THE ADVANTAGES OF SEAWATER DESALINATION FOR REGIONAL COOPERATION IN WATER RESOURCES MANAGEMENT

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Abstract

Increasing demand for water has shifted attention in the last three decades to the role of desalination that has become a key to close the gap between water demand and supply in water-scarce but resource-rich region. Water supply by desalinated water is gradually prevailing among other countries caused by decline of the production cost. Consequently, the installed capacity of desalination in the world is predicted to double by 2025, which means that 2 % of fresh water supply in the world will rely on desalination technology.

However, further desalination enhancement is still controversial. Proponents insist that desalination already have been a mature technology and its cost will continue to decline down to affordable prices for anyone, and emphasizes that it can enlarge the resource pie, that is "it is only a realistic solution". Opponents respond that the facile expansion of desalination will lead to unacceptable consumption of fossil energy with regards to global warming; also a myriad of non-structural methods to alleviate water shortages such as existing water resources sharing, changing uses' behaviors would remains unimplemented. Both seem to be reasonable, also both are not discussing the whole picture of this matter. No wonder that desalination differs from traditional water systems. It has advantages in water cooperation which are inherently lack in conventional water resources, also has disadvantage which have to be managed carefully. What is important is to clarify different characteristics of desalination in terms of integrated water management. It is time to determine how to use desalination technology wisely from now on.

1 DESALINATION, "SILVER BULLET" OR "FORBIDDEN FRUIT"?

1.1 Current status of desalination

Desalination technology can produce freshwater which we are facing shortage, unfortunately, from seawater or blackish water which is abundant around us, fortunately. Therefore it naturally seems to be "Silver bullet" to resolve our facing water difficulties. Desalination of saline water has been practiced regularly for over 50 years, and a great deal of efforts has been done to make it available. Accordingly, it comes to be a well-established means of water supply in many arid and water-shortage regions of the world, where the lack of fresh water cannot be overcome with traditional water supply or transfers from elsewhere. Also, desalination technology has become feasible, technically and economically, to produce large quantities of water of excellent quality.

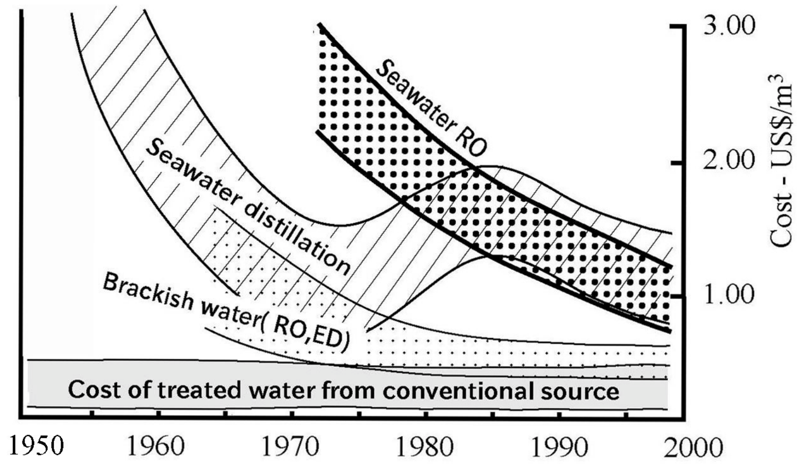

Figure 1 Desalination cost ranges over time

(Source: Buros 1989; Murakami 1995 revised)

Challenges, however, still exist to produce desalinated water for relatively large communities, for their continuous growth, development, and health, and for modern efficient agriculture, at cheaper costs (Gleick 2000).

Until quite recently, desalination was always last on the list of alternative water supply. Yet the long standing cost barrier has been broken drastically during the last decade and is down to the level of \$0.50 to \$0.80 /m^3 of desalinated seawater mainly due to technological improvements, and the declining cost tendency continues (as show in **Figure 1**). Desalination of brackish water is even cheaper, at costs ranging from \$0.10 to \$0.35 /m^3. Consequently, many countries, not only in the arid regions but also other counties receive which relatively much rainfall such as Japan and Taiwan, are now considering desalination as an important source of alternative water supply (Semiat 2000).

