Water Resources Management **17:** 447–461, 2003.

A Decision Tool for Allocating the Waters of the Jordan River Basin between all Riparian Parties

ZIAD A. MIMI[1]* and BASSAM I. SAWALHI[2]
[1] *Assistant Professor, P.O. Box 14, Civil Engineering Department, Birzeit University, Palestine;*
[2] *Graduate Student, Institute for Water Studies, Birzeit University, Palestine*
(author for correspondence, e-mail: ziadmimi@yahoo.com; Fax: +972 2 2982 984)*

(Received: 1 November 2002; in final form: 29 August 2003)

Abstract. Shared water resources are strong sources of conflict in the Jordan River basin shared by Israel, Jordan, Palestine, Syria and Lebanon. The control and allocation of water has been explicitly made a part of the ongoing peace negotiations. This article calls for the application of international water law in the resolution of water disputes in the negotiating process. The challenging task for negotiators is to translate water law principles into operating rules and procedures for the equitable apportionment of waters from shared water resources. The negotiators need a decision tool based upon objective criteria or standards to reach equitable entitlements to shared water resources by all parties. This paper introduces a multi-criteria decision tool as a possible approach to the problem of allocating the waters of the Jordan River between all riparian parties. The prime principle of the criteria is equitable allocation factors identified by water law. A general mathematical model was derived in which the proportional entitlements of the Jordan River basin waters were determined to the five riparians. It is hoped that, water negotiators review this approach.

Key words: conflict resolution, equitable allocation, International river basin management, Jordan river basin, middle east, riparian water rights, transboundary waters

1. Introduction

Shared fresh water resources have been the source of international friction and tension for many years, in many places. World wide, approximately fifty percent of all land area is contained within international drainage basins, and more than 200 rivers are shared by two or more nations. These geographical facts have led to the geopolitical reality of disputes over shared international rivers, including the Nile, Jordan, and Euphrates. Shared water resources are especially strong sources of conflict in the Middle East particularly in the Jordan River basin shared by Israel, Jordan, Palestine (West Bank and Gaza), Syria and Lebanon. In this basin, water has been the roots, means, and causes of war. The control and allocation of water has evolved into an issue of 'high politics', and it has been explicitly made a part of the ongoing peace negotiations (Gleick, 1994).

The present problems that are related to water in the Jordan River riparian countries that are generally characterised by aridity and water scarcity are many

and varied and the disparity between water supply and demand is growing with time due to rapid population growth (Mimi and Smith, 2000). Unless all states cooperate and jointly manage their shared water resources they all stand to lose in terms of the long-term viability of their water systems. States can no longer fully satisfy their needs from common resources without adversely affecting (whether in terms of quantity or quality) the supply available to others. Both surface and groundwater resources of the basin suffer from overuse. The Jordan River south of the Lake Taberias becomes almost dry at summer times because of upstream diversion works. Because of this decreased flow the level of the Dead Sea has fallen from 392 to 407 m below sea level over the last years. As a result, groundwater levels have dropped and signs of the salination of the Jordan Valley' soils can be seen (Salameh, 1992). In other words, the only real choice all sides face is between a lose-lose situation if they do not cooperate, and a potential win-win situation if they do.

Over the past 100 years, many management plans and attempts to reach agreements over water resources in the Jordan River basin have been proposed. Al-Kloub and Abu-Taleb (1998) discussed the major formal plans like the Main Plan/Unified Plan (1953), Cotton Plan (1954), Arab Plan (1954), and Johnston Plan (1953). Countries in the region have continued to develop their water resources, often at the expense of other countries. Subsequent to the dissolution of the Johnston Plan, both Israel and Jordan decided to proceed with their water projects situated entirely within their own boundaries. As a result Israel constructed the National Water Carrier, which brings water from Lake Taberias to the south and central regions of Israel. Jordan further developed the East Ghor Canal off the Yarmouk River for irrigation.

In the Jordan River basin, the international water laws that regulate riparian rights are not well observed. No comprehensive agreements between all neighbouring countries exist, except the bilateral Jordanian-Israeli agreement signed in 1994. The agreement guarantees to Jordan about 215 million cubic meters per year (Mcm yr^{-1}), and sets the rules for rehabilitating the Jordan River water and for protecting the quality of shared water resources in both states (Al-Kloub and Abu-Taleb, 1998).

