant quantity.

Additional studies will have to be undertaken to forecast industrial water demands reliably for the post-2010 period. All that can be said confidently at

present is that like the urban water demand, the National Hydrological Plan has also overestimated industrial water demand, by a significant amount.

(5) *Macro-agricultural situation.* A fundamental shortcoming of the plan is that it uses basically a business-as-usual incremental scenario for the future. It does not consider the fact that the macro-agricultural situation in the Levante basins is likely to undergo very major structural changes during the post-2010 period, as a result of which the projected market and demand for the agricultural products may not materialize. This will have a very significant impact on water requirements.

In other words, the National Hydrological Plan does not consider the world as it is likely to be in 2010 and beyond: it assumes implicitly and explicitly that the past trends will continue more or less along similar lines over the coming decades. During the next 20 years, the world is going to change radically, and with it water use patterns and management practices. Since the plan has been conceived mostly under static trends, it ignores completely the major changes that are likely to occur during the coming decades. These changes will ensure that many of the fundamental hypotheses on which the National Hydrological Plan is formulated are somewhat erroneous and, in some cases, even irrelevant. One of the assumptions which is likely to be proved wrong is that agricultural production in the Levante basins will continue to increase in the coming decades.

By the time the plan is implemented, the world's economies are likely to be more integrated, certainly much more than at present. Agricultural support policies in the existing EU member countries are likely to be radically different by 2010, and most certainly by 2015. Market price support for agricultural products and output-related payments has already started to decline in the EU countries. Furthermore, agricultural policies are now under close review in most countries participating in the current multi-lateral negotiations under the aegis of the WTO, and in response to changing national priorities and international requirements. The outcomes of these forthcoming agricultural trade policy reviews and their possible reflection in terms of an agreement under the WTO negotiations will have far-reaching implications for the agricultural sector during the post-2010 period. Spain in general, and the Levante basins in particular, will not be an exception to these changes.

The Uruguay Round Agreement on Agriculture has had some impacts in partially opening markets in agricultural products. Even after this agreement, high tariffs and trade barriers are distorting domestic agricultural production, market prices and regional and international trade in agricultural products. These distortions are likely to be reduced significantly within the next 20–30 years due to more economic integration and evolution of freer trade practices. Under this expected scenario, the Levante basins may not have much competitive advantage in marketing the agricultural products they are producing at present for cost reasons, especially after the 2015 period.

New countries are joining the EU. Several new members are likely to join before 2010. It is also highly likely that within the next 15 years, Turkey may become a member of the EU, or at least will have a free trade agreement with the EU. Turkey's agricultural production could increase substantially if it becomes a member of the EU. Its level of economic development is in line with the average EU accession candidates, and not too far behind the levels of develop-

ment in Greece, Portugal and Spain when they joined the EU. If either of the above assumptions proves to be correct, it will be very difficult for the farmers of the Levante basin region to compete economically with very similar products that Turkey could produce, which it could market at a much lower cost. This is an important consideration, especially as Turkey is developing its Southern Anatolia region on a priority basis, with an estimated development cost of €32 billion, a significant part of which has already been spent.

A major consideration for the Southern Anatolia Development Project is the expansion of the irrigated area, a significant part of which is already operational, and the construction of an international airport in this region which could transport agricultural products efficiently to the European markets. With low labour costs, and lower water costs (the region has two major rivers, the Euphrates and the Tigris), this region can produce and export similar agricultural products much more cheaply than the farmers of the Levante basins.

In addition, availability of agricultural labourers is not a problem for Turkey, whereas it is a major constraint for Spain, since many of the current agricultural workers are mostly illegal immigrants from North Africa. The expansion of agricultural activities in the region will invariably require more labourers. These agricultural tasks are not attractive for EU citizens because of low pay and hard work. The availability of work may also be seasonal. Thus, if agricultural production and the associated activities are to increase, it will mean the use of more illegal immigrants in the future. Politically, it may not be an easy task, since the EU is taking accelerated steps to reduce illegal migrations from all fronts. Even if the migrants are available, their social and economic integration into Spanish society will be a difficult and complex task, which should not be underestimated.

In order to reduce illegal immigration from North Africa to Spain, the EU may have to consider economic packages so the migrants can be gainfully employed in their own countries. Since agriculture is an important activity in Morocco, a realistic guess will be that there will be increasing liberalization of agricultural trade between the EU and Morocco, so that fewer people will consider migrating to Spain illegally. Again, if the trade and tariff barriers are reduced, the Levante basin area will not be able to compete with similar agricultural products from Morocco for reasons of costs and labour availability. Also, the very close proximity of Spain to Morocco would mean that the transportation costs for the agricultural products would be minimal, and fresh produce could be sold in Spain promptly.