In contrast, the treatment cost of water from ground and/or surface water in many regions is now higher than before, even dating back as far as in ten years ago (World Bank 1993). The costs to produce freshwater from conventional water resources in western countries range from \$0.40 to \$0.75/m^3 before distribution. As the result, the cost gap between desalinated water and conventional water is narrowing year by year. Also, some counties which subsidize consumer prices, do not reveal the true costs necessary to produce fresh water, but it is predicted that true costs will be applied more and more frequently in the future by introducing water pricing policy which reflects true cost prices of freshwater to decrease water demands and develop public awareness on water, so these prices will tend to increase. As desalination cost progressively break through the level of real conventional freshwater cost, the change of water-pricing policy may contribute to a broader use of desalination technology, especially in coastal areas.

At present, only about 1 % of the world's potable water is derived from desalination plants. The total capacity is about 32.4MCM/day as of 2001, as compared from 20.3 MCM/day in 1995, of which approximately 60% comes from seawater and 40% from brackish water (IDA 2002). The increase in desalination has been 6 % per year over the last twenty years; the quantity of desalinated water is multiplied by 1.8 every ten years. A recent market expectations reveals that new desalination plants could be supplying up to 120 MCM/day by 2025 in the 18 driest countries in the world, where water supply per capita falls well short of daily demand (Bremere et.al 2001).

1.2 Pros and Cons of further enhancement of desalination

Water supply with desalination technologies at acceptable cost is coming on the horizon due to technological breakthrough in recent years. Consequently, a sort of optimism that desalination technologies will eventually resolve the world water shortage seems to dominate in the discussion over the future role of desalination. The protagonists tend to emphasize that desalination can expand the capacity of water supply and its cost still has been acceptable and will continue to decline. Also, populations are growing along the many coastal regions of the world. By 2025, mega-cities may very well be home to some five billion people (Stikker 2002). From this point of view, the desalination capacity will have to expand unlimitedly in order to alleviate water scarcity according to continuous population growth. In addition, if augmentation of water supply by desalination increase more than ever, it be may difficult to predicted whether or not the environmental impacts of desalination ranging from brine disposal to energy consumption will intensify even though they are seemingly negligible or manageable at present. Unlimited enhancement of technical-complicated desalination would affect the sea of which crucial role in the ecosystem remain little-known, and would call other intricate "Unknown Unknowns" problems in the word of Homer-Dixon (Homer-Dixon 2000).

Given that we divide the ways to alleviate water shortage, it is primarily divided into two ways, or two paths (Wolff and Gleick 2002). One path - the "hard path" – relies, almost exclusively, on centralized infrastructure and decision-making: dams and reservoirs, pipelines and treatment plants, water departments and agencies. After their words, desalination technology may be defined as "the hardest path".

The second path - the "soft path"- may also rely on centralized infrastructure, but complements it with extensive investment in decentralized facilities, efficient technologies, and human capital. The soft path strives to improve the overall productivity of water use rather than seek endless sources of new supply. In a word, the problem in water shortage is more one of politics and management. According to this argument the large-scale introduction of desalination is a "Forbidden fruit" because it is considered as:

- requiring an unacceptable level of fossil fuels in light of global warming
- too costly, too large in scale, and too technical for universal solutions
- an impediment to awareness raising and efficient water management

As many have said, we have to recognize that the water resource management should move from manipulation of natural water system to manipulation the human system as a management tools. That is, we should change our profligacy and lack of water-consciousness through developing a "water ethics" (Postel 1992). However, a new ethics must be based a balance between humans and technology and among structural and non-structural approaches. Rarely have either worked alone and it is time to stop characterizing them (Delli Priscoli 1998).

The gulf between the pros and cons seems to arise from the lack of recognition of seawater as a water resource. The recent trend apparently indicates that we have to rely on desalination technologies to meet increasing water demand, willingly or not. Then, it is time to characterize the role of desalination in order to use it wisely in the context of integrated water resources management.

2 CHARACTERIZING SEAWATER DESALINATION AS A WATER RESOURCE

2.1 Characterizing conventional freshwater problems

Prior to address the role of desalination in integrated water management, it is important to be clear on characteristics and difficulties of conventional freshwater problem on basis of insightful previous studies beforehand. Current difficulties of conventional water resources are follows;

1. Degradation (Pollution)

2. Scarcity (Shortage)

3. Misdistribution (Inequitable allocation)

4. Disaster or accident (natural or caused by humans)

According to Rogers (1992), each of these problem categories is a sort of externality on water systems, which involves an important change from a previous status quo marking the availability of water resources. When there resources are shared among countries and their availability becomes threatened, the potential for transboundary freshwater dispute exists.