Currently, Arabs and Israelis are trying to break the political cycle of conflict within the framework of the Middle East peace process negotiations. Barring a collapse of the process, they will at some point have to confront the complex problem of water, including the definition of entitlements to shared fresh water resources. The challenge, however, will be to negotiate a fair and reasonable assignment of entitlements based on existing international water law. Therefore, the negotiators need a decision tool based upon objective criteria or standards to reach acceptable entitlements to shared water resources by all parties. This paper introduces one such multi-criteria decision tool and provides one possible approach to the problem of allocating the waters of the Jordan River between all riparian parties.

The approach depends on the discussion of the principles of a comprehensive water-sharing regime drawn from the international law of transboundary waters.

2. The Jordan River Basin System

The Jordan River originates in the southwestern Anti-Lebanon range, on Mount Hermon (Jabel Esh-Sheikh), which is covered with permanent snow. The river flows through Lebanon, Syria, Jordan, Palestine and Israel. The discharge that feeds the upper part of the Jordan River is derived principally from the group of karstic springs located on the Western and southern slopes of Mount Hermon.

The river flows southwards for a distance of 228 km along the bottom of a longitudinal graven known as the Rift Valley before emptying into the Dead Sea. Its principal tributary, the Yarmouk, forms the boarder between Syria and Jordan and divides Israel and Jordan in the Yarmouk triangle. Based on the nature of the hydrology, hydrogeology, and water use, the Jordan river system may be classified into three sections, namely: (1) Upper Jordan River that includes three major head-water streams: (i) the Dan, (ii) the Hasbani and (iii) the Banias; and (iv) the Huleh valley and (v) Lake Tiberias; (2) Yarmouk river which is the largest tributary of the Jordan river system; (3) Lower Jordan river which flows through the deepest portion of the Rift Valley to enter the Dead Sea at 401 m below sea level, the lowest point of the earth. The natural flow of the river in the absence of extraction is estimated from 1250 to 1600 Mcm yr^{-1} at the entrance to the Dead Sea (Soffer, 1994; Lonergan and Brooks, 1994). Figure 1 shows the Jordan River System with the main existing and planned water projects including the National Water Carrier and the East Ghor Canal discussed earlier.

3. International Water Law

International water law and international institutions must play a leading role in solving water conflicts and reducing the associated risks of war and pollution. International water law may be the acceptable basis of an agreement for the ripari-ans of the Jordan River basin. In 1991, the International Law Commission (ILC), an organisation created by the United Nations developed the Helsinki Rules and completed the drafting and provisional adoption of 32 articles on the law of the Non-Navigational Uses of International Watercourses. In 1997, the United Nations General Assembly adopted a Convention on the Law of the Non-Navigational Uses of International Watercourses. The pertinent aspect of international water law is the following principles spelled out in the above convention and Helsinki Rules that help to reduce tensions and encourage effective and productive negotiations by the parties involved. It should be noted that these principles are not ranked according to priority (Gleick, 1994; UN, 1997):

- equitable allocation;