If these future scenarios prove to be correct, the agricultural production in the Levante basins may very well start to decline and not increase, as is currently expected under the National Hydrological Plan. In this case, by the time the diverted waters can enter the Levante basins, the agricultural water demands may actually start to decline. This must be a strategic consideration for the plan before a final decision is taken as to its implementation. This issue requires major studies by the macro-economic and trade experts, rather than the water professionals, as has been the case thus far for the plan.

Conclusions

By any account, the National Hydrological Plan is a mega-project. If implemented, it will very significantly change the landscape of the entire water

diversion region, starting from the downstream of the Ebro River all the way to Almería. Also, once implemented, the impacts will be permanent and mostly irreversible. Accordingly, it is absolutely essential that the need for the National Hydrological Plan should be carefully assessed first, along with careful and reliable analyses of its cost-effectiveness and environmental and social impacts, before the construction starts.

Because it is a mega-project, which will unquestionably have a long gestation period before its construction is completed, it is essential that it addresses the conditions of the region, as they are likely to be when the National Hydrological Plan is expected to be fully implemented. Hence, the plan must be forward-looking, and should realistically assess the conditions that are likely to prevail during the post-2010 period. In addition, it must reliably analyse the impacts of non-water-related issues of the post-2010 period which are likely to affect the water sector significantly. For example, changes in patterns of agricultural trade, the requirements of the EU on water and environmental issues, increasing integration of national economies and the impacts of globalization are some of the important issues which must be properly and adequately considered within the overall framework of the plan.

Based on all the present indications, it is now certain that the world in 2020 will be vastly different to what it is today. The National Hydrological Plan, if constructed, will remain operational not only during the post-2015 period, but also most probably during the 22nd and even the 23rd centuries. It is thus a fundamental necessity that the plan is based on a realistic understanding of the future conditions, instead of being a mere extension of the past and present trends and experiences, which may be of limited validity in 15–20 years' time, and totally out of date beyond 2025.

In the area of water management, practices will change dramatically during the next 20 years. In fact, in all likelihood, *water management practices will change more during the next 20 years than in the past 2000 years*. Thus, any project with an economic life span of 100 years or more must be future-oriented.

On the basis of an in-depth analysis carried out, it can be considered that *the plan is very conventional and static*. It is based on the experiences, expectations and trends of the 1980s and the early 1990s, rather than the likely scenarios of 2020 and beyond. Accordingly, many of the fundamental assumptions which underpin the National Hydrological Plan will become obsolete well before even the construction of the plan is completed, let alone for the rest of the 21st century.

Much of the water demands that have been forecasted by the plan are unlikely to materialize, due to increasing emphasis on demand management practices, and major structural changes in the agricultural sector that will occur by 2020 because of expansion of the EU, the culmination of the ongoing negotiations that are being undertaken under the auspices of the WTO and greater market access within the EU to agricultural products from developing countries, such as Morocco, so that people can be encouraged to stay in their own countries rather than migrating illegally to the EU.

Furthermore, if any additional water is needed beyond the 2015 period, much of it (especially over the last half of the diversion route) can be provided from other, alternative sources such as desalination and the use of rubber and fabric bags for transferring water over the ocean. The costs of these alternatives are already cheaper than the costs of deliverable water in the Levante basins with the National Hydrological Plan. In addition, the costs of the alternative sources

of water will most certainly continue to decline during the next decade and beyond, due to rapid technological developments. In contrast, and equally certainly, the current projected costs of water in the southern parts of the diversion project will rise significantly by the time the project is completed. At the end of the diversion project, the current projected cost per cubic metre of water delivered is nearly twice the cost of desalinated sea water. Accordingly, *the differences between the unit costs of delivering the water through the National Hydrological Plan and the alternative sources will only widen in the future, making the project economically unviable.*

No comprehensive environmental and social impact analysis of the National Hydrological Plan is available at present. These studies must be undertaken on an urgent basis. It is likely that these environmental and social costs will be very high, and that the costs of their amelioration will be equally high. Incorporation of these environmental and social costs will not only further increase the cost of the National Hydrological Plan, but also its desirability may have to be seriously questioned, due to its anticipated adverse impacts.

To conclude, the National Hydrological Plan in its present form cannot be justified for economic and environmental reasons. The plan will not be necessary if demand management practices are efficiently formulated and implemented, and because alternative sources of water will be available at a much lower cost. If the National Hydrological Plan is constructed, it is likely to be a very expensive 'white elephant', and a magnificent monument to bad planning for decades, and even centuries, to come.

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