Over all water-related problems, transboundary freshwater disputes have been a center of contention for a long time. For many arid and semi-arid countries, transboundary freshwater bodies have been only the new additional sources of water that could be economically developed to meet their increasing water demand. An international river is a common property resource shared among the basin states. Water used in river basins has the property that both positive and negative externalities usually have their effect in only one direction, that is, downstream. This unidirectional feature of water use means that resolution of basin conflicts through mutual control of externality in the river water has caused in difficulty. The downstream riprians must often balance the asymmetrical water relationship by the use or exchange of resources from outside the water domain, for example, economic or military power in the upstream direction (Rogers 1992), or must be reconciled themselves to the weaker standpoint. This asymmetry adds another difficulty to the current water problems, and the settlements must be more complicated to settle for the future, considering rapid population increase in the world.

2.2 Characterizing the geopolitical features of seawater desalination

Seawater desalination plants locate by the sea and uses seawater as feed water to produce fresh water. In comparison, conventional water supply system, which uses river water and groundwater as feed water, also needs some treatments to meet some standards before distribution. In this sense, seawater is regarded as a sort of "fresh water resource" and has different geopolitical characteristics from conventional fresh water resources as described below.

Seawater as a water resource is multidirectional and symmetrical

Opposed to the unidirectional feature of the international river, the sea has multidirectional nature by and large. Even though there are differences of accessibility among littoral states stemming from the length of shoreline or the direction of ocean current, it can be said fairly that there is no absolute dominance in terms of quality, quantity and accessibility as the disparity between upstream and downstream in the river system. That is, the littoral states have to share both positives and negatives from the sea. In fact, this multidirectional feature of the sea requires the countries to act more cooperative in maritime issues than in freshwater issues. UN convention of the Law of the Sea, the Global Programme of Action for the protection of the marine environment from the land activities (GPA) and the Regional Sea program headed by UNEP are the major examples.

Thinking of seawater as a fresh water resource for seawater desalination, cooperative marine environmental protection by littoral states would be important, in particular water quality. The desalination cost varies according to location, salinity and source of energy, needless to say, feed water quality. Man-induced pollutant such as oil spills has resulted in increase of production cost in some desalination plant in the Arabian Gulf, and this adverse impact is not unidirectional and symmetrical among littoral states in the long run.

Climate independence

One of the great advantages of desalination is that it is not climate dependent. Fresh water supply via the desalination plant is guaranteed year-around regardless of the year-to-year fluctuation of rainfall.

It is repeatedly emphasized to make regional water treaties and international agreement over water flexible in case of unexpected shortages as an institutional safety net (Gleick 1993). Nevertheless, almost the treaties of international rivers, which do allocate specific quantities, allocate a fixed amount to all riparian state (Wolf 1999). Taking Israeli - Jordan case in 1999 as an example, a water dispute stemmed from Israel's decision to cut Jordan's allocation in summer down to 40% of the fixed amount in Peace Treaty because of less precipitation in two consecutive winters. Jordan rejected to Israeli plan to reduce water supplies, but the dispute was finally settled through negotiation. This drought exposed the vulnerability of shared water resources to call a political instability. It is difficult to predict precisely what the global warming will impose on water resources, but the yearly fluctuation of rainfall is likely to intensify. Desalination can serve a technical safety net in such climate change era.

Creation of a sense of ownership

Desalination creates a sense of security by virtue of the state's ownership of the resources and installation it considers vital (Nachimani 1997). Water disputes in the Middle East are, in large part, couched in terms of ownership right. It is commonly recognized that there is a need to state's ownership-oriented attitude is disintegrated to establish the regional cooperation in water system. Nonetheless, severe stress of conventional freshwater resources is scarcely an impetus to throw it away so far. A sense of ownership is inherently a win-lose proposition to impede a further cooperation, but by using the alternate definition of the problem as one of water usage, creative and collaborative problem and negotiation may be possible (Specter 2001).

We have to remember that the political reality is always looming in a manner as "in some parts of the world, people just hate each other" and "Which flag flies over the pumping station can be wildly more important than the marginal cost of pumping water"(Wolf 2002). Ownership right of freshwater is closely related to state's land ownership, namely "high politics" of war and diplomacy prior to "low politics" of economics and welfare. If cooperation over water management would not be accomplished until larger issues of mutual recognition and refugees are settled as Lowi (1990, cited by Wolf 1995) concluded, the new sense of water ownership by desalination may be a toehold to let moonlight into the realm of "high politics". Desalination can assure a new indigenous water supply; a creation sense of water security is one of the irreplaceable roles of desalination in the political context.