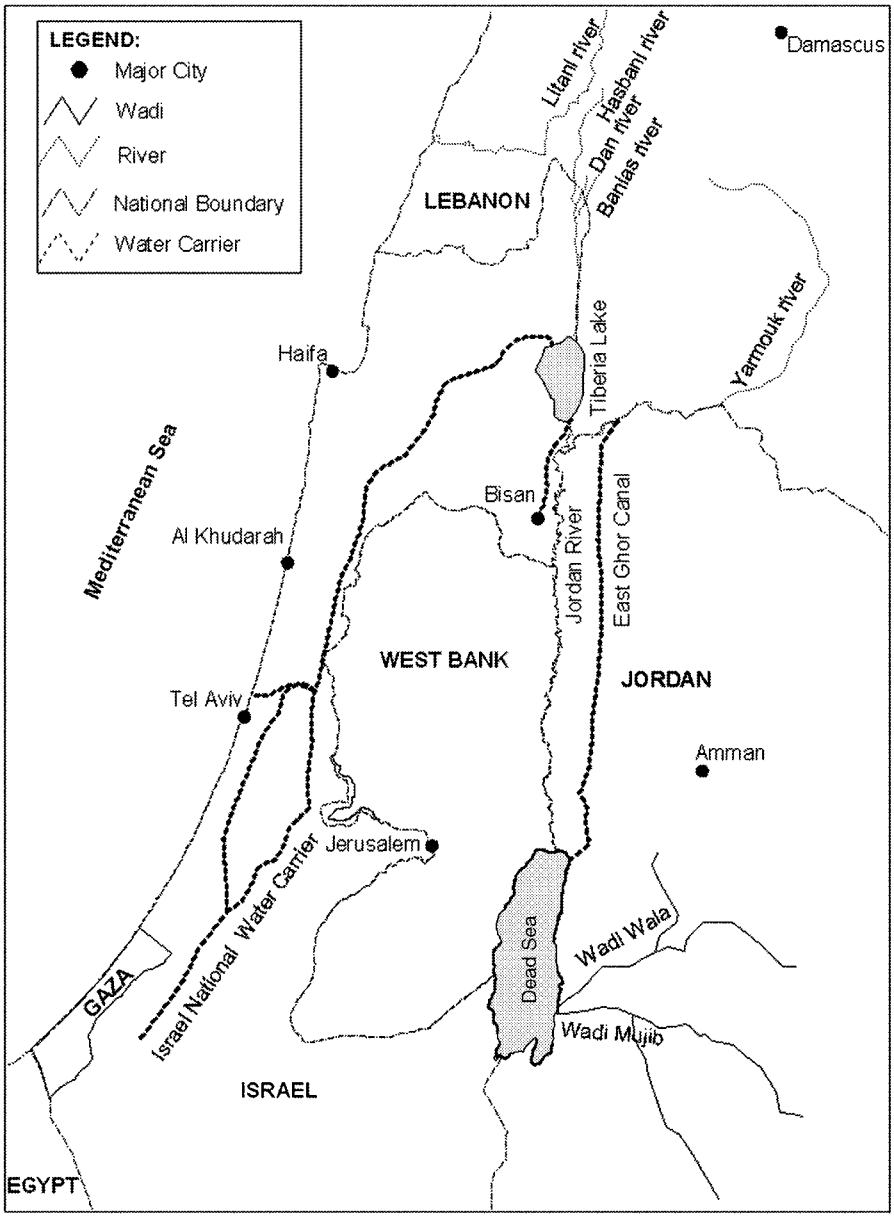

Figure 1. The Jordan River system.

Table I. Factors associated with equitable water use

Factor	Definition
F1	The geography of the basin, including in particular the extent of the drainage area in the territory of each basin state.
F2	The hydrology of the basin, including in particular the contribution of water by each basin.
F3	The climate affecting the basin.
F4	The past utilisation of the waters of the basin, including in particular existing utilisation.
F5	The economic and social needs of each basin state.
F6	The population dependent on the waters of the basin in each basin state.
F7	The comparative costs of alternative means of satisfying the economic and social needs of each basin states.
F8	The availability of other resources.
F9	The degree to which the needs of a basin state may be satisfied, without causing appreciable harm and substantial injury to a co-basin state.

- obligation to resolve water related disputes peacefully;
- obligation not to cause harm to other riparian states;
- obligation to exchange hydrologic and other relevant data and information on a regular basis.

The international water law by itself is nonbinding and lacks enforcement mechanisms. This is true, but it may also be the 'best we have got' as a guide for negotiations and contain 'checks and balances' that, if approached in good faith, would protect the interests of all parties. Questions remain about the relative importance of these principles and means of enforcement (Caponera, 1994; Elmusa, 1994). In some ways, the more challenging task for negotiators is to translate those principles into operating rules and procedures to determine the equitable apportionment of waters from shared water resources. One assumes that Arab and Israelis would wish to abide by international water law.

The principle of equitable allocation is one of the most important developed by ILC and the Helsinki statements. At the same time, it is one of the most difficult to define, given the multitude of variables that should be taken into account (Gleick, 1994). The principle of equitable allocation means that each basin state is entitled to a reasonable and equitable share in the beneficial use of shared water. 'Equitable' does not mean equal use. Rather, it means that a large variety of factors, including population, hydrology, climate, existing uses, and so on, must be considered in the allocation of water rights. Table I lists the diverse factors that the International Law Association associated with equitable water use (Eaton and Eaton, 1994; UN, 1997).

Table II. Alternative equity standards (share in percent)

Equity standard No.	F1	F2	F3	F4	F5	F6	F7	F8	F9
Israel share	9	12	10	60	8.4	16.4	6.7	19	8.4
Jordan share	39	38	12	25	5.3	14.5	26.7	21	5.3
Lebanon share	3	8	29	1	11.6	11.2	20	9	11.6
Syria share	37	31	29	12	70.8	47.1	13.3	8	70.8
Palestine share	12	11	20	2	3.9	10.8	33.3	43	3.9
Total	100	100	100	100	100	100	100	100	100

It is to be noted that each factor is not to be considered in isolation, but looked at together with all the other factors, without any of them being given priority. This theory neither purports to identify fixed criteria in the sharing of international water, nor to protect existing water rights. Rather it aims at establishing a mechanism for cooperation and negotiation with a view to reaching an agreement (Caponera, 1994).

4. An Approach for Allocating the Waters of the Jordan River Basin

There has been much written in recent years about the application of water law in the Jordan River basin, as well as the development of different allocation schemes based on the interpretation of these 'laws' or using other criteria. These publications include Assaf *et al*. (1993), Shuval (1994), Moore (1994), Gleick (1994), Caponera (1994), Elmusa (1994), Al-Kloub and Abu-Taleb (1998), and Haddadin (2000).

The approach presented here will provide one possible approach to the problem of allocating the waters of the Jordan River between all riparian parties. The approach translates the principle of equitable utilisation into a set of procedures to determine the riparians' entitlements to the shared waters.

The nine equity factors (Table I) were applied yielding alternative nine equity standards (Table II). These equity standards served as benchmarks against which various possible allocation outcomes were measured. The equity factors and the derivation of the equity standards summarized in Table II are stated below.

It should be emphasized that the particular equity factors used in this research and their derivative allocation standards were selected for illustrative purposes only and are not claimed to be exhaustive; as many or as few factors as are deemed relevant can be incorporated into the approach. Moreover, the following numerical example is to demonstrate the workings of the decision tool. It is not claimed that the entitlements as calculated here are those that should be adopted in practice.

Table III. Catchment area and riparian contributions in the Jordan River Basin (km^2)

	Israel share	Jordan share	Lebanon share	Syria share	Palestine share	Total
Catchment area (km^2)	1867	7663	664	7301	2344	19839
F1 equity standard (%)	9	39	3	37	12	100

Source: Elmusa (1997).

Table IV. Riparians' contribution to the flow of the Jordan River Basin

	Israel share	Jordan share	Lebanon share	Syria share	Palestine share	Total
Discharge (Mcm yr^{-1})	155	506	115	416	148	1340
F2 equity standard (%)	12	38	8	31	11	100

Source: GTZ (1996).

4.1. FACTOR F1 – GEOGRAPHY

The geography of the basin determines the amount of rainfall caught and, consequently, the total volume of surface and ground water run-off into the mainstream courses (influenced by such factors as the climate regime, topography, geology, soil characteristics, vegetation cover and drainage network of the catchment). Thus, the proportion of the catchment area laying within each watercourse state represents only one measure of the inflow to the basin coming from these states. Table III presents one estimate of each riparians' share of the Jordan River catchment area and the equity standard derived from this factor.

4.2. FACTOR F2 – HYDROLOGY

The hydrology of the Jordan River basin affect the discharge of the stream that can be defined as the total volume of water flowing past a given point in a known unit of time. Table IV offers one estimate of the average annual riparians' contribution to the discharge of the Jordan River basin and the equity standard derived from this factor.

4.3. FACTOR F3 – CLIMATE

The climate affecting the basin is related to many climatic factors such as precipitation, evapotranspiration, temperature and humidity that should be considered. In

Table V. Average annual rainfall over the Jordan River Basin

	Israel share	Jordan share	Lebanon share	Syria share	Palestine share	Total
Rainfall (mm)	184	222	508	508	361	1783
F3 Equity standard (%)	10	12	29	29	20	100

Source: GTZ (1996).

Table VI. Existing utilisation of the Jordan River Basin

	Israel share	Jordan share	Lebanon share	Syria share	Palestine share	Total
Quantity (Mcm yr^{-1})	810	340	5	165	20	1340
F4 Equity standard (%)	60	25	1	12	2	100

Source: GTZ (1996).

this research precipitation was considered for the Jordan River basin as shown in Table V (other factors could be considered as well).

4.4. FACTOR F4 – UTILIZATION

Israel is currently the dominant user of the waters of the Jordan River basin. With the capture of the Golan Heights during the Six-Day War and the extension of the security zone into southern Lebanon, Israel became the major user of the Jordan River. Table VI presents the existing utilization of the Jordan River basin and the equity standard derived from this factor.

4.5. FACTOR F5 – ECONOMIC AND SOCIAL NEEDS

The economic and social needs of each basin state can be quantified by estimating the projected water demands form all sources for domestic, industrial and agricultural sectors for the five riparian states as summarised in Table VII.

Table VII. Projected water demands (million m^3)[1]

	Israel	Jordan	Lebanon	Syria	Palestine	Total
Water demand for the year 2025 (million m^3)	2800	1760	3850	23555	1290	33255
F5 equity standard (%)	8.4	5.3	11.6	70.8	3.9	100

Source: ESCWA (2002) except the figures for Israel, which were compiled by the authors from GTZ (1996).

Table VIII. Projected population for the year 2015 (millions)

	Israel share	Jordan share	Lebanon share	Syria share	Palestine share	Total
Population 1998	6.0	4.6	4.2	15.3	2.7	32.8
Population 2015	7.6	6.7	5.2	21.8	5	46.3
F6 equity standard (%)	16.4	14.5	11.2	47.1	10.8	100

Source: World Bank (2000).

Table IX. GDP for the Jordan River Basin riparians (millions U.S.$)

	Israel share	Jordan share	Lebanon share	Syria share	Palestine share	Total
GDP (1998)	100525	7393	17229	17412	3589	146148
Rank	1	4	3	2	5	
F7 equity standard (%)	6.7	26.7	20	13.3	33.3	100

Source: World Bank (2000).

4.6. FACTOR F6 – POPULATION

The countries of the Jordan River Basin have a high rate of population growth that is likely to intensify freshwater conflicts in the future. A much higher population level will inevitably lower per capita water availability, which might exacerbate freshwater tensions in the region. Table VIII presents the projected population for the countries of the Jordan River basin and the equity standard derived from this factor.

4.7. FACTOR F7 – COMPARATIVE COSTS OF ALTERNATIVES

Alternative water resources refer specifically to potential sources such as desalination and imported water that are not presently exploited. The impact of these alternatives on the equation of equitable apportionment depends on their availability and comparative costs of harnessing them (Elmusa, 1994). Both desalination and importation of water could be available alternatives since all riparian states have ground brackish water and enjoy sea front on the Mediterranean Sea. Moreover, there are numerous schemes that have been proposed for transporting water via pipelines or canals from the 'water rich' countries in the Middle East like Turkey, to poorly endowed countries (Murakami and Musiake, 1994).

The comparative costs are a yardstick of the parties' ability to harness alternative resources. The party that is more capable of paying for water and tapping the desalination option than other riparian states would be entitled to a smaller share of the common waters (just within the confines of this factor). In this research,

Table X. Renewable water resources and water demands in the countries of the Jordan River Basin

	Israel	Jordan	Lebanon	Syria	Palestine
Total renewable water resources (million m^3)	1104	627	3100	21475	215
Water demand for the year 2025 (million m^3)	2800	1760	3850	23555	1290
WSI (for the year 2025)	254	281	124	110	600
F8 equity standard (%)	19	21	9	8	43

Source: ESCWA (2002) except the figures for Israel, which were compiled by the authors from GTZ (1996).

GDP was taken as measure of comparison to reach the equity standard as shown in Table IX.

The comparative costs can be restated as the relative ability of the consumer to pay for higher priced alternatives supplies such as desalinated water. Based on the present consumer prices in all riparian states as well as on various estimates of desalination costs, the following can be inferred. In Israel, desalinated brackish and saline water is affordable for municipal use and economical for agriculture, while desalinated seawater is affordable for domestic use and may be economical for some crops. Palestinian, Syrian, Lebanese, and Jordanian consumers, conversely, would be heavily burdened by the costs of desalinated water (Kally, 1994).

4.8. FACTOR F8 – AVAILABILITY OF OTHER RESOURCES

Renewable water resources, water demands and Water Stress Index (WSI) in the countries of the Jordan River basin are presented in Table X. The WSI is the ratio of water withdrawal or demand to water availability. The state that has less WSI would be entitled to a smaller share of the common waters (just within the confines of this factor). Accordingly, Table X was compiled to obtain the equity standard.

4.9. FACTOR F9 – APPRECIABLE HARM

The words 'appreciable harm' have created definitional problems to all riparian states (Elmusa, 1994). Goldberg (1992) defined appreciable harm as the costs that can be objectively measured as result of denial of allocation. The implication of this factor is obvious: to achieve equitable division no riparian can deny water to a co-riparian if that denial causes appreciable harm. Water must be reallocated to stop the infringement. To assess the significant harm in this research, the following statement for the ILC cited in Goldberg (1992) may be helpful: '*harm must be capable of being established by objective evidence. There must be a real impairment of use, i.e. a detrimental impact of some consequence upon, for example, public*

Table XI. Weight of alternative equity standards[a]

Equity factor	F1	F2	F3	F4	F5	F6	F7	F8	F9
Average weight (%)	8	15	14	20	12	10	8	8	5
Range	7–12	12–16	12–15	17–22	10–13	8–11	7–9	7–11	2–7

[a] Table compiled by the authors based on the collected questionnaires.

health, industry, property, agriculture, or the environment in the affected state'. In other words, appreciable harm can be gauged by its impact on the social, economic and environmental needs. Accordingly, if the appreciable harm factor is broadened to focus on the social and economic needs, it will become effectively identical with Factor F5 (economic and social needs) discussed previously. Therefore, Factor F9 (appreciable harm) will have the same equity standards derived for Factor F5.

5. Optimal Allocation Outcome to the Shared Surface Water Resources

It could be argued that some of the equity factors discussed above should be given greater prominence when determining states' entitlements. But which factors? To answer this question, and to facilitate the development of a realistic weight for each factor, a questionnaire has been designed and sent to ninety water experts all over the world including experts from the five riparian countries. The water experts who work in water institutions, universities and non-governmental organizations involve professional economists, irrigation engineers, water resources engineers and lawyers. The questionnaire summarized the international water law, the problem and the approach of the research. The main task for the experts was to assign a weight for each of the nine equity factors (the summation of all weights should be one hundred). Table XI presents the average weight for each equity factor obtained from the collected answered questionnaires.

Returning to the nine alternative equity standards (Table II), there is no manifestly 'best' division of waters; the standards do not converge on any one particular allocation outcome. The task, then, was to identify that outcome which did the 'least upset' to the nine equity standards taken together, i.e. to distinguish an optimal allocation outcome which, while not necessarily the best when measured against each equity standard in isolation, was the least worst of all outcomes when all nine were taken equally into account.

Each equity standard listed in Table II can be written as $F_i = (X_{i1}, X_{i2}, X_{i3}, X_{i4}, X_{i5})$ that specify the proportional shares of the Jordan River basin waters allocated to the riparians, where i refers to the equity standard, X_{i1} represents the Israeli, X_{i2} the Jordanian, X_{i3} the Lebanese, X_{i4} the Syrian, and X_{i5} the Palestinian shares. The sum of the five shares equals 100%. To illustrate, the first and second alternative

equity standards can be written, respectively, as F_1 (9, 39, 3, 37, 12) and F_2 (12, 38, 8, 31, 11).

Any allocation outcome can be written as $X_j = (X_1, X_2, X_3, X_4, X_5)$ that specify the proportional entitlements of the Jordan River basin waters allocated to the five riparians, where X_1 represents the Israeli, X_2 the Jordanian, X_3 the Lebanese, X_4 the Syrian, and X_5 the Palestinian entitlements. The sum of the five entitlements equals 100%.

The optimal allocation outcome can be written as $X_j^* = (X_1^*, X_2^*, X_3^*, X_4^*, X_5^*)$ and can be defined as the one that minimises the square of the summation of the distances (d) measured outward from itself to all equity standards. The objective function was derived (Equation (1)) to satisfy the above stated criterion (minimizes the square of the summation of the distances). The mathematics of the objective function considered the weight of the equity factors.

$$\text{Minimize } d = \sum_{i=1}^{9} W_i \sum_{j=1}^{5} \left(X_{ij} - X_j^*\right)^2 , \tag{1}$$

where

i = 1, . . ., 9, refers to the equity standards.
j = 1, . . ., 5, refers to the riparian countries.
d = square of the summation of the distances between the allocation outcome and the equity standards.
X_j^* = the entitlements of the j^{th} country from the shared water (%).
W_i = the weight of the ith equity factor (%).
X_{ij} = the share of the ith equity factor for the jth country (%).

To find the optimal allocation outcome (X_j^*) from set of possible allocation outcomes where the objective function has its smallest value (i.e. to optimize Equation (1)), the point where the first derivative of the equation equals zero was found. Accordingly, the first derivative of Equation (1) was found and equalled to zero ($\frac{\partial d}{\partial X_j^*} = 0$). This leads to Equation (2), which is the optimal solution of Equation (1).

$$X_j^* = \frac{\sum_{i=1}^{9} W_i X_{ij}}{\sum_{i=1}^{9} W_i} . \tag{2}$$

Applying Equation (2) to the Jordan River basin and based on Tables II and XI, the optimal allocation outcome specifies the proportional entitlements of the Jordan River basin waters allocated to the five riparians. The equation yields the following

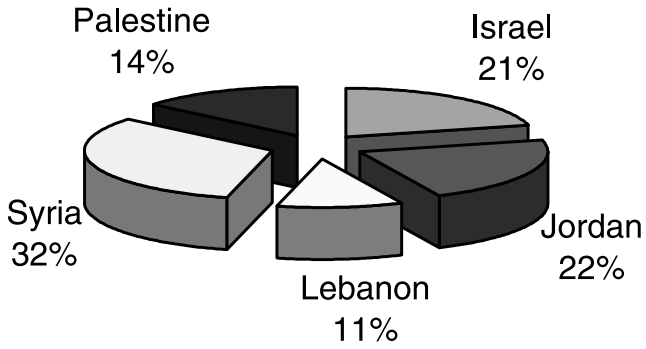

Figure 2. Optimal allocation for the river basin.

results (21, 22, 11, 32, and 14%), where 21 represents the Israeli, 22 the Jordanian, 11 the Lebanese, 32 the Syrian, and 14 the Palestinian entitlements as presented in Figure 2.

As noted earlier, the aim of this exercise is not to provide a definitive solution to the question of all riparians' entitlements. Rather, it is to demonstrate a methodology by which such entitlements can be calculated. Ultimately, the choice of standards to include is one for the negotiating parties themselves, should they decide to use this decision tool in support of their negotiations. In the final analysis it is only through direct negotiation that an eventual agreement can be reached and it is not the task of this paper to prejudge the outcome of that process.

6. Conclusions

The scarcity of water in the Jordan River basin makes water allocation one of the central issues to be resolved in the Arab-Israeli conflict. In this basin, the international water law that regulate riparian rights are not well observed. This article calls for the application of the international water law that can play a positive role in the resolution of water disputes in the negotiating process.

The methodological approach presented in this paper may be one way of approaching the problem of water allocations of the Jordan River basin and hopefully will provide some input into the negotiating process. It may be controversial and raise many objections, however, it is presented as food for thought.

The procedures described in this paper for determining the optimal allocation outcome used nine operational definitions of the ILC equity factors; clearly, these definitions were not exhaustive. One of the first tasks for negotiators, therefore, is to define and utilize such other factors as are deemed relevant to this particular water sharing problem. Assuming this methodology was adopted as a decision support tool in the context of the Middle East peace process negotiations, it would be up to the parties to decide which of the ILC equity factors are applicable to the Jordan River basin and to determine the appropriate utilization of these factors. They may

reject any or all the equity standards used in this analysis, or include others not considered here.

Sharing water resources data is considered a basic tenet of water international law, yet accurate long-term data on shared and disputed water resources in the Jordan River basin are often restricted. This restriction must stop if any progress is to be made in resolving water disputes, and all water resources data should be immediately and fully released to all parties.

References

Al-Kloub, B. and Abu-Taleb M.: 1998, 'Application of multi-criteria decision aid to rank the Jordan-Yarmouk Basin co-riparians according to the Helsinki and ILC rules', *Water International* IWRA **23**(3), 164–173.

Assaf, K., Alkatib, N., Kally, E. and Shuval, H.: 1993, *A Proposal for the Development of a Regional Water Master Plan*, Israel-Palestine Centre for Research and Information, IPCRI Publishers, Jerusalem, p. 192.

Caponera, D.: 1994, 'The Legal Institutional Issues Involved in the Solution of Water Conflicts in the Middle East: The Jordan', in J. Issac and H. Shuval (eds), *Water and Peace in the Middle East*, Elsevier Publishers, Amsterdam, pp. 163–179.

Eaton, J. and Eaton, D.: 1994, 'Water Utilisation in the Yarmouk-Jordan, 1192–1992', in J. Issac and H. Shuval (eds), *Water and Peace in the Middle East*, Elsevier Publishers, Amsterdam, pp. 93–106.

Elmusa, S.: 1994, 'Towards an Equitable Distribution of the Common Palestinian-Israeli Waters: An International Water Law Framework', in J. Issac and H. Shuval (eds), *Water and Peace in the Middle East*, Elsevier Publishers, Amsterdam, pp. 450–468.

Elmusa, S.: 1997, *Water Conflict: Economics, Politics, Law and Palestinian-Israeli Water Resources*, Institute for Palestine Studies, Washington, DC, p. 408.

ESCWA: 2002, *Assessment of Legal Aspects of the Management of Shared Water Resources in the ESCWA Region*, United Nations, New York, p. 142.

Gleick, P.: 1994, 'Reducing the Risks of Conflict over Fresh Water Resources in the Middle East', in J. Issac and H. Shuval (eds), *Water and Peace in the Middle East*, Elsevier Publishers, Amsterdam, pp. 41–54.

Goldberg, D.: 1992, *Projects on International Waterways: Legal Aspects of the Bank's Policy*, World Bank, Washington, DC, p. 230.

GTZ: 1996, *Middle East Regional Study on Water Supply and Demand Development*, Al-Najah University Press, Nablus, p. 350.

Haddadin, M. J.: 2000, 'Negotiated resolution of the Jordan–Israel water conflict', *Internat. Negot.* **5**(2), 263–288.

Kally, E.: 1994, 'Costs of International Conveyance of Water and Costs of Sea Water Desalination', in J. Issac and H. Shuval (eds), *Water and Peace in the Middle East*, Elsevier Publishers, Amsterdam, pp. 289–300.

Lonergan, C. and Brooks, D.: 1994, *Watershed: The Role of Fresh Water in the Israeli–Palestinian Conflict*, International Development Research Centre, IDRC Publishers Ottawa, p. 310.

Mimi, Z. and Smith, M.: 2000, 'Statistical domestic water demand model for the West Bank', *Water International*, IWRA **25**(3), 464–468.

Moore, J.: 1994, 'Partining the waters: Calculating Israeli and Palestinian entitlements to West Bank aquifers and the Jordan River Basin', *Middle East Policy* **3**(2), 91–108.

Murakami, M. and Musiake, K.: 1994, 'The Jordan River and the Litani', in A. Biswas (ed.), *International Waters of the Middle East from Euphrates-Tigers to Nile*, Oxford University Press, Oxford, pp. 117–155.

Shuval, H.: 1994, 'Proposals for the integrated management of the shared transboundary water resources of the Jordan River Basin', *Water Science and Technology*, IAWQ **30**(5), 187–193.

Salameh, E.: 1992, 'The Jordan River System', *Proc. of a Symposium on Jordan's Water Resources and Their Future Potential*, University of Jordan Press, Amman, p. 570.

Soffer, A.: 1994, 'The Relevance of Johnston Plan to the Reality of 1993 and Beyond', in J. Issac and H. Shuval (eds), *Water and Peace in the Middle East*, Elsevier Publishers, Amsterdam, pp. 107–122.

UN: 1997, *Convention on the Law of the Non-navigational Uses of International Watercourses*, <http://www.thewaterpage.com/UN_Convention_97.html> (July 12, 2001).

World Bank: 2000, *2000 World Development Indicators*, The International Bank for Reconstruction and Development, Washington, DC, p. 389.