# WATER RESOURCES MANAGEMENT IN THE LOWER ASI-ORONTES RIVER BASIN

## Issues and Opportunities

Aysegül KIBAROGLU and Ronald JAUBERT (Eds)

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# THE ASI-ORONTES RIVER BASIN

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# Preface


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This book is a product of the International Workshop, *"Water Resources Management in the Asi-Orontes River Basin: Issues and Opportunities,"* which was convened at MEF University in Istanbul in November 2014. The workshop was attended by a group of distinguished academics, experts, policy-makers, and practitioners. It was organized as part of a research program on the Orontes River basin led by the Graduate Institute of International and Development Studies with the support of the Global Program Water Initiatives of the Swiss Development and Cooperation Agency. The program aims to analyze water management challenges and perspectives in the Asi-Orontes River basin and to establish a multidisciplinary scientific and technical network on water management including Lebanese, Syrian and Turkish organizations. The first phase of the program initiated in 2012 focused on upper and the middle reaches of the Asi-Orontes River basin. The second phase includes the lower reach of the basin largely located in the Hatay province in Turkey.

The Workshop participants have been acknowledged for their dedication to spend significant efforts to improve the living conditions of the people in the Asi basin on both sides of the political boundaries. It is hoped that the people in Turkey and Syria can have access to sufficient, clean drinking water; secure food through efficient and equitable agricultural and irrigation practices, as well as to operate industries and services in an efficient and environmentally-friendly manner.

The main focus of the book is the challenges and opportunities in water resources management in the Turkish section of the Asi River basin. As such, the contributions represent a coherent whole with components of many relevant aspects of water and land use, development and management in the lower Asi River basin. In this context, technical, social, economic, political and humanitarian issues in the Asi River basin are addressed at local, national, regional and international levels.

Contributors come from diverse backgrounds and different professions (academics, government officials, experts and practitioners), different disciplines (engineering, natural, applied, social sciences) and also different countries (Turkey, Syria, Switzerland, France, Germany). By benefitting from the expertise and the dedication of this colorful group of distinguished participants, the ultimate objective of the book is to produce a much-needed synthesis of academic works and technical studies that are conducted on the Asi River basin.

Part I of the book starts with the chapter by Ronald Jaubert and Myriam Saddé-Sbeih, which provides an overall analysis of the complexity and uncertainty of water management in the Orontes river basin. Ahmed Haj Assad and Omar Shamaly elaborate on population displacements, drinking water availability, collapse of drinking and agricultural water infrastructures, and decline of agricultural production in the Orontes river basin in Syria under the current conditions of the ongoing civil war. The river basin is a key region in the conflict and it comprises some of the most conflict-affected urban and rural districts in the country.

Part II starts with the chapter by Ethemcan Turhan and Aysegül Kibaroglu on the political economy/political ecology of the Turkish section of Asi River basin with a focus on population, economy, governance and agriculture as the key sector in the region. Next, the Turkish water managers discuss the issue of water resources development and management in the Asi River basin in Turkey. In this context, Bulent Selek's contribution presents the conditions and the problems in the basin, with specific references to the issues of flood protection and works towards building of the Friendship Dam. Cengiz Han Kilicaslan describes the objectives of the Asi River Basin Protection Plan and the role of the Asi River Basin Management Committee as a new way of planning, managing and protecting the river basin in Turkey with the adoption of a series of laws, and regulations in accordance with the process of harmonization with the European Union.

The book continues with the invaluable analyses in Part III made by distinguished academics from the regional universities in Turkey, namely the Mustafa Kemal University and Ardahan University. The contributions by Seref Kilic and Aysel Guzelmansur Gurkan address issues of land use planning and land coverage. While Necat Agca elaborates on the issues pertaining to groundwater water quantity and quality, the contribution by Ayse Bahar Yilmaz surveys the studies related to water quality and pollution in the Turkish portion of the Asi River and the impact of water quality changes on aquatic organisms. The contribution by Berkant Odemis describes the present situation of agricultural water management and measures required for sustainable agricultural production in the Turkish portion of the Asi transboundary basin. On the other hand, Atilla Karatas suggests a hydrographic planning approach in Hatay with its special location on the lower course of Asi River Basin where it is directly affected from all changes that occur in the soil and water resources in the basin.

The book culminates in Part IV with two chapters. Waltina Scheumann and Omar Shamaly review the transboundary dam projects and analyze the incentives for Turkey and Syria for negotiating the Friendship Dam in terms of actual and potential benefits, costs and externalities, notwithstanding the fact that the dam project was halted due to the emergence of conflict in Syria. Aysegul Kibaroglu and Vakur Sumer review the contending theories on transboundary water politics, and thereby analyze transboundary water relations between Syria and Turkey in the Asi River basin particularly by scrutinizing the dynamic set of relations in political-economy domain.

***Acknowledgements***

We would like to thank Defne Gonenc, Tugba Evrim Madem, Seyfi Kilic, Cansu Gulec for their assistance in organizing the conference at MEF University and Priti Patnaik for editing the chapters. Special thanks for designing and formating the book go to Catherine Fragnière.

# Addressing the Complexity and Uncertainty of Water Management in the Orontes River Basin

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Water management at the scale of a watershed is generally a complex issue not only because of the multiple interactions between the hydro-physical and socio-economic-political systems, but also between the components of the two systems that are further encumbered by many uncertainties.

River basins are dynamic systems evolving in time and space in response to internal and external changes. The limits of a watershed are defined by the topographic drainage divide. However, subsystems interacting in the drainage area do not have such clear-cut boundaries. Their spatial and temporal limits can be defined in different ways depending on the perspective and the problem at hand. Boundaries of river basins, as dynamic systems, are thus flexible and cannot be strictly defined. Properties of nested subsystems with numerous interconnections and imprecise spatial and temporal limits are uncertain. Water management problems are consequently unavoidably "ill formed". They indeed have no single best solution but, in contrast, multiple answers, generally difficult to precisely measure and control, responding more or less to the needs of different interest groups (Brown 2009).

Complexity and uncertainty are constituent features of river basin systems; they can be interpreted as an opportunity for concerted water management or used as an obstacle. In this respect, technical and scientific expertise plays a central role depending on how complexity and uncertainty are addressed. Expertise commissioned by specific interest groups generally aim to provide specific solutions, often predefined, responding to the commissioners' need. To do so, complexity and uncertainty are necessarily minimized to simplify the problem. Results produced by studies related to different interest groups will provide different answers according to their disciplinary perspective. Depending on the political context, this may or not open grounds for negotiations between the concerned interest groups while excluding others.

Addressing the complexity and uncertainty as such cannot provide direct solutions to water management problems. The aim is to develop a knowledge base to analyze the sources of complexity and uncertainty, the nested hydro-physical and socio-economic-political systems and subsystems in order to identify options and challenges and opportunities for concerted water management.

The Orontes River basin is undoubtedly complex. The history of human settlement and the spatial distribution of activities are largely related to the availability and exploitation of water resources (Weulersse 1940). The oldest dated water infrastructures, dating back to the Bronze Age, are found in the upper reach of the basin. These installations were extended in the Hellenistic, Roman and Byzantine periods and restored from the 1920s (Chambrade and Saadé-Sbeih 2015). While the Orontes River and the numerous springs located in the basin were the main source of water until recently, underground resources currently provide over 50% of the water extracted in the basin. Furthermore, over 80% of the surface water originates from springs fed mainly by the karstic hydrogeological structures (Zwahlen et al. 2014; Droubi 2013). Groundwater management has become a critical issue and is strongly related to the socio-economic-political system which was partly shaped in relation to the access to water.

The Lebanese section of the Orontes River basin, the northern Beqaa valley, is often viewed as poor and marginal. However, it is an area where large private investments in irrigation development have been made in the past three decades. The Lebanese and Syrian sections of the basin, in many respects, contrast each other, in terms of the intensity of the exploitation of water resources, the structure of the economy and the role of State in governing water resources. They are also closely interlinked making transboundary water management a complex issue in which the water-sharing agreement between the two countries is one element among others (Hamade et al. 2015).

With more than four million inhabitants, the Orontes River basin in Syria, is an area of prime importance for both agriculture and industry. The basin contains the two major urban centres of Homs and Hama, several medium size cities and a wide range of industrial activities. The land irrigated using surface water and groundwater covers over 290’000 hectares, and is close to the area irrigated in the Euphrates basin that has received more a lot of attention in the past four decades. Prior to the conflict, the Orontes basin provided a quarter of the agricultural production and accounted for a third of industrial production of the country. The distribution of population, agricultural and industrial activities are largely related to the availability and access to water resources. The oldest water infrastructure dates back to the Bronze Age. Those in the upper reach of the basin could even be older. These installations were extended in the Hellenistic, Roman and Byzantine periods and restored from the 1920s. The Al Ghab Irrigation Development Plan initiated in the late 1950s was the first agricultural achievement of the Ba’ath Party after it took power in 1963 (Métral 1984). Farmers cultivating irrigated lands in the Orontes basin were among the main beneficiaries of the agrarian reforms and the centralized agricultural policy until the second half of the 1970s. Later, the Euphrates river basin program became the national priority for irrigation projects.

The Orontes basin became one of the first industrialized regions of Syria with the establishment in Homs of state plants such as the sugar factory in 1948 and oil refinery in 1957. Industrialization accelerated in the 1990s with the establishment of private factories in particular chemical and pharmaceutical plants. The agricultural and industrial development in the region, led to a strong growth in the population of the basin reflecting the large ethnic and confessional diversity of the country.

The city of Hama is sadly notorious for having suffered a 27-day siege to crush the insurgency led by the Muslim Brotherhood in February 1982. The massive offensive that resulted in a death toll of 10,000 to 40,000 put an end to the Islamist opposition that first became active in the 1970s. At this time, the urban and rural population of the Orontes basin was, however, largely supportive of the regime. Following the progressive deterioration of economic and social conditions, the rural basis of the regime steadily eroded.

From the 1980s, new developments such as small and medium capacity dams induced a growing asymmetry that favored the western sectors of the basin. Furthermore, parallel to the centralized planning of agricultural production, the regime adopted a clientelist strategy permitting, among others, the drilling of unauthorized wells and smuggling of subsidized diesel and fertilizers. In the late 2000s, the proportion of illegal wells in the districts of the Orontes basin located in the provinces of Hama and Homs were respectively 56% and 59%. Uncontrolled groundwater extraction led to a decline in the flow of springs feeding irrigation schemes and other domestic and industrial water supply networks. Industrial expansion and urban growth generated a growing water pollution problem. The two water treatment plants, with limited efficiency, could only provide a partial solution to the pollution problem. The erosion of the rural basis of the regime accelerated in the 2000s with the economic crisis affecting the planned agricultural sector. The center of the Orontes basin, once a stronghold of the Ba'ath party, became a protest hotspot. The state-controlled prices of strategic agricultural commodities such as wheat, cotton and sugar beet remained unchanged from 1996 to 2007. This induced a marked decrease in farm income because of the rise in the cost of labor, equipment and unsubsidized inputs. In the course of the 2000s, the clientelist redistribution did not disappear, instead benefited a much smaller group to the detriment of a large number of former beneficiaries including farmers, traders and government employees. The crisis was exacerbated by two dry years in 2007 and 2008. This increased the need for irrigation. In 2007, the removal of subsidies on diesel and the year after, on fertilizers were a drastic shock. Farmers were meant to be compensated by the rise in the prices of strategic commodities and direct payments to offset increasing production costs. In reality, the removal of subsidies further impoverished a large number of farmers. In 2010, the poverty rate reached 30% - three times more than the average in rural areas of the country - in the Al Ghab plain that was once a flagship project of the centralized agricultural policy.

The Orontes basin comprises some of the most conflict-affected areas in Syria today such as the city of Homs and the rural districts of Al Qusayr and Ar Rastan (Haj Asaad and Jaubert 2014). Two-thirds of the four million inhabitants of the basin have been displaced over the past three years. They have taken refuge in areas relatively unaffected by violence, some of which later became combat areas. Many fled, or were forced into exile mostly in Lebanon and Turkey. While some areas are almost empty, in others, the population has more than tripled. Access to safe drinking water is a critical issue for over 2.5 million people and agricultural production has shrunk by over 70%. There is an immediate need to improve drinking water supply and to support agriculture in areas less affected by the fighting. From a post-conflict perspective, the rehabilitation of the domestic and agricultural water infrastructure will be a priority to ensure the sustainable return of displaced populations. Beyond emergency relief interventions, the prioritization and allocation of resources for reconstruction will be determinant factors in the reconciliation process.