Temporal reliability

Desalination technology can ensure to supply freshwater within a predicable time period. Speed of completing something is very important in some cases. The pace of population growth and decline of water availability with a tangible time scale, for example, world population will reach about 7 billion by 2025 (UN 2001). However, when we discuss the importance of decreasing of water demand, we seldom refer all means to alleviate these problems with time for completion. In fact, till when will water profligacy be eradicated? How long does it take to implement effective regional cooperation on water resources management? Increasing water demand never stands still to wait for us in the meantime; if anything, the demand augmentation might well overwhelm these improvements in speed. Conventional water resources development, in which new resources are quite few, is no longer tenable to fight against the speed of increasing demand. In the meanwhile, desalination technologies can assure a certain amount of water along the timeline when the plant is completed. We should never forget that the combat against water problem is not only a matter of quality and quantity but also an attempt against the time limit.

Many aspects particular to conventional water resources such as current and future quantitative shortage, transboundary issues, its ownership, climatic vulnerability and asymmetry of upstream and downstream can both provoke conflict and induce cooperation. By comparison, characteristics of seawater desalination can reinforce the weakness of the conventional water resources, which hinder the cooperation over water issues. The advantages of seawater desalination in cooperative water management will be discussed in the following section.

2.3 Seawater desalination: Preventive tools for cooperative water resources management

It becomes commonsense that freshwater water sources should be share equally among stakeholders to use more effectively and wisely as well as to prevent future water-caused conflicts. Many aspects of conventional water resources exist intrinsically in a precarious balance between conflict and cooperation at present. It can lean toward undesirable side, conflict unless we try to manage. On the other hand, as discussed in the previous section, seawater desalination has favorable features which can shift the balance toward cooperation, rather than toward conflict.

Wolf (1996) suggested possible steps to be taken to implement a regional water development plan that incorporates the political realities of the region as well as the limitation imposed by economics, hydrology and demography. Then, what can seawater desalination contribute in steps toward a regional water development? The answers to his suggestions are below;

1. Disintegrating the control of water resources to address past and present grievances to re-establish property rights. A separation of inadequate existing control of water resources might be a precondition to future integration.

The fresh water supply by seawater desalination is relative new and small, therefore and present water ownership does not exist at present. A sense of water security can be established independent of contemporary, occasionally hostile, fresh water ownership dispute.

2. Examining the details of initial positions for options to induce cooperation. The creative solutions needed from to move from distributive bargaining (win-lose or zero-sum) over the amount of water each entity should receive to integrative bargaining (win-win), that is, inventing options for mutual gain.

The marine environmental degradation will reflect the cost of freshwater production symmetrically among littoral states. It means that the cooperative protection of marine environment is a mutual gain to keep the production cost in low level, and eventually is called as integrative bargaining in terms of “seawater as a water resource”.

3. Designing a plan or project, starting with small scale implicit cooperation and building toward to ever-increasing integration, always helping political relations. Starting on that small-

scale cooperation, and mindful of the concerns of equity and control, projects might be developed to increase integration within in the watershed, or even between watersheds over time.

It is frequently a hurdle to find a toehold for "small scale implicit cooperation" in conventional water resources management. In the meanwhile, existing frameworks for the protection of marine environment might well be corresponding to "small cooperation" in the discourse and will provide a good opportunity for ever-increasing cooperation in the coastal water management including seawater desalination.

The environmental impacts of seawater desalination are seemingly negligible and manageable in the present situation of installation. However, the capacity of seawater desalination will be expanding in the coast regions in the world. Based on the concept of "preventive diplomacy" to facilitate cooperative water management, the earlier to prevent externalities caused by seawater desalination, the better. Also, the water security for the water-scares countries is undoubtedly a super ordinate goal, as compared to the protection of marine ecosystem. To sum up, seawater desalination can deserve a catalyst to cooperative water management and to prevent and resolute the water-related conflict if well-designed cooperative framework is implemented in the region.

3 ADVANTAGES OF REGIONAL COOPERATION ON SEAWATER DESALINATION: CASE STUDY OF THE GULF OF AQABA

3.1 The Gulf of Aqaba – Overview

The Gulf of Aqaba is a semi-enclosed water body attached to the Red Sea (**Figure 2**). It is a part of the Syrian-Africa Rift Valley system, as well as the Dead Sea, with a length of about 170 km and a width range of 5-25 km, average about 15 km. The Gulf of Aqaba is shared by Egypt, Israel, Jordan and Saudi Arabia, and its unique ecosystem and biodiversity have been environmentally degraded for the last 30 years, threatened by oil spills, sewage discharges, tourism development, and other land activities. Development and implementation of a comprehensive strategy and plan for environmental protection, both must be required equally (World Bank 1996).

3.2 Socio-economic development and environmental threats in the Gulf of Aqaba

The Gulf of Aqaba has also an important role for socio-economics development, but circumstances are slightly different by each littoral state. Egypt's coastal zone currently hosts no significant manufacturing industries but tourism is expanding rapidly in their relative longer shoreline; Jordan's coastal zone is the only outlet to the sea and a crucial important area to the national economy, and established in 2000 as a free economic zone (Aqaba Special Economic Zone: ASEZ) to boost socio-economic development. Socio-economic activities in the coastal region are roughly classified into the following categories.

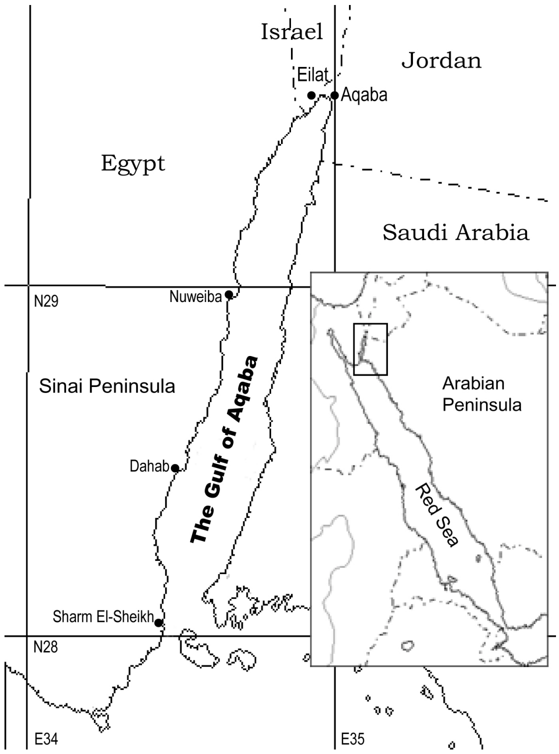

Figure 2. The Gulf of Agaba

(1) ***Port activities***: Port activities in the Port of Aqaba, which has become one of the major shipping centers in the region. The only port in Jordan is naturally an essential key to further development as defined in "Master plan 2000-2020" established by Aqaba Special Economic Zone Authority (ASEZA) and the Jordanian government. Port activities cause the major threats to marine environment: oil spills, solid wastes and phosphate dust.

(2) ***Tourism***: its unspoiled coral reef and biodiversity are invaluable treasure for the future aquatic tourism expansion in the Gulf of Aqaba. Egypt, Israel and Jordan encourage facilitating tourism development, attracting new luxury hotels in an undeveloped stretch of shoreline. However, unregulated aquatic tourism may lead to the damage of the invaluable coral reef. Currently, the coastal region is in boom of hotel construction, and most of them possess a private small desalination plant by each.

(3) ***Industries***: Industrial production is the largest revenue generator in the Aqaba region from fertilizer and mineral processing, accounting for approximately $360 million in Jordan. Land-based pollutions from industries such as have been major threats to the marine environment and coastal groundwater for last decades.

3.3 Water situation in the Gulf of Aqaba

Average annual rainfall in the Gulf of Aqaba is around 50 mm/year, so rain-fed water supply cannot be expected. Water supply for industrial, municipal and tourism is provided by fossil groundwater in Jordan, brackish/seawater desalination in Egypt and Israel. Given that the population growth and socio-economic development, seawater desalination is the only reasonable solution in order to respond the increasing demands in this area. For example, the population in the city of Aqaba is 95,000 in 1998, and is predicted to be 199,900 in 2020; as a result, the water demand will increase from 17MCM up to 23MCM (this value is estimated with the future improvement of unaccounted for water, JICA 2001). Jordan has started to implement desalination pilot plant with 1 MCM / year, and it is supposed to be 5 MCM by 2010. In Israel, RO desalination plant for brackish water has been operated in Eilat since 1970s, and the current capacity reaches 44,700m3/day (=16.3MCM/yr). In Egypt, the current total water demand of three major areas in the coastline, Dahab, Nuweiba and Sharm El-Sheikh, is estimated to 14.6MCM/year relying on desalination and over 40 hotels and tourist resorts are under construction (Rayan et al. 2001).

3.4 Socio-economic development, Marine environment protection and Water supply by seawater desalination: Cooperative framework for marine environment as a water resource for seawater desalination

In the Gulf of Aqaba, socio-economic development, marine environment protection and water supply are closely interdependent for each littoral state and will be more closely when seawater desalination will be implemented. This interdependency, both positive and negative, is not upstream-downstream relationship but almost multidirectional. Still now, a myriad of marine pollutions is threading environment in the Gulf of Aqaba. Future expansion of seawater desalination may be a new serious thread to the coral reef (Mabrook 1994). Its unique environment, home of the world's north-most coral reef ecosystems, is also basis for the aqua-tourism., which is a key component for socio-economic development in the region. Also, as described earlier, marine pollutions will lead to the cost increase in the shape that further pretreatment is required.

Existing cooperative frameworks in the Gulf of Aqaba

To establish cooperation over conventional water resources and make it stable, it has been discussed a need to link freshwater allocation issues to other issues like water environment (See for example, Shmuel 1999). In fact, however, given that inter-state conflicts and inter-sectorial disputes over scarce freshwater, the linkage to water environment happens to be more intractable because this linkage implies to lessen a portion of meager freshwater for other sectors. By contrast, seawater is more plentiful and some cooperative frameworks for marine environmental protection still exist over years. If the hypothesis of linkage is effective, existing framework for marine environmental protection could be the stepping board.

Of the many multilateral conventions on marine protection, it should be noted that the Regional Sea Programme following the Stockholm Conference on the Human Environment of 1972. The first Annex of the 1973 Convention on Marine Pollution (MARPOL) established "special areas" requiring heightened protection from oil pollution. In these special areas, including the Red Sea and the Gulf of Aqaba, discharges of oily ballast water were limited and treatment equipment mandated. The UN also began incorporating environmental concerns into its larger multilateral treaties, including the 1982 Convention on the Law of the Sea (Zwirn 2001). Also, Gulf of Aqaba Environmental Action Plan, set by Global Environmental Fund since 1996 (World Bank 1996), is implemented to protect globally unique ecosystems and biodiversity. Additionally, Jordan and Israel have established a Joint Committee for the Environmental Management of the Gulf to develop a bi-lateral regional environmental protection program since 1998. These existing platforms can be invaluable advantages for regional cooperation in water resources in which seawater desalination is likely to play an important role for water supply for the future.

4 CONCLUSION

Desalinated water supply will occupy only 1 % of the total water supply, up to 2-3 % ten years later. Conventional water supply will have to remain essential on the water resources management from now on, so we never over- and underestimate the role of desalination. It is neither “Silver bullet” nor “Forbidden Fruit”. Rather, it is just like “antibiotics”, for augment' sake. Its efficacy must be remarkable, whereas its abuse may call unexpected results unless well prescription – for example, something like resistant to antibiotics. Water resource management should be primarily encouraged to improve effectiveness of conventional freshwater use, both technically and socially. Desalination technology has a potential to contribute to water issues by giving us a catalyst to find the way out of an impasse we are getting stuck with. In the end, Things should be emphasized are follows;

1. Seawater desalination will be expanded inevitably to soothe the water scarcity, in particular the coastal region s in the world where high population growth is expected. However, desalination has different characteristics from conventional water systems which are both favorable and unfavorable. If the cost is reduced further, desalination may be likely considered as a deceptively simple solution for policymakers, private sectors and international donors. The abuse of desalination would lead to other environmental uncertainties and impediments to improvement on effectiveness of conventional water resources. An adequate management for seawater desalination should be established as soon as possible before reaching the point of no return.

2. Thing should be remembered by policymakers, private sectors and international donors is that seawater desalination has more cooperative features through technology exchange, marine environmental protection and sharing water resources than transboundary fresh water resources. Accordingly, it has a significant function to augment water supply by itself, likewise it should be served as a catalyst to call further cooperation in marine environment protection, socio-economic development and existing freshwater management, that is, synergy effects. Unlike freshwater issues in which there are few multilateral regimes for cooperation, there are existing frameworks in maritime issues over years regarded as the first step to the cooperation over freshwater supply. It is essential for use to take advantage of good points of both and to avoid being suffering from disadvantages.

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