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# The Effects of the Conflict in the Orontes River Basin in Syria

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## 1. Introduction

The Orontes (Asi) River basin is a key region in the ongoing conflict in Syria and will remain so during the post-conflict transition period. Massive population displacements and widespread destruction are linked to the highly strategic nature of the basin due to the ethnic and sectarian diversity of the population, the borders areas with Lebanon and Turkey, and the access to the coastal areas and the Damascus-Aleppo highway. Furthermore, the region has large water and agricultural resources. Since mid-2013, pro-government forces and opposition forces each control about 40% of the Orontes basin. About half of the remaining 20%, are combat areas in the center and south of the basin. In the areas to the east, control is undefined or shifting from one side to another. These areas with low population density are not a major strategic stake, barring the Salamiyah district and the communication lines in the region. Northern areas extending over the provinces of Idlib and Afrin were the first to escape the control of the regular forces, followed by the regions of Qalamoun, ArRastan and Al Qusayr. The latter was retaken by pro-regime forces in June 2013.To the north, the cities of Idlib and Jisr ash Shughur that were pro-regime enclaves were taken by rebel forces in March and April 2015.The two cities of Al Fu'ah and Kafraya remain under the control of pro-regime forces.

Territorial control and combat zones are related in part to the sectarian distribution of the population. In the middle reach of the Orontes basin, the population is predominantly Alawite to the west of the river and is Sunni to the east; both sides have Christian, Shia, Ismaili, and Circassian enclaves. In the north, the Afrin district population is predominantly Kurdish.

From the standpoint of the pro-regime forces, the location of combat areas can be interpreted as a strategy to partition the country. Indeed, since 2013, the fighting has been concentrated in the center of the river basin where areas are besieged and are subject to heavy bombardment. These correspond to large irrigation schemes along the Orontes River with high economic stakes. This is also the case of the Al Qusayr district and the Al Ghab plain. While the Al Qusayr area is controlled by pro-regime forces, in the Al Ghab area, rebel forces (Jaish Al fateh) have taken the cities of Ariha et Jisr Ash Shughur in May 2015 and control about 50% of the Al Ghab plain.

The offensive led by these forces in the Yabrud district to control the access to the Qalamoun region, aims to ensure territorial continuity between the areas controlled by the regime and the northern Bekaa valley. Further, the Qalamoun is an area of refuge for people expelled from Al Qusayr. Springs, wells and water networks are strategic for territorial control and have been deliberately targeted to interrupt water supply in certain sectors.

## 2. Population displacements

The conflict has led to a mass exodus from one of the most densely populated regions of the country. Three quarters of the four million inhabitants of the Orontes basin have been displaced during the past three years. Some of these displaced populations have returned to their areas of residence after hostilities ended. Some have been forced to shift, according to the changing locations of clashes or have moved due to the depletion of their resources. In some cases, such as the Al Qusayr district, inhabitants fled to the Qalamoun region. But moving combat zones have led to a second - and sometimes third - exodus, within a few months, with no possibility of returning to their home villages.

The map shows a zoning of the basin based on proportion of displaced people and the main hosting areas. About 1.6 million people from the Orontes basin have been displaced and have found refuge in Syria or in neighboring countries - mainly in Lebanon and Turkey. The most affected areas were emptied of almost all their population on account of fighting or bombing, or because they were expelled from districts declared as military zone to prevent the return of the population. The two main military zones were established in strategic sectors of the Qatinah and Al Qusayr districts, which comprise a large irrigation scheme and located close to the Lebanese border, and to the north of An Nabk.

The main hosting areas under control of opposition forces are located in the north, in the districts of Afrin, Harim, KafrTakharim, Salqin, Ad Dana, Al Atarib, and Dar Ta`Izzah, hosting areas are also found in the districts of Ma'arrDibsah and Ahsim, north of Ma'arrat an Nu'man, where refugees mainly come from the Orontes basin, and south in the Assal al Ward district. The latter area is currently threatened by the ongoing offensive of pro-government forces on the city of Yabruk. The two main hosting areas controlled by the regime are the Salamiyah district and the outskirts of the city of Hama. The villages of Akkum and Daminah al Gharbiyah, located on either side of the military zone of Al Qusayr host, displaced populations from neighboring villages whose populations have been expelled.

Displacements have profoundly altered the geographical distribution of the population by draining high density areas located in the center of the basin while greatly increasing the population in the peripheral areas ill-equipped to handle large flows of refugees.

## 3. Access to drinking water

Prior to the conflict, 95% and 89% of urban and rural households respectively were connected to the public water supply system. This, however, did not prevent from shortages nor assure access to safe water. According to data from the Ministry of water resources, in 2010 the availability of drinking water per capita in most rural areas in the Orontes basin ranged from 50 to 75 liter per day (l/d). The quality of drinking water was poorly reported. Data from the Ministry of Public Heath, for the country as a whole, indicate that in 2006, out of 8610 samples 6% were contaminated with coliforms. The rate of contamination was probably higher in the Orontes basin because of the lack of treatment plants and the high level of pollution.

The public water supply system in the Orontes basin comprises about 1500 wells equipped with electric pumps and two main pipe networks supplying the main cities. Groundwater is the main source of drinking water. Wells are used to feed small rural networks generally at the village level - one exception being the Al luji network which supplies 39 villages from one main pumping station. The Homs pipe network is fed by the Ain Altanour and Alsamak springs located on the west bank of the Orontes River close to the Lebanese border. The Hama-Salamiyah pipe network supplies the two cities plus Al Qusayr, Qatinah, ArRastan and to 65 villages along the network. The latter is fed from an intake on the Orontes River close to Umeiry. Water is treated in a purification plant 11 km south of Al Qusayr.

Access to safe drinking water is currently critical in large parts of the Orontes basin which has led to a sharp increase in waterborne diseases. For over 50% of the population living in the basin, safe water supply per capita is less than the 20 l/d defined by the World Health Organization as the short term survival requirement in emergencies[1]. Power cuts and damage to pumping stations are the main causes of drinking water shortages. Public water networks in rural areas are dependent on power supply which is severely affected by the conflict. Areas under the control of pro-regime forces are however generally better served than those under the control of opposition forces.

At the time of writing, the two pipe networks are functional. The Homs pipe network has so far suffered no major damage The Hama – Salamyah water pipe was damaged on January 26, 2014, north-west of Al Wa`r, and repaired within 3 weeks. However, the supply of besieged villages north of Homs is intentionally cut. Water supply was also interrupted in several neighborhoods of Homs; Bab as Siba, Qarabes, Al Qusur, Al Khalidiyaj, Al Bayadah, Ashereh, Nazhen, Jub al Jandali, Jurat ash Shayyah and in the old city. In most rural areas where the availability of drinking water per capita is reported to be less than 10 l/d, public networks are out of function as a result of the destruction of pumps, particularly in areas north of Hama, or due to permanent power cuts. In certain areas, water of unknown quality is supplied in limited quantities by mobile tankers, which can cost as much as SL 5000/$m^3$. The Qalamoun region is one such case. The reported availability of drinking water does not necessarily reflect the situation of displaced people who have settled in isolated shelters with no connection to the public water network.

## 4. Agricultural water infrastructures and production

Prior to the conflict, the Orontes basin contributed about 25% of the total agricultural production in Syria. Over 50% of the crop production was grown on around 295,000 hectares of land irrigated from surface and/or ground water resources. The basin comprises 6 state managed irrigation schemes making up a total of 128’960 hectares (Table 1).

Irrigation from groundwater expanded substantially in the past thirty years in particular in the district of Qusayr and east of the city of Homs. Close to 60% of water withdrawn for irrigation came from groundwater resources.

Crop production in the Orontes basin was reduced by over 70%, due to the sharp decline in irrigated areas. To a lesser extent, production decreased because of the reduction in cultivated areas and in the yields of rain-fed crops. Irrigated areas shrunk more than half in the entire basin. The six major irrigation schemes, which used to provide more than half the production of the basin, have been strongly affected by the total or partial interruption of the water-supply. Part of the water infrastructure was destroyed during the fighting by bombing and passage of military vehicles, but the water supply has often been deliberately cut by disconnecting the supply to the channels and by plugging wells. Access to irrigation water is as strategic as the drinking water supply for territorial control.

**Table 1 – Irrigation schemes**

| Irrigation schemes | Area (Hectares) | Main productions |
|---|---|---|
| Al Qusayr | 6,800 | Apricot trees, apple trees, vegetables |
| Homs - Hama | 20,190 | Wheat, sesame, vegetables |
| Al Hulah | 2,200 | Wheat, potatoes, vegetables |
| Al Asharinah & Al Ghab | 65,560 | Wheat, cotton, sugar beet, groundnuts, vegetables, sesame, potatoes, vegetables |
| ArRuj | 15,500 | Wheat, cotton, sugar beet, sesame, potatoes, vegetables |
| Afrin | 18,500 | Apricot trees, pomegranate, vegetables |
| **Total** | **128,750** | |

Supply in the district of Al Qusayr was interrupted in 2011, following the obstruction of springs and cutting the supply of the main channel. Part of the secondary channels was damaged by fighting in 2013. In addition, out of 6,342 agricultural wells, 2,620 were plugged. Half the pumps and motors were looted. In the largest part of the Al Qusayr district, 20,500 hectares of irrigated land have been dried off and are no longer cultivated, since nearly entire populations of 23 cities and villages have been expelled. As many as 5,565 pumping facilities, out of the 11,460 recorded in the area, were destroyed or looted.

The Homs irrigation schemes, was abandoned in 2012. The latter scheme is fed by the Qattinah water reservoir whose main channel was destroyed, upstream of Homs. Almost all secondary channels were heavily damaged by bombing and are no longer usable.

The outskirts of the city of Hama have been relatively untouched by fighting. Damage to water systems is limited. The irrigated area has however dropped by over 60%. The land north of the city in the districts of KafrZaytah, Kurnaz and Qal `at al Madiq is irrigated from groundwater and has now dried up due to the lack of fuel and electricity to power the pumps. In addition, 6,500 hectares in the KafrBuhum and Harbinafsah districts, used to be irrigated by the public network. The latter is not damaged, but there is no water supply due to the destruction of the Qattinah main channel. The greatest damage is in the area of Murk - KafrNabudah – Halfaya, where 42% of wells were plugged and 71% of pumps were destroyed or looted.

The decline in irrigated areas in the Acharne and Al Ghab plains can be explained by the fall in the level of the Apamea and Qastun reservoirs, which are currently at the minimum threshold level required to supply irrigation canals. The water volume flowing in the Al Ghab plain network fell from an annual average of over 300 million $m^3$ in 2010-2011 down to 70 million $m^3$ in 2012-2013. In the western part of the Al Ghab plain, which is supplied by springs, most of the land is still irrigated.

The ArRuj area in the province of Idlib is irrigated from groundwater. Pumping stations were damaged and the 15,000 hectares perimeter was completely dried up. About 13,000 hectares of formerly irrigated land are currently used for the production of rain-fed wheat and barley. Almost 2,000 hectares located near a military base are inaccessible. The irrigation network supplying 18,500 hectares located in the Afrin district is almost out of service in 2013. These lands were then used for rain-fed crops. Pumps were restored and most of the irrigation scheme is currently functional.

The main rain-fed cropping areas are located at the periphery of the basin to the east and north in areas relatively untouched by the fighting. Production has declined by 20% to 30% due to the lack of fuel, prices of fertilizers and seeds have drastically increased. Furthermore, farmers are faced with the risk of crop destruction, especially by fire, and of losing access to their fields at harvest time.

Before the conflict, the Orontes basin was one of the prime tree production regions in Syria, with 471'00 hectares of orchards, mainly olive groves. It also accounted for a large part of the livestock production. In early 2014, the state of orchards was assessed in 112 villages in the provinces of Idlib, Homs and Hama. Nearly 15% of 26,000 hectares of orchards have been destroyed. These surfaces were burned accidentally or intentionally or cut for military reasons or for collecting firewood, whose price has tripled over the past three years. Furthermore, 40% of surfaces are no longer accessible, mainly in the districts of Al Qusayr, ArRastan and An Nayrab.

Damage to cattle and sheep were evaluated in the villages of the Orontes basin located in the provinces of Idlib and Homs. Cattle herds were depleted by 90% and 60%, the number of sheep dropped by 60% and 40% respectively in the provinces of Idlib and Homs.

The effects of the conflict on poultry production have been partially assessed in the province of Idlib. The production capacity was reduced by 60% between 2010 and 2013. Out of a total of 206 production units in 2010, 122 were no longer in business in 2013, due to the total or partial destruction of buildings and production equipment and/or because of the lack of food supply.

**Figure 1 – The Orontes River basin: Population displacement in Syria, December 2015**

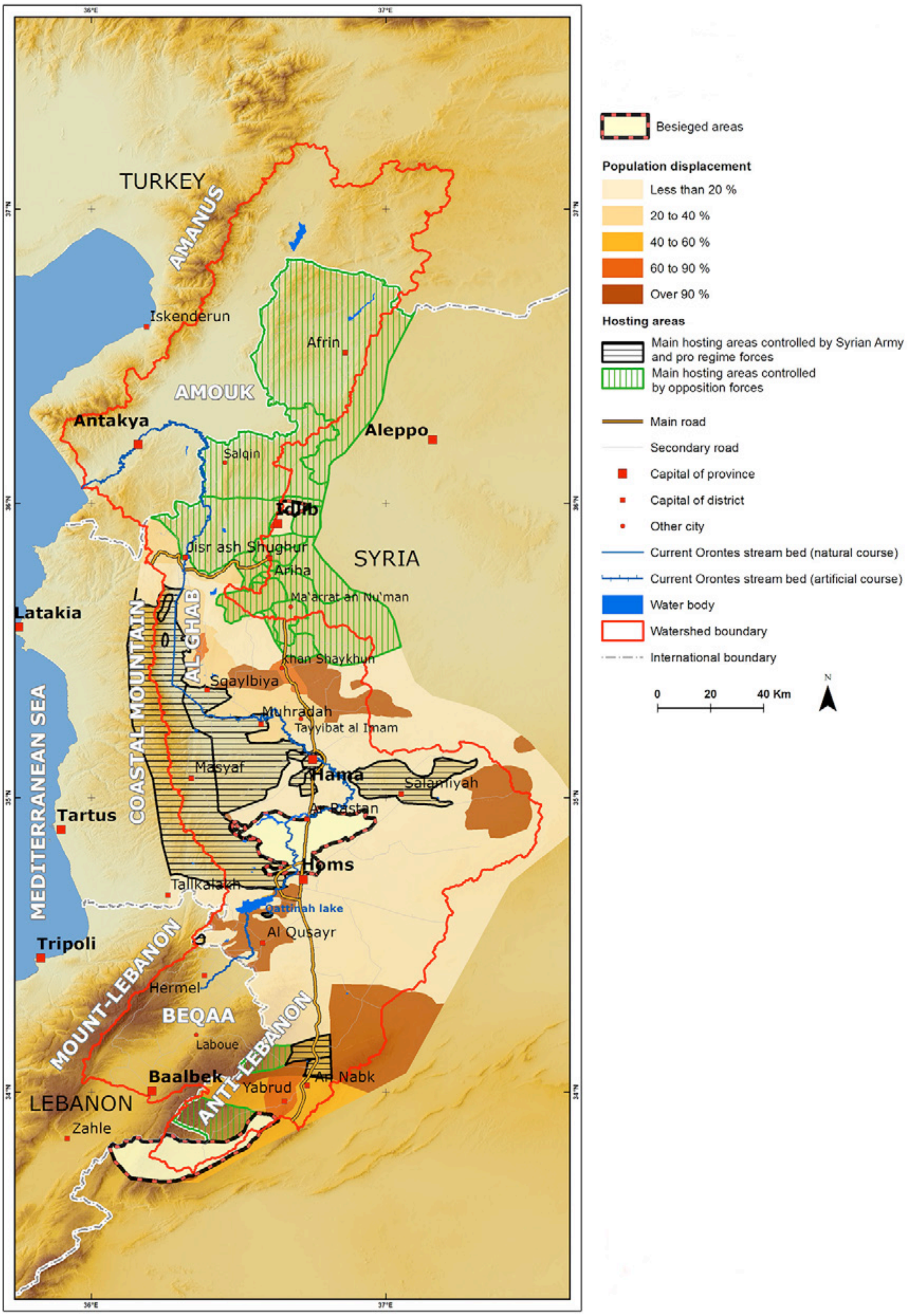
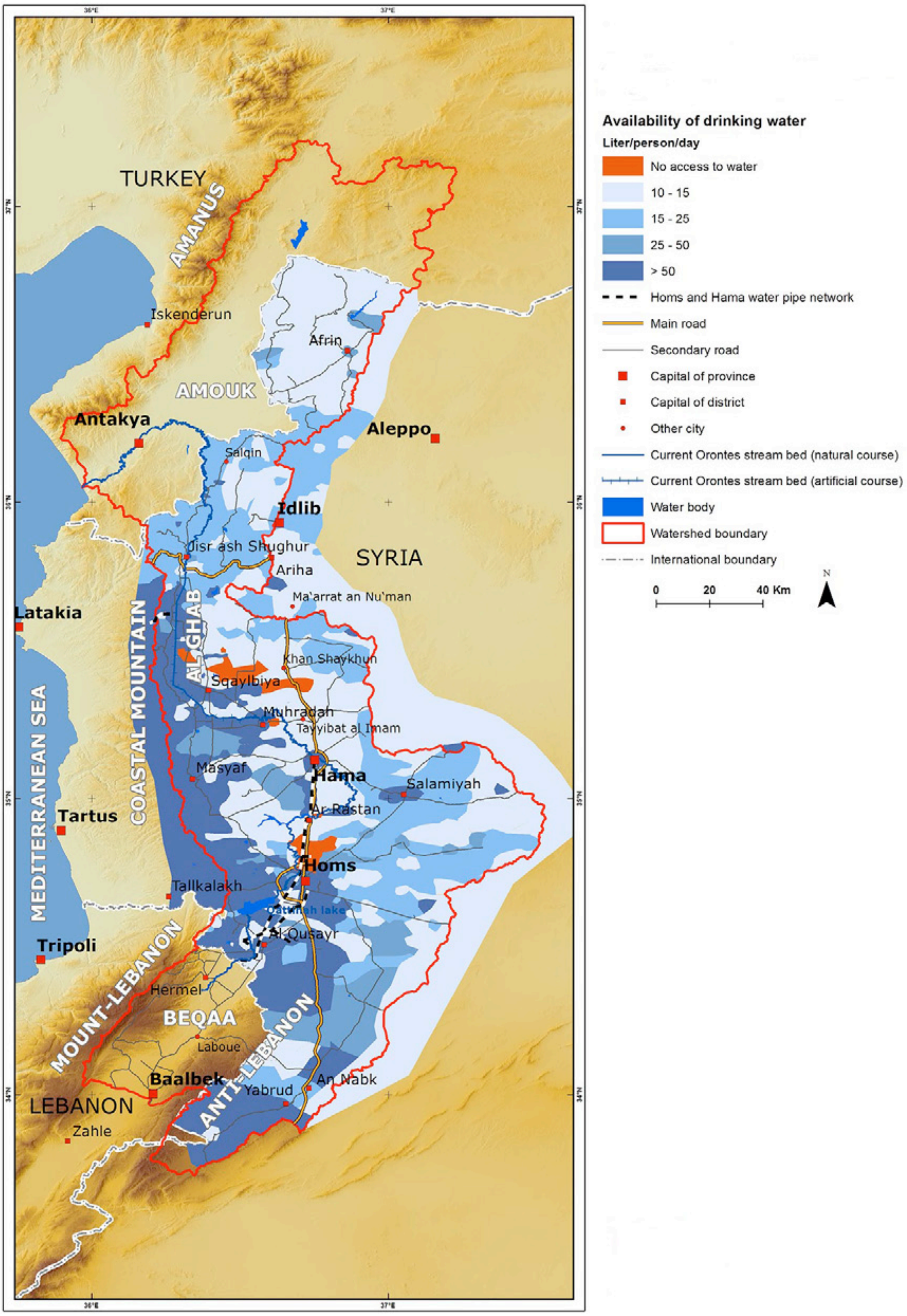


**Figure 2 – The Orontes River basin: Availability of drinking water in Syria, December 2015**



# Political Economy and Political Ecology of the Turkish Section of Asi River Basin

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## 1. Introduction

In his picturesque 1991 novel on the Levant, aptly titled "Ports of Call" (*Les Échelles du Levant*), acclaimed Lebanese-French author Amin Maalouf asks: "*Is that period, where people of different origins used to live side-by-side with languages mixing, a remembrance of the past? Is it a messenger for the future? Those who have seen this dream, are they the ones stuck in the past or those who dream of the future? I cannot respond this but my father believed in it*". In this brief extract, Maalouf refers to a time where the borders have been more porous and transient not only between people but also between landscapes in the Levant. Asi River is a prime example of such a landscape.

The Turkish section of the Asi River Basin is a historically contested territory with not only a rich cultural/historical heritage and rapidly changing population dynamics but also a region with a high value-added agricultural production. Hatay – the city where Asi River enters Turkey – is surrounded by the Syrian border to its east and the Mediterranean Sea to its west while also forming the southernmost part of Turkey. This study focuses on the political economy/political ecology of the Turkish section of the Asi River Basin with a focus on population, economy, governance and agriculture as the key sector in the region vis-à-vis the Asi as a local socio-ecological metabolism.

Hatay is clustered along with Kahramanmaras and Osmaniye classified as TR63 NUTS (Nomenclature of Territorial Units for Statistics) since 2002 in order to improve statistical data collection in line with EU standards, to keep up with Turkey's bid for the membership of the EU (Sobacı 2009). The NUTS system includes 12 Level I categories (with population exceeding 3 million people), 26 Level II categories (with population between 800.000 and 3 million people) and 81 Level III categories (with population between 150.000 and 800.000) (see Figure 1). Hence, majority of the socio-economic development figures used in this study are derived from statistics for the TR63 region, which includes Hatay, Kahramanmaras and Osmaniye. Within the TR63 region covering these three cities, Hatay appears as a key economic center having 16 districts. Hatay is an economic center in the region with two ports of entry with Syria (Cilvegozü and Yayladagi) and is a major trade route with the E-5 highway connection that links Europe with the Middle East, passing through it. And yet it has an urbanization rate of 58.6% well below the national average of 77.3%. Hatay as a province has a surface area of 5867 km$^2$, approximately half of which is agricultural land (DOGAKA 2014).

After forming the Turkish-Syrian border for 31 km, the Asi enters Turkish soil from the village of Apaydin and travels 97 km within the Turkish territory before it reaches the Mediterranean at the Samandag district (Provincial Directorate of Environment and Urbanization 2013). The Turkish section of the Asi River Basin has an area of 18,972 km$^2$ making up for 50% of the basin area with 46% contribution to annual runoff (Scheumann et al. 2011). It is estimated that the annual water potential of the Asi in the Turkish territory is 1200 hm$^3$/year with an average flow rate of 67 m$^3$/s (Provincial Directorate of Environment and Urbanization 2013:22). All in all, the Asi serves a total estimated population of 5.86 million in three countries (Turkey, Syria and Lebanon) (UN-ESCWA and BGR 2013).

**Figure 1 – Map of TR63 region (Hatay-Kahramanmaras-Osmaniye)**


(Source: DOGAKA 2014)

## 2. Downstream Asi River basin as a local socio-ecological metabolism

### 2.1. Population

Hatay has historically been a port of entry and transit route for civilizations. Located at the border between Syria and Turkey but also forming the easternmost Mediterranean coast of Turkey, Hatay proved to be a gateway for different population movements over centuries. As of 2013, the total official population of Hatay stood at 1.506.066 (TUIK, 2014). Being higher than the Turkish national average of 41%, 46% of Hatay's population is under 25 years of age making it a young and vibrant city. Average household size in the city is 4.11 people, placing it at the 19$^{th}$ rank in national figures on household size (ibid).

The population density in Hatay stands at 258 people/km$^2$ (Turkish average being 100 people/km$^2$) and makes it a highly populated region vis-à-vis its land size (TUIK 2014). While the downstream Asi basin is an epicenter drawing people due to the attractive economic opportunities it provides, it is also a region laden with increasing uncertainty in both its climatic characteristics as well as its changing demographics. It should be noted that in 2012–2013, Hatay was a city with a net outward-migration, which may turn out to be a long-term pattern for its natives (TUIK 2013).

The exacerbating conflict in Syria has led to a massive influx of refugees since the arrival of the first group on 29$^{th}$ April 2011. Figures of DOGAKA (Eastern

Mediterranean Development Agency) suggest that 92% of 351.435 entries to Turkey in 2012 were undertaken by Syrian nationals (DOGAKA 2014). Hatay Governor Ercan Topaca stated in a recent speech that there are about 245.000 Syrians registered in the city, now constituting 15% of the provincial population (Hürriyet 2015). The total number of Syrian nationals living in cities country-wide stands at about 1.938.999 people (UNHCR 2015). Given the current turmoil in Syria, one also has to be cautious of particularly volatile remarks in the literature on political geography of the region, that argue that Arab ethnic dominance in the region after the annexation of Hatay to Turkey on 29 June 1939 remains an obstacle to "national unity" (Atasoy et al. 2013). Given the current conditions, population-wise uncertainty might have long-term effects on the economy and on natural resources of the region.

Significant changes came to being in local governance in Hatay with the entry into force of new legislation (No: 6360) on metropolitan municipalities (Adıgüzel and Tek 2014). A key change that came through in the administrative governance of the city has been a rise in the number of Hatay's provinces (including the city center) from 12 to 16.

With these new regulations in place, while metropolitan municipality borders are drawn closer to provincial borders at the same time there appears significant new questions for local governance. This is most visible in the cases where new municipal configuration brings up new municipal tax burdens for the citizens living in rural areas. Adıgüzel and Tek (2014) underline that this change does not only split administrative units to alter the voting patterns (creating disadvantage to opposition parties) but also consolidates zoning and planning powers under the metropolitan municipality hence creating an obstacle for achieving decentralized governance and participation. These authors warn that this situation may also lead to a democratic deficit in urban planning and administration.

**Table 1 – Population of districts of Hatay (without Syrian migrants, TUIK 2014)**

| Province | Population | Province | Population |
|---|---|---|---|
| Altınozü | 61.882 | Iskenderun | 245.083 |
| Antakya | 347.974 | Kirikhan | 107.049 |
| Arsuz | 79.782 | Kumlu | 13.241 |
| Belen | 30.061 | Payas | 38.959 |
| Defne | 134.570 | Reyhanli | 88.925 |
| Dortyol | 115.251 | Samandag | 116.151 |
| Erzin | 41.297 | Yayladagi | 28.610 |
| Hassa | 54.231 | ↗ | |
| **Total** | | | **1.503.066** |

## 2.2. Economy

According to the Ministry of Development's (2013) most recent socio-economic development report, Hatay ranks the 46th out of 81 cities in Turkey. As such, it is placed in the Tier-3 cities category in the socio-economic development in Turkey. Hatay's share in the public budget summed up to 304.093.000 Turkish Liras (approximately 110 million euros with the exchange rate of 1€ = 2.76TL) in 2010. One can see that the lion's share of these public funds for Hatay, were spent on transportation (43,10%) followed by education (22,28%), agriculture (11,88%) public health (8,52%) and the rest of public utilities (10,98%) including infrastructure, drinking water provision, electrification and so on (Hatay Valiligi 2011). As of 2012, the population served with running water was 1.118.743 (Provincial Directorate of Environment and Urbanization 2013) in a city of 1.506.066 (TUIK 2014).

Hatay, similar to the rest of TR63 region, also has a low employment rate, which stood at 40.3% in 2013 (TUIK 2014). Work force participation by graduates with higher education was 13.8% in the city, lower than the national average of 18.2%. One can possibly suggest that the high level of unemployment is also linked to the education levels in the province. As such, 2011 figures for employment reveal that 25.3% of the provincial population is employed in agriculture, 24.3% in industry and 50.4% is employed in services (DOGAKA 2014). These figures also relate to public spending in key public services such as education, health, utilities etc. Table 2 below shows that the public spending in Hatay has been steadily increasing since 2000s.

**Table 2 – Public Spending in Hatay, 2000-2008**

| Year | Budget Share (x 1000 TRY) | National Rank in Public Spending |
|---|---|---|
| 2000 | 46.123 | 17 |
| 2001 | 61.702 | 15 |
| 2002 | 106.328 | 19 |
| 2003 | 155.449 | 14 |
| 2004 | 113.351 | 16 |
| 2005 | 287.265 | 9 |
| 2006 | 265.242 | 9 |
| 2007 | 240.895 | 11 |
| 2008 | 235.335 | 13 |

(Hatay Valiligi, 2011)

According to TUIK (2014), gross added economic value in TR63 region covering (Hatay, Kahramanmaras and Osmaniye) in 2011 was 5,904 USD/capita making it significantly lower than the Turkish national average, which stood at 9,244 USD/capita that year. These figures show that TR63 region is a producer of products with a low value-addition, which makes it a relatively cheap manufacturing region. According to 2012 figures, 54% of employment in the TR63 region is informal (DOGAKA 2014). This number goes up to 93% in agriculture. Hatay ranks 7th in Turkey in terms of overall import figures with net worth of imports equaling to 4.420.192.000 USD (Ministry of Development 2014).

Hatay is also increasingly becoming a key energy hub, particularly with wind-energy investments that ranks four in Turkey in terms of installed capacity (178 MW). However the city also has development plans for 5 thermal power plants (1 natural gas conversion, 4 coal-fired power plants) in the pipeline, which may have potential adverse effects on water bodies in the region including the Asi due to high amount of cooling waters they require. Moreover while there are two hydropower plants (HPP) operating in Hatay currently, there are plans for development of 5 additional HPPs with a total capacity of 35,70 MW (DOGAKA 2014). Designation of the eastern Mediterranean region of Turkey as an energy hub would inevitably bring serious ecological consequences both to the natural ecosystems and social systems in the region.

A recent assessment on the economic impacts of Syrian migration into Hatay found out that without the migrant in-flux, imports would have been the same whereas exports from the region would have increased by 24% (ORSAM 2015). The same study (using a perception survey with $n = 94$ in Hatay) also concluded that prices of goods in the city went up after the arrival of Syrian migrants. Although demographic characteristics (age, gender, profession etc.) of the participants of this survey are not clearly defined, the authors of this study suggest that 78% of the respondents in Hatay perceived a downfall in wages and increase in rents with the arrival of the Syrians (ibid). Nonetheless an econometric assessment by Akgündüz et al. (2015) found that while housing and to a lesser degree, food prices increased, employment rates of natives in various skill groups remained largely unaffected in the migrant-receiving cities of Turkey. Although this seems to be the case for the formal economy, as Arslan et al. (2015) showed recently illegal economic activity such as drug trafficking rose exponentially after the onset of the conflict in Syria with an increase of 84% from 2010 to 2011 followed by further significant increases in 2012 and 2013.

## 2.3. Governance

The 2015-2019 Strategy Report prepared by Hatay Metropolitan Municipality suggests that among the strengths of this administrative division are the proliferation of non-governmental organizations and citizen ownership [on the administrative matters] (Hatay Büyüksehir Belediyesi 2014). Considering the potential adverse ecological impacts in the region due to rapid industrialization and new mobility patterns, it is worth noting that this strategy foresees a gradual decline in investments for environmental protection and control between 2015 and 2019 while increasing social assistance and public services approximately three-fold during the same period. Hatay is a vibrant city in terms of civil society activities. As of the end of 2013, there were 1116 formally established associations (DOGAKA 2014) with 77.145 members and 98 foundations[1] of all sorts (religious, cultural, educational etc.) in Hatay.

A striking issue with regard to governance in Hatay, is the high number of "strategy" documents produced by various public institutions. It will not be far-fetched to say that almost all public institutions (Governorship, Special Provincial Administration, Metropolitan Municipality, Regional Development Agency etc.) prepared strategy documents with participatory[2] approaches. Organized in a similar participatory fashion, the Asi River Basin Management Committee was established and held its introductory meeting at the end of 2013[3]. This river basin management institution, which is composed of both public institutions (governorships, universities, relevant ministerial bodies) and irrigation unions, NGOs, is a significant step in the integrated planning of downstream Asi Basin within the framework of National Basin Management Strategy (2014-2023) (entered into force on 04.07.2014, Official Gazette No: 29050). This body that aims to integrate efforts for water management in the Asi basin and in its adjacent provinces, held its latest annual meeting in mid-April 2015 chaired by the deputy-governor of Hatay (DSI 2015a).

1 http://hatay.vgm.gov.tr/sayfa.aspx?Id=668&Bolge=13
2 For example, the strategic plan of the metropolitan municipality involves satisfaction surveys with citizens (n=722) as well as with its own employees (n=86).
3 http://www.dsi.gov.tr/haberler/2013/12/12/asihavzasihaberi

## 3. Access to water and sanitation

### 3.1. Pollution in downstream Asi

A key topic of concern in the Turkish section of the Asi is water pollution. Earlier assessments on the water quality in Hatay yielded a "low-level of pollution" categorized as 2nd level pollution according to Ministry of Environment's classification (Tasdemir and Goksu 2001). However, more recent assessments show that pollution in Asi reached high levels by making it a water body with 4th level pollution (Provincial Directorate of Environment and Urbanization 2013). Water Pollution Control Bylaw (No: 25687, entry into force: 31.12.2004) defines 4th level polluted waters as "highly polluted surface waters". A study undertaken between February 2006 and August 2007 revealed that Asi enters Turkey with the above threshold (mg/L) content of pollutants such ammoniacal nitrogen ($NH_3$-N) known as poisonous to humans, nitrate nitrogen (NO2-N) posing health risks for drinking water, zinc (Zn) and potassium (K) (Korkmaz and Karatas 2009: 32). For example, while the acceptable threshold level for $NH_3$-N in rivers is 0.5 mg/L, observations showed that in February 2006 this level was 6.1 mg/L at Asi River's entry point to Turkey (ibid.). Ammoniacal nitrogen originates from landfill leachate and also found in waste products, such as sewage and liquid manure linked to uncontrolled disposal of human and animal waste into flowing water bodies. These findings call for a specific caution on water pollution in the downstream Asi especially given that 68% of the municipal population is served with a sewage system and 37% of the municipal population is served with a wastewater treatment plant. (DOGAKA 2014).

Asi River Delta also faces significant pollution not the least from upstream sources including not only industry and agriculture but also household wastes (Ozsahin 2010). Ozsahin and Atasoy (2015) further contend that the main problem in the lower Asi Basin is the misuse of soil and shortcomings in land use/land use change. Such shortcomings inevitably lead to soil erosion, which in turn deteriorate the water quality and severely impact agriculture in the region. As these authors suggest, such problems can be remedied by better use of advanced agricultural and irrigation techniques, which do not solely aim at boosting the yield and expand agricultural production. This requires an integrated and holistic approach to water and land management, examples of which can be seen in novel approaches such as the Nexus approach (Bizikova et al. 2013).

### 3.2. Irrigation

Irrigation constitutes a key strategic use of the Asi River's water along with energy production and ecosystem self-replenishment. As Scheumann et al. (2011) report, the Turkish section of the river already has four irrigation projects in operation, two in the pipeline and six under planning. Currently the extent of irrigated areas in Hatay stand at 22,086 ha with new projects possibly adding 79,100 ha (3 projects, Amik-Afrin, Amik-Tahtakoprü and Asagi Ceyhan-Aslantas irrigation projects) to this number (DSI 2015b). Considering that the total irrigable agricultural land size in Hatay is 206,553 ha (Provincial Directorate of Environment and Urbanization 2013), this means that completion of hydraulic works in downstream Asi River would bring irrigation to 48% of all irrigable land in the region.

### 3.3. Flood protection and coastal erosion

Hatay is a flood-prone city with a damaging history of floods (see Balaban 2009). Heavy precipitation and unplanned urbanization trigger flood events. External factors such as dam breaks (like in 04.06.2002 in Syria) or rapid water releases from reservoirs (without early warning) to protect Syrian lands from inundating, also caused significant losses in Turkey in the past. Hence, in order to avoid highly damaging floods on the lower Asi, a protocol was signed basin between Turkey and Syria on flood early warning system on 27.06.2008 (Selek 2014). This protocol ensured that two flow measurement stations, respectively at Shaghur Bridge and Derkus Town, were established. However initially due to technical problems and later due to political turmoil, this system, which would be able to receive early flood warning signals 60 hours in advance, was not operationalized (ibid.)

Another major issue in downstream Asi is the coastal erosion in Samandag delta, where the river reaches the sea (Ozsahin 2010). Since water-retention structures not only retain water but also transport sediments, it is highly likely that hydraulic structures both in the Turkish section and the Syrian section of the Asi contribute to coastal erosion. In addition, the uncontrolled sand extraction from the delta for the construction sector is also likely contributing to coastal erosion.

Eventually hydraulic structures constructed to hold water for irrigation or energy purposes, inevitably contribute to the deterioration of natural landscapes in the downstream, most visibly, in the region where the Asi reaches the sea.

### 3.4. Public health and drinking water

Public health is a key aspect of the governance in the Turkish section of the Asi Basin. A key indicator is the rate of birth, which stands at 20.1 per thousand inhabitants in Hatay in comparison with the Turkish national average of 16.9 per thousand inhabitants in 2013 (TUIK 2014: 44). On the other hand, while the national average for child mortality is 11.6% figures for Hatay reveal this indicator as 14.1%. Average municipal drinking water extraction in Hatay is 227 litres/cap.day (TUIK 2014), while the coverage of villages with potable water connection is 92% (DOGAKA 2014). Current hydraulic works in "Greater Karacay Drinking Water Project" is anticipated to provide potable water for 17 municipalities until 2037. DOGAKA (2014) report that the public health spending in Hatay has been steadily decreasing from 11.18 million USD in 2008 to 4.37 million USD in 2012 at fixed prices[4]. Nonetheless national public health spending rose from 515.8 million USD to 710.9 million USD in the same period (DOGAKA 2014). A study on out-of-the-camp refugees in Hatay (covering 114 households with 159 Syrian families) revealed that "43% of families fear exposure to animal excreta, while the same percentage of families have cited open defecation as a serious risk and 38% worry about the lack of garbage collection" (STL, 2013). Nearly 83% of the respondents mentioned that they had access to safe water whereas 98% told that they lacked access to hygiene supplies (soap, diaper, detergent etc.) due to prohibitive prices (ibid).

## 4. Agriculture in the downstream Asi River basin

Hatay, that lies at the downstream section of Asi Basin, is a key agricultural producer in Turkey. According to DOGAKA (2014b), Hatay hosts a total of 254.983 ha of agricultural land 130.892 ha of which is sown. Nearly 34.847 ha of this sum is dedicated to vegetable growing while 82.478 ha is used for fruit cultivation (ibid.) Majority of these agricultural lands in Hatay are concentrated in Antakya and four other districts, including Kirikhan, Reyhanli and Altınozü. Districts such as Dortyol, Erzin, Samandag and İskenderun, however, emerge as main horticulture producers in the province vis-à-vis total agricultural land use in Hatay. These latter districts focus on agricultural outputs with higher value-added products such as citrus (DOGAKA 2014). In 2013, Hatay had 2.2% share of the agricultural production in Turkey, summing up to 2.7 billion TL worth (TUIK 2014).

The region also hosts olive groves with an area of 50.975 ha producing 195.620 tons/year, which constitutes 11% of the national olive oil input (Hatay Provincial

4 1 USD = 3.04 TRY on 29.09.2015

Directorate of Food, Agriculture and Livestock 2013). Hatay was also responsible for 37% of parsley, 29% of tangerine, 13% of lettuce and 10% of carrots produced in Turkey in 2012 (ibid.).

As a result, Hatay's economic contribution to national gross agricultural production in 2012 stood at 2.965.447.000 Turkish Lira (approximately 1.070.000 euros with an exchange rate of 1 € = 2.77 TRY in 2012) making up for approximately 1.5% of economic value-added in Turkey's overall net agricultural production (ibid.). Moreover economic value of agricultural exports from Hatay accounts for nearly 33% of the overall economic value of exports (DOGAKA 2014).

**Table 3 – Main crops having high importance for the agricultural economy in Hatay**

| Product | Total Dedicated Area (ha) | Yield (tons) |
|---|---|---|
| Wheat | 80.650 | 402.674 |
| Maize | 23.583 | 302.293 |
| Forage Corn | 37.882 | 201.919 |
| Lettuce | 1522 | 26.854 |
| Parsley | 1918 | 22.480 |
| French Beans | 2094 | 20.771 |
| Melon | 1758 | 38.625 |
| Zucchini | 850 | 17.633 |
| Cucumber | 1868 | 53.488 |
| Aubergine | 2308 | 62.850 |
| Tomato | 7037 | 229.558 |
| Pepper | 4072 | 72.495 |

(Hatay Provincial Directorate of Food, Agriculture and Livestock, 2013)

**Table 4 – Extent of irrigated farmland in Syrian and Turkish sections of Asi Basin (in hectares)**

| Year | Syria | Turkey |
|---|---|---|
| 1960 | 90.000 | 64.000 |
| 1970 | 124.000 | 68.000 |
| 1980 | 164.000 | 86.000 |
| 1990 | 155.000 | 95.270 |
| 2000 | 227.000 | 110.224 |
| 2006 | 268.000 | 125.645 |
| 2011 | N/A | 176.515 |

(Korkmaz and Karatas 2009; DOGAKA 2014)

A key issue of concern in downstream Asi basin is the double-edged problem of increased pollution load and decreased flow rate. This has significant consequences for the agriculture in the region. Korkmaz and Karatas (2009) report that there has been a decrease in cotton yield in the region due to this double problem. Meanwhile, these authors report that Syria is said to witness a 158% increase in its agricultural yield in period 1992-2003. These figures however are not clearly referenced, are old, and need to be fact-checked particularly given the ambiguous nature of identifying whether the water of Asi alone provides this increase.

**Table 5 – Status of agricultural land in Hatay**

| Total Agricultural Land (ha) | Total Irrigable Land (ha) | Total Irrigated Land (ha) |
|---|---|---|
| 275.578 | 206.553 | 176.515 |

(Hatay Provincial Directorate of Food, Agriculture and Livestock 2013)

Findings of a FAO mission in 2013 however contradict these claims. FAO mission that took place in late January 2013 found out that Syrian agriculture has been witnessing severe decline as the conflict continues, with wheat and barley production showing a 55% drop, vegetables 60%, and fruit trees and olive oil production 40% (FAO 2013). Moreover in a recent analysis, Jaafar et al. (2015) found that irrigated agricultural production in the Syrian section of Asi dropped between 15% and 30% in 2000–2013, with hotspots in Idleb, Homs, Hama, Daraa and Aleppo. Using GIS and remote sensing of vegetation, these authors suggest that northern Lathikiya (on the Syrian–Turkish border), the banks of the Asi River, parts of Idleb, and Aleppo were suffering from the highest EVI declines (Enhanced Vegetation Index, an indicator of agricultural production) (ibid). Although decline of water supply (through recurring droughts) and lack of hardship in accessing energy to harness surface and ground water alike are issues, the main factor (as the authors argue) in this decline appears to be the Syrian conflict itself. This phenomenon has and will continue to have significant impacts on the water quality in downstream Asi topped with the demographic changes in the region over the years to come.

## 5. Future of socio-ecological systems in Turkish section of Asi basin

According to Swyngedouw (2009), "hydro-social research envisions the circulation of water as a combined physical and social process, as a hybridized socio-natural flow that fuses together nature and society in inseparable manners". This chapter also stresses "the inseparability of the social and the physical in the production of particular hydrosocial configurations" (ibid). According to Stockholm Resilience Center's definition (SRC, 2015), socio-ecological systems refer "the linked systems of people and nature" which emphasizes that delineation between social and ecological systems is artificial and arbitrary. In this sense, Asi connects not only its upstream and downstream countries, namely Lebanon, Syria and Turkey, but also cuts across boundaries of ecosystems and social constellations. A holistic approach to planning and management of the Asi basin based on not only water quantity and quality indicators, but also socio-economic development, ecosystem well-being and human welfare in the basin may improve the socio-ecological conditions to a great extent. Careful consideration of agricultural and industrial development, urban sprawl and energy investments are key to such improvements. Therefore it is crucial that decisions on big and irreversible investments (such as potential hydraulic fracking activities in the region, see DOGAKA 2014 and Üstün, 2013 for Turkey's reserve map) should be taken with a grain of salt.

As another big hazard in the region, flashfloods along the Asi basin should also stimulate the decision makers to plan the urban settlements and economic activities in accordance with novel approaches like pressure-and-release model, that defines disasters as an interaction and a compound function of vulnerability and hazard (Wisner et al. 2004). De Stefano et al. (2012) identified that Asi is currently classified in the medium hazard category, with hazard defined as exposure to hydrologic variability and future change in variability. Therefore planning for disaster risks in the region should include multiple exposures to hazards, not least since there are districts with multiple disaster risks overlapping (Demirkesen 2012). For instance, Hassa, Kirikhan, Antakya and Samandag provinces are said to be under "the risks of both river flooding and earthquake" (ibid.). Irvem and Topaloglu's (2012) findings also confirm this by suggesting that Antakya town center has a very high risk of being exposed to floods in the Turkish section of the Asi basin. Hence an integrated approach to disaster preventions and risk aversion strategy is required in Hatay considering the rapid socio-ecological changes.

## 6. Conclusion

The Asi River Basin is a water body that flows through parts of Lebanon, Syria and Turkey as one of the veins of socio-ecological metabolism of the Eastern Mediterranean. This chapter has presented some of the political ecology/political economy dimensions of the Asi River within this region, considering that this transboundary water body has a socio-ecological metabolism of its own. While, as Smith (2006) argued forcefully, "society is forged in the crucible of nature's metabolism", nature as a water system in this case is equally "the amalgam of simmering social change". This assertion is nowhere more valid than the downstream Asi River Basin, whose population has multiplied rapidly with the influx of refugees fleeing the on-going social unrest in Syria within the past four years since the onset of the conflict. Hence while the water flowing into the Turkish territory has changed quantity and quality-wise due to the impediments of this violent conflict on populations in Syria, it has also changed the population dynamics and societal configuration downstream with more people now aligning and hence producing socio-ecological pressure on the water body along the 97 km long tract in Turkey.

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# Development and Management of Water Resources of Turkey with Specific Reference to Asi Basin

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## 1. Introduction

The Asi River originates in Lebanon, passes through Syria and flows into the sea after passing through the territory of Turkey. The river is on the agenda for Turkey because of floods, water scarcity, water quality and its negative effects on ecosystem. With the aim of reducing risks from these threats on the Asi basin, the Friendship Dam was planned to be constructed for flood prevention, irrigation and energy security on the border region of Turkey and Syria according to the principle of benefit-sharing in 2009. The dam is the most important cooperation effort in the field of water resources on the Asi basin. In this study, Turkey's water resources development and management efforts specific to the Asi basin are evaluated. The study also discusses floods in the Asi River together with the best possible precautions against floods. Moreover, the study examines the works performed on the planned Friendship Dam so far, as well as the studies carried out in line with benefit-share principle for water resources development. Finally, it gives some suggestions concerning future interests.

## 2. Turkey's policies for the management of transboundary rivers

Turkey has widespread experience in water policies and implementation because nearly 40% of her total water resources are transboundary and boundary rivers and 22% of her land borders are formed by the rivers (Bilen, 2009). Long term relations with the European Union on the west, Middle East on the east and Russia on the north, have contributed to Turkey's expertise in the field of water management.

Turkey is upstream to the Euphrates-Tigris, the Kura-Aras, and the Coruh basins whereas it is downstream to the Asi and the Maritsa rivers (Bayazit and Avci, 1997). Nearly one-third of the whole territory of the country (256,000 km2) belongs to the transboundary river basins. The average water potential of the transboundary rivers inside Turkey is about 64 billion cubic meters per year, which is equivalent to 37 percent of the overall water potential of the country (DSI, 2016).

Turkey's policy has been in favor of negotiating and concluding the issue of transboundary rivers in an agreeable way among the riparian countries. Turkey is for bringing the rational use of water into forefront instead of sharing transboundary waters according to an arithmetic formula. In addition, it supports "equitable utilization" and "no significant harm" principles of international water law and benefit sharing approach in transboundary rivers. Finally, data and information should be shared among the riparians for the effective use of the transboundary rivers.

Turkey is situated in a semi-arid area and storage facilities (dams) are essential to address periodic instabilities in precipitation and to attain the required amount of water in the required time (Figure 1). So, ground and underground storages collecting water during the period of excess water are needed as safety units for the periods during which precipitation does not meet the needs. This constitutes the most important component of “water security”.

**Figure 1 – Distribution of precipitation in Turkey**


Turkey supports water management at the river basin level. Reuse of water, supply optimization, demand management via increasing the effective use of water, participatory and transparent management, access to water, building a developed and integrated policy, regulatory and institutional frameworks, and inter-sectoral approach are among the major implementation principles. As Turkey’s policies and implementations are of concern, boundary and transboundary waters have integrity.
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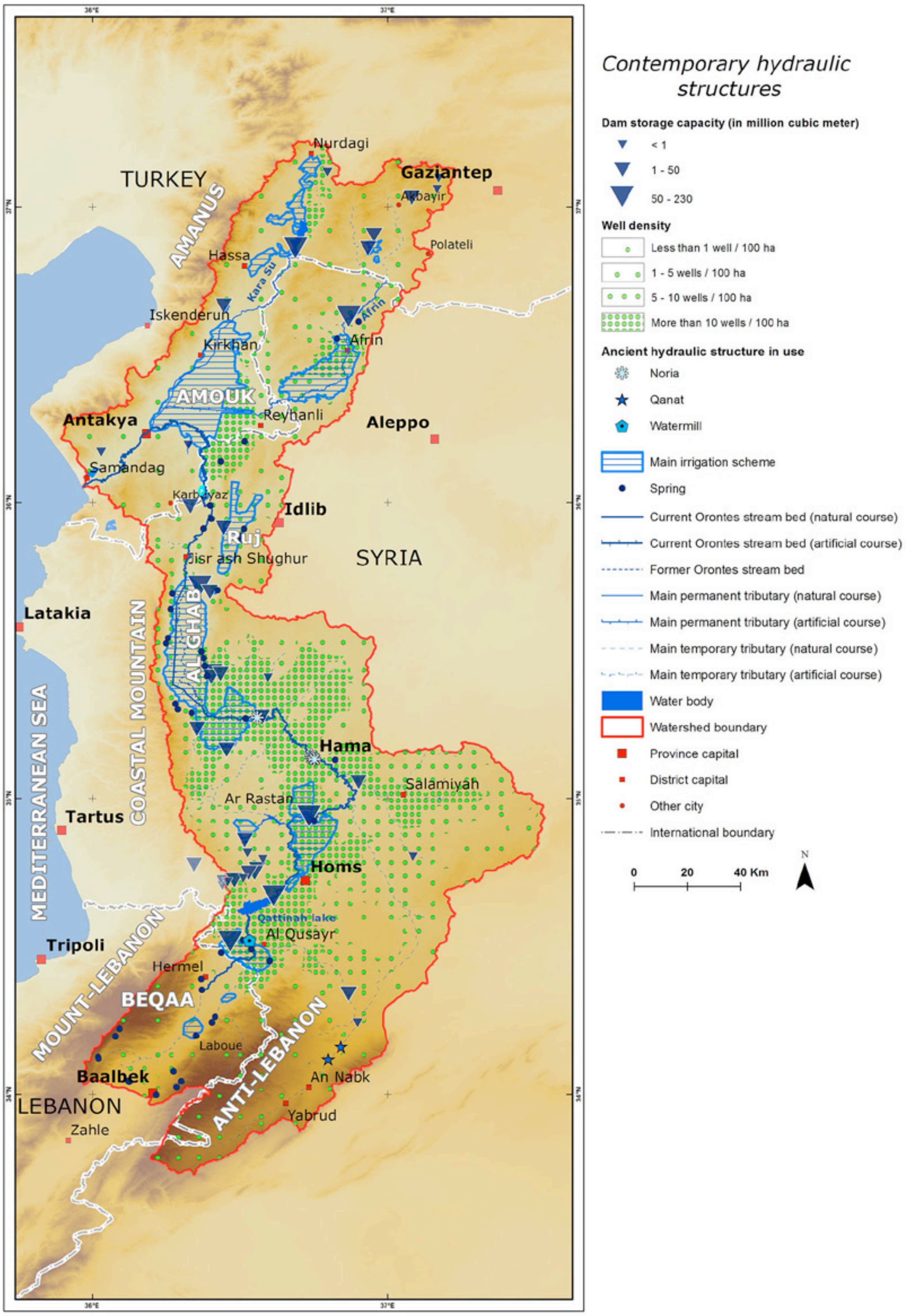
## 3. Water potential of Asi basin

The Asi River basin spreads across the territories of Lebanon, Syria and Turkey (Figure 2). Asi River rises from the Bekaa valley of Lebanon; flows nearly 35 km through the Bekaa Valley and flows into the Homs (Hama) Lake into the territories of Syria. The 20,000 hectares Hama-Homs irrigation scheme is fed by the Lake. Another important project on the Asi River is the Ghab irrigation scheme including approximately 70,000 hectare of lands. The water of the Asi River, controlled by Rastan and Maharde dams, is used for irrigation in the region

The Asi River constituting nearly 50 km of the border between Turkey and Syria, enters Turkey from Esrefiye. The Asi River’s flow rate at the point it gets into Turkey enormously decreases in the summer months. As a result of the extensive water use in Syria, flow rates at the Turkish border decreased to 0 $m^3/s$ in the summer months of 2007-2011 period.

**Figure 2 – Overview of the Asi River basin**

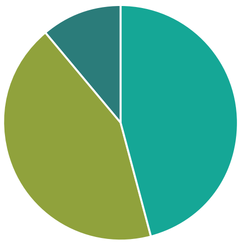



https://www.water-security.org/article/contemporary-water-infrastructure

Although the monthly average flow rate in summer months has increased up to 10 m3/s following to the political instability in Syria, which in turn caused a decrease in activities in the water sector like agriculture. However, it is hard to expect that this 10 m3/s flow can be kept constant with the expected political stability of the country.

The first measurement to develop the water resources of the Asi basin on the Turkish side was conducted by the General Directorate of Electrical Power Resources Survey and Development Administration in 1942. The State Hydraulic Works (DSI) began measurement activities in 1963. According to the first studies that were compiled into a report in 1958, the annual average water potential of the Asi River was determined as 3.4 billion m3/year (DSI, 1958). The total water potential of the basin measured with the averages of 1941-80 was 2.9 billion m3/year. Currently the water potential of the basin has decreased to 2.8 billion m3/year, and nearly 1.3 billion m3/year of this amount belongs to Turkey. When the water potential contributions of the countries are considered, shares of Lebanon, Syria, and Turkey are 11%, 46% and 43% respectively (Figure 3).

**Figure 3 – Contribution per country to the water potential of the Asi River basin**




## 4. Land resources of Asi basin

60% of the land resources of the Asi basin are used for agriculture, 37% of the lands are forest and semi-natural, 2% are composed of artificial areas and the rest is wetlands. About 165,000 hectares of the basin are irrigated (Figure 4). The Asi basin includes fertile lands including Amouk Plain and is very important for agricultural production.

Agriculture has a major importance in the economic development in the Turkish territories of the basin. For this reason, irrigation projects have been developed. The most important one is the Reyhanli Dam Project that will irrigate 60,000 hectares. This Project is currently under construction. Another important project is the Tahtakopru Irrigation Project – with a total of 45,000 hectares to be irrigated by increasing the height of the already existing Tahtakopru dam by 11 meters. Investigation studies are still being undertaken. There are irrigation and drinking water projects at the upstream of the Afrin tributary of the Little Asi River.

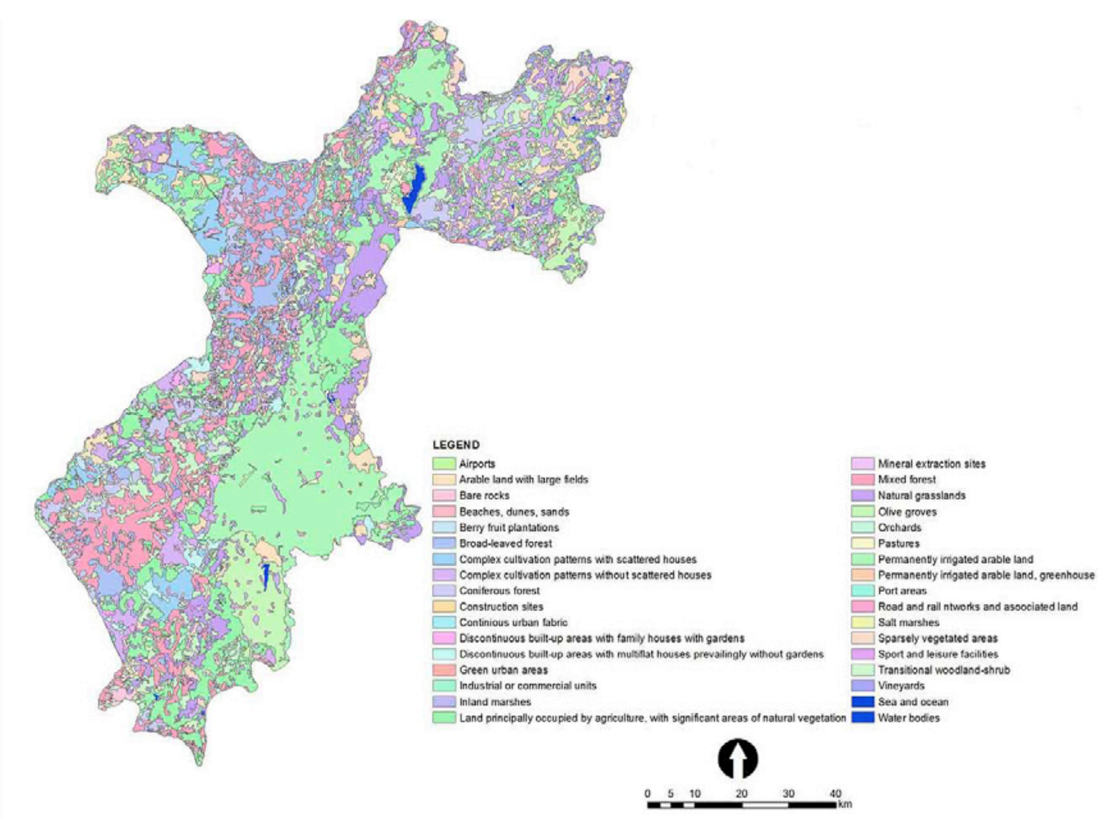
## 5. Cooperation areas in water resources management in the Asi Basin

Three important problems in terms of water resources of the basin are water scarcity, floods, and water quality deterioration with negative impacts on ecosystem balances. These areas also serve as opportunity areas for the reciprocal comprehension and cooperation.

### 5.1. Water scarcity

The waters of the Asi River is most consumed by the projects in Syria. Although Lebanon's consumption is relatively less, Syria's irrigation project – especially the Ghab Project – is an important water user in the area. In the summer months, almost no water comes to Turkey. Turkey has a total of 165,000 ha irrigable land in the basin. This is an important area for cooperation to ensure the effective use of water in irrigation.

Figure 4 – Land use map of the Turkish section of the Asi River basin




## 5.2. Floods

The frequent floods from both the tributaries of the Little Asi River which originates on the Turkish territories and the Asi River flowing from Syria cause considerable damages.

During the floods on the Turkish side in February 2003, 110 houses were damaged and 10,000 hectare of land was affected. The negative effects on the Yarseli irrigation and the damage on Antakya city center are shown in Figure 5 and Figure 6.

Figure 5 – Yarseli irrigated area, February 2003

**Figure 6 – Flood in Antakya, 2003**

The last flood occurred in 2012 in the Amouk Plain (Figure 7). Nearly 8,500 hectare of irrigable land, the Hatay airport, villages and bridges in the region were all submerged during the flood. The agricultural damage caused by the flood reached approximately US$ 10 million.

The situation is similar in Syria. The floods in 2002 are an example, Syria opened the gates of El Zeyzoun dam located near the city of Hama causing the sudden release of 70 million m3 of water. 22 Syrians lost their lives and the flood damaged several villages (FAO, 2008: 5). 1600 hectares of land on the Turkish side were flooded, damages amounted US$ 6 million.

The two countries have agreed in principle to carry out joint studies for decreasing the damages caused by the floods. The establishment of a flood early warning system and the Friendship Dam are two important areas of cooperation within this context.

Figure 7 – Flood In the Amik plain, 2012

Figure 8 – Flood in June 2002 caused by the collapse of the El Zeizun Dam in Syria

### 5.2.1 Flood early warning system

Syria constructed two remote access flow observation stations on the Asi River on the Suhkur bridge and in Derkus town to establish a flood Early Warning System However the communication system is not able to remotely access the stations because of the inconsistency in the communication lines of the two countries (Figure 9). It would be possible to get a warning about the possibility of a flood in Hatay 60 hours before its occurrence if the system was operational.

Figure 9 – Flood warning station in Syria

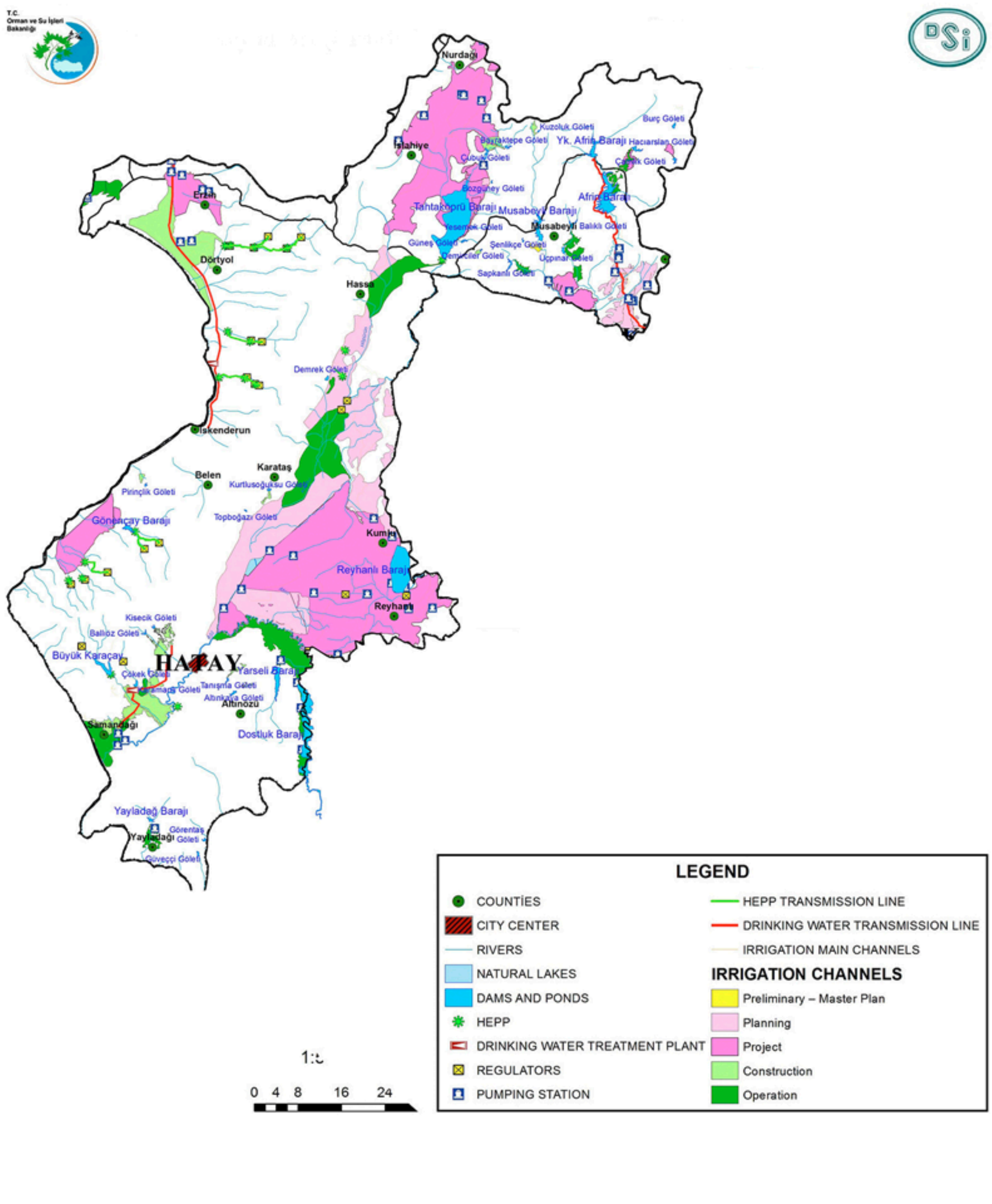
### 5.2.2 Works towards the Friendship Dam between Turkey and Syria

After the first Prime Ministers' Meeting at the Turkey-Syria High Level Cooperation event held in Damascus, Syria on 23 December 2009, a number of Memorandum of Understandings were signed to address the issues on Syria's water intake from the Tigris River, the construction of the Friendship Dam on the Asi River, environment, protection of water resources, as well as the fight against droughts.

During the Bilateral Ministerial Meeting held in Syria on 19-20 June 2010, fourth meeting of the Joint Technical Working Group for Preparing the Feasibility Study and Final Planning of the Asi River Friendship Dam was held, and the document entitled Special Technical Specification of Friendship Dam was signed

The two countries have strongly cooperated in defining the characteristics of the Friendship Dam to take necessary precautions for the protection of Syria's historical Derkus town and the important drinking water resource from Ayn-Zerka.

**Figure 10 – Irrigation developments**



The main aim of the Friendship Dam is flood control with a 50 million m3 flood protection volume. Following the construction of the dam, 8,000 hectares of agricultural land will be irrigated and 6,000 hectares of agricultural land will be protected from flood hazards. Moreover, 13,47 GWh/year of energy will be produced with 8,94 MW installed capacity (Figure 10).

The groundbreaking ceremony of the Friendship Dam was held in 6 February 2011 with the participation of the President of Turkey and the Prime Minister of Syria. But, there has been no progress in the Project because of the political instability in Syria.

### 5.3. Deterioration of the water quality and its effects on the ecosystem

The effects of the development projects on water quality and on the protection of the ecosystem are another cooperation area among the riparian countries situated in the basin.

There are nine water quality stations in the Turkish territories of the Asi River basin. According to the assessment of the samples taken from these stations, the ammonium and sulphate concentrations are high on the Turkish-Syrian border, total phosphorus and sulphate concentrations are too high and the water is of poor quality according to the water quality classification system of Turkey (Surface Water Management Regulation, 2015). The low water quality can be attributed to irrigation return flow and intensive textile production.

In addition, the delta created by the Asi River, which is very well known as a caretta caretta (sea turtles) reproduction area and famous for its sand dunes (sand hills), is expected to be under the gradually increasing water stress due to the heavy irrigation projects that are under planning in the basin.

## 6. Conclusion

The problems of the Asi River basin do not differ greatly from those of other transboundary river basins. First of all, because political borders and the natural drainage line of the basins do not overlap, the decision-making process in each riparian considers the political borders instead of the natural borders. This handicap requires joint studies by the riparians based on mutual benefits in resolving the problems in the long term.

One of the main problems in the basin is the uneven distribution of river flows, which causes floods and droughts. Establishment of a flood early warning system and operation of upstream dams in a way to leave necessary flood volumes will help to decrease life loses and other damages faced during flood times.

Regulation of flows by constructing a dam by two riparian countries can play key role for the solution of the flood problem at the Turkish territories. Considering the joint studies carried out in 2009 were contributed by experts of two countries to understand the technical perspectives of each other and enabled them to initiate the joint dam project, it is possible to resume the studies following the re-establishment of the security conditions in the basin

Eliminating the pressure over water quality and ecosystem balances can only be possible with better understanding of the river system. In this regard, water uses and requirements of every country has to be set forth together with the present water potential of the river basin. Considering nearly no water flows through the Turkish border in summer months, some conventional and non-conventional measures have to be put into the agenda in the short run.

In this regard, some pilot projects which aims to increase efficient use of water in different sectors, especially in agriculture has to be supported. Moreover, domestic and industrial wastewater treatment plants have to be completed and reuse of treated wastewaters, as well as return irrigation waters have to be supported.

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# Legal and Institutional Basis of the Asi Basin Management Committee

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## 1. Introduction

The degradation of quality of water resources and the reduction in available water resources in addition to the diminishing amount of water per individual are triggered by a number of reasons such as climate change, rapid urbanization induced by population growth and an increased agricultural activity aimed at meeting the need for water and food.

All these negative impacts have rendered it is necessary to develop a planning and management approach focused on river basin management strategies at the basin and the national level. This must include new ecological criteria, concepts of international coordination and solidarity, a new institutional structure and a legislative basis. Consequently, a planning and a management approach at basin level has been developed within the framework of the European Union Water Framework Directive (WFD), that covers environmental infrastructure, protection plans and management methods. As a result of implementation of this planning and management approach, positive outcomes have been attained.

This study describes the process of developing legislative and institutional infrastructure as well as implementation practices in Turkey that were designed in accordance with the Water Framework Directive. The study also describes the applications performed within the scope of the Protective Action Plan for the Asi Basin and the relevant management plan, adopted by the Asi Basin Management Committee.

## 2. Legislation for the implementation of Water Framework Directive in Turkey

The foundations of the legislation relevant to planning and management approach at basin scale, which was adopted in accordance with the WFD, were laid in Turkey based on the following steps:

- Establishment of the General Directorate of Water Management (SYGM, in Turkish acronym), that is charged with the task of designing river basin management plans and carrying out legislative work related to holistic management of river basins as per Article 9 of the "Decree on Organization and Duties of the Ministry of Forestry and Water Affairs", as published in issue number 27984 of the Official Gazette on 04.07.2011;

- Introduction of Basin Protection Action and Management Plans, aimed at protection of the amount, physical properties, chemical and ecological quality of surface and groundwater; regulation of working procedures and principles relevant to water basin management plans; and management of the protection of basins covering surface and groundwater resources (including coastal waters, yet excluding seas) as per Article 6 of the "Regulation on Protection of Water Basins and Designing Management Plans", published on issue number 28444 of the Official Gazette on 17.10.2012; and
- Introduction of Basin Management Committees as per the "Communiqué on Organization, Duties, Working Procedures and Principles of Basin Management Committees" (published in issue number 28681 of the Official Gazette on 18.06.2013) for the purpose of ensuring coordination among the relevant institutions, laying out working procedures and principles of monitoring applications and defining the scope as well as working procedures and principles of organization of basin management committees.

After the establishment of the overall legislative and institutional infrastructure, "Basin Protection Action Plans" were issued and "Basin Management Committees" were formed for a total of 25 basins in 2014. As of 2015 and the forthcoming period, execution meetings will be held among Basin Management Committees and efforts will be made to make sure that the basin-scale planning and management approach become well-established through contributions of local stakeholders in line with the current National Basin Management Strategy.

Within the framework of the Regulation and Communiqué and based on the "2014-2023 National Basin Management Strategy", "Basin Management Committees" (BMC's) (committees comprising local stakeholders, led by Coordinating Governors and monitored by the Basin Steering Board) shall follow decisions made by the "Water Management Coordination Council" (WMCC) (council formed by central stakeholders), conduct Committee and Supreme Committee stakeholder meetings, carry out necessary revisions in accordance with the roadmap drawing in the Basin Protection Management Plan, update Basin Protection action Plan Task Schedules and make sure that the workflow remains in order. Additionally, they will make the contributions required for conversion of Basin Protection Action Plans into Basin Management Plans.

## 2.1. Regulation on Preparation of Water Basin Protection and Management Plans

***Chapter One***
***Purpose, Scope, Basis and Definitions***
**Purpose**
**Article 1** – (1) The purpose of this Regulation is to regulate working procedures and principles relevant to protection of quantity, chemical and ecological quality of surface and ground waters in a holistic manner as well as to the preparation of water basin management plans.
**Scope**
**Article 2** – (1) This Regulation covers working procedures and principles relevant to preparation of basin management and protection plans, which embody surface and ground water resources including coastal waters, with the exclusion of seas.
**Legal Basis**
**Article 3** – (1) This Regulation was issued on the basis of the 2nd, 9th and $26^{th}$ articles of the Decree number 645 on Organization and Duties of the Ministry of Forestry and Water Affairs, dated 29/6/2011.
**Protection of water basins and preparation of Basin Management Plans**
**Article 6** –

(1) Basin Management Plans for all basins shall be issued by the Ministry within the framework of the working procedures and principles laid out in Annex 2 and on the basis of basin protection action plans.
(2) In the basin management plans, it is important to protect and adapt the utilization of not only water resources, but also water with natural mineral content and geothermal water resources in terms of quantity and quality.
(3) For the purpose issuing, implementing, monitoring and evaluating basin management plans aimed at protecting and planning amount, physical and ecological aspects of surface and ground waters from a holistic perspective, the Ministry shall form a Basin Management Committee for each basin in order to provide support for the aforementioned tasks. In case a basin covers more than one province, in accordance with the quantity as well as physical, chemical and ecological quality of the relevant ground and surface water, a Basin Management Committee shall be led by the provincial governorate to be assigned by the Ministry. Committees are composed of the representatives from the provincial organizations of the institutions affiliated by the members of the Water Management Coordination Council, local governments, universities and non-governmental organizations. The Ministry defines the organizational structure and the working procedures and principles of the Committees.
(4) The Ministry consults opinions of the relevant institutions and organizations to ensure their active participation during the process of issuing Basin Management Plans.
(5) The ministry shall inform the public and encourage their active participation during the process of preparing, reviewing and updating Basin Management Plans;
a) Schedule and work plan to constitute basin management plans;
b) Characterization reports;
c) Important water management problems found out in their basins; and
c) Sharing of draft basin management plans.
(6) Basin management plans take into consideration and encapsulate all complementary plans and projects that will ensure that water resources reach good status in terms of quantity as well as physical, chemical and ecological quality. Such plans and projects are attached to basin management plans.
(7) A program of measures is included in each basin management plan for the purpose of attaining and preserving good water status.
(8) Issued basin management plans are published by the Ministry and updated every six years at the latest.
(9) Basin Management Plans are integrated into the Ministry’s central database.
(10) The basin management plans take the water management issues into account during periods of drought.
(11) The environmental objectives set out in basin management plans are taken into consideration when transferring water in between water basins.
(12) It is mandatory to prepare disaster management plans, determine caution and implement such plans in order to prevent or mitigate accidental pollution of water bodies, including cases involving oil pipelines.
(13) Probability of floods and drought, which are possible consequences of climate change, are taken into account when drafting plans at basin scale.
(14) Necessary plans are prepared together with EU member states in trans-boundary basins.

## 2.2. Communiqué on Organization, Duties, Working Procedures and Principles of Basin Management Committees

***Chapter One***
**Purpose**
**Article 1** – (1) The purpose of this Communiqué is to ensure coordination among the relevant institutions and lay out working procedures and principles necessary for monitoring of the implementation, in order to issue and implement basin protection and management plans aimed at protecting and planning surface and ground waters (including coastal waters, yet excluding seas) through a holistic approach.
**Scope**
**Article 2** – (1) This communiqué covers organization of the basin management committees and principles and working procedures regarding their functions.
**Legal Basis**
**Article 3** – (1) This communiqué was issued on the basis of article 9 of the Decree 645 on Organization and Duties of the Ministry of Forestry and Water Affairs (dated 29/6/2011) and article 6 of the Regulation on Protection of Water Basins and Designing Management Plans that was published in issue number 28444 of the Official Gazette on 17/10/2012.
**Definitions and acronyms**
**Article 4** – (1) The wording and acronyms below are used to represent the corresponding meanings specified:

a) Ministry: Ministry of Forestry and Water Affairs.

b) Basin protection action plan: A plan issued for the purpose of protecting potential of water resources for all types of use, ensuring orderly utilization, preventing pollution and improving quality of polluted water resources.

c) Basin management committee: A committee established for each basin under the organizational principles specified in this Communiqué for the purpose of preparing basin management plans, monitoring plan implementation processes and evaluating implementation within the scope of each basin.

c) Head of basin management committee: Governor of the province, in case the basin lies within the boundaries of only one province; or governor of the province specified in Annex 1, who is to be assigned in accordance with basin-specific issues, in case the basin covers more than one province.

d) Members of basin management committee: Representatives from the provincial organization of the institutions and organizations to which members of the Water Management Coordination Council are affiliated, representatives of local governments and representatives of universities and non-governmental organizations to be determined by the Head of the Basin Management Committee.

e) Basin Steering Board: Central board that comprises senior-level officers, deputy director of central organizations of the institutions, which are members to the Water Management Coordination Council.

f) Basin management plan: A plan issued for the entire basin through taking a sustainable protection-utilization balance into account in order to protect, improve and maintain water resources and habitats existing in a basin.

g) SYGM: General Directorate of Water Management.

h) Water Management Coordination Council: The Council established as per the Prime Ministry Circular Note number 2012/7 published on issue 28239 of the Official Gazette on 20/3/2012.

i) National Basin Management Strategy: It refers to the organized strategy, that was devised for the purpose of providing guidance for decisions and investment plans regarding protection, development and sustainable utilization of natural resources in water basins in Turkey; and leading efforts to be made in order to adequately and sustainably meet expectations of the society with regards to the economic, ecological and social benefits of basins as well as to services related to them.

***Chapter 2***

***Organization and Duties of the Basin Steering Board; Organization, Duties, Working Procedures and Principles of Basin Management Committees***

**Article 5** – (1)The Basin Steering Committee shall be chaired by the Undersecretary of the Ministry. The Board shall comprise at least the relevant General Directors or an assigned representative from the Ministries who are members of the Water Management Coordination Council and the President of the Turkish Water Institute or an assigned representative. The Basin Steering Committee shall meet quarterly.

(2) Duties of the Basin Steering Board are:

a) Monitoring and promoting short-, mid- and long-term applications determined for the basins for which the relevant Basin Protection Action Plans have been completed.

b) Ensuring coordination among the institutions for basins with Basin Protection Action Plans that are still in the process of preparation.

c) Ensuring and monitoring coordination between institutions for conversion of Basin Protection Action Plans into Basin Management Plans.

c) Monitoring and coordinating the relevant developments within the scope of the National Basin Management Strategy.

d) Ensuring coordination and evaluation of the process to determine special provisions introduced or to be introduced for drinking and domestic water basins.

(3) The Basin Steering Board may, if deemed necessary, invite the concerned Head and member(s) of the Basin Management Committee to the meeting.

(4) SYGM shall provide secretariat services to the Basin Steering Board.

**Constituting the Basin Management Committee**

**Article 6** – (1) A Basin Management Committee shall be formed by the Ministry for each basin.

(2) Basin Management Committees shall be led by the governor of the province in case the basin lies within the boundaries of only one province; or the governor of the province specified in Annex 1, who is to be assigned in accordance with basin-specific issues, in case the basin covers more than one province.

(3) In order to represent all stakeholders of a basin, Basin Management Committee members shall include representatives of provincial organizations of the relevant institutions, universities, non-governmental organizations and local governments as well as other experts from necessary fields.

(4) Under the leading position of the Governor specified in Annex 1, Basin Management Committees shall comprise Provincial Municipality Mayors, General Directors in charge of the Water and Sewage Administrations affiliated to metropolitan municipalities, General Secretaries of Special Provincial Administrations established in municipalities other than metropolitan municipalities; Regional Directors of the General Directorate of State Hydraulic Works, Ministry of Forestry and Water Affairs and of the General Directorate of Forestry and General Directorate of Meteorology within the basin; Provincial Directors of Environment and Urbanization, Provincial Directors of Food, Agriculture and Livestock; Regional Directors of Ilbank A.S., General Secretaries of Development Agencies, representatives of the Ministry of Energy and Natural Resources, Directors of Public Health, representatives of irrigation unions; an officer of the SYGM at least at the rank of Unit Director; and a representative from each Organized Industrial Zone, universities and Non-governmental Organizations active in the field of water management, to be unanimously determined by a representative of the Chamber of Industry and Commerce and committee attendants.

(5) If deemed necessary by the Head of the Basin Management Committee, the following may be added the committee as well: A private sector representative, Regional Directors of Transportation, Maritime Affairs and Communication present within the basin, Provincial Directors of Disaster and Emergency, a representative of the Ministry of Foreign Affairs, a representative from irrigation cooperatives

and the aquaculture industry, a representative from among power plant authorities, representatives of privately-run hydroelectricity plants and experts of any other required fields.

(6) A supreme committee comprising at least sixteen members excluding the head of the committee and involving at least one representative for each of the institutions listed in paragraph four shall be formed within each Basin Management Committee. Each institution and organization shall determine its own representative to take part in this committee. The Head of a Basin Management Committee shall be entitled to increase the number of supreme committee members to twenty-five, if deemed necessary. Supreme Committees shall be tasked with assessing suitability of and approving decisions made by Basin Management Committees.

(7) Secretariat services shall be provided to the Basin Management Committee by the Regional Directorate/Unit Directorate of State Hydraulic Works based in the relevant coordinating governorate area.

**Duties and working procedures and principles of Basin Management Committees**

**Article 7** – (1) Duties of Basin Management Committees are as follows:

a) Contributing to basin protection action plans and basin management plans to be issued by the Ministry;

b) Monitoring and assessing implementation of basin protection action plans and basin management plans, reporting to the relevant institutions for the relevant actions to be taken;

c) Monitoring the actions taken to protect drinking and domestic water resources, ensuring that special provisions are applied;

c) Contributing to revision of basin management plans, if deemed necessary;

d) Evaluating audit and action results presented by the relevant institutions or organizations, and submitting findings to the steering board in a report;

e) Providing information access consulting opinions and ensuring active participation of the public, during the processes of issuing, reviewing and updating the Basin Management Plans; informing the public about preparatory processes relevant to plans; planning decisions before they are finalized initially through local meetings and then via the press, and understanding public opinion on the matter; announcement of the planned decisions via local meetings and the press before they are finalized and taking into account the opinions of the public;

(2) Basin Management Committees shall submit reports about their work to the Basin Steering Board every quarter in the format determined by the Ministry;

(3) Basin Management Committees shall meet monthly. Supreme committees to be formed within each Basin Management Committee shall conduct a meeting in every three months. If deemed necessary, the Head of a Basin Management Committee may decide to conduct an additional meeting. In order to conduct a committee meeting, the absolute majority of members should be present. Committee decisions are to be accepted unanimously. In case of equality of the votes, the vote of the Head of the Committee shall determine the majority.

***Chapter Three***

***Final Provisions and Effective Date***

**Article 8** – (1) This communiqué shall enter into force as of the date of its publication.

Execution

**Article 9** – (1) Provisions of this communiqué shall be executed by the Ministry of Forestry and Water Affairs.

**Table 1 – Coordinating Governorates Determined by the Ministry**

| | Basin | Coordinating Governorates | Other Provinces in the Basin |
|---|---|---|---|
| 1 | Ergene | Tekirdag | Edirne, Kirklareli |
| 2 | Marmara | Istanbul | Kocaeli, Canakkale, Bursa, Tekirdag, Yalova |
| 3 | Susurluk | Bursa | Balikesir, Kutahya, Manisa, Canakkale, Bilecik, Izmir |
| 4 | North Aegean | Canakkale | Balikesir, Izmir, Manisa |
| 5 | Gediz | Manisa | Usak, Izmir, Kutahya |
| 6 | Kucuk Menderes | Izmir | Aydin, Manisa |
| 7 | Buyuk Menderes | Aydin | Usak, Izmir, Afyonkarahisar, Denizli, Burdur, Isparta, Kutahya, Manisa, Mugla |
| 8 | West Mediterranean | Mugla | Antalya, Burdur, Denizli |
| 9 | Antalya | Antalya | Isparta, Burdur |
| 10 | Burdur | Burdur | Denizli, Isparta, Antalya, Afyonkarahisar |
| 11 | Akarcay | Afyonkarahisar | Konya |
| 12 | Sakarya | Sakarya | Ankara, Eskisehir, Bilecik, Kutahya, Konya, Afyon, Bursa, Bolu |
| 13 | Western Black Sea | Kastamonu | Zonguldak, Bolu, Duzce, Karabuk Bartin, Sinop, Cankiri |
| 14 | Yesilirmak | Amasya | Corum, Samsun, Tokat, Yozgat, Sivas, Gumushane, Giresun, Erzincan, Ordu, Bayburt |
| 15 | Kizilirmak | Samsun | Kirsehir, Kayseri, Yozgat, Nevsehir, Kirikkale, Kastamonu, Cankiri, Corum, Sinop, Sivas |
| 16 | Konya | Konya | Aksaray, Ankara, Isparta, Mersin, Karaman, Nevsehir, Nigde |
| 17 | East Mediterranean | Mersin | Karaman, Konya, Antalya |
| 18 | Seyhan | Adana | Kayseri, Sivas, Nigde, Kahramanmaras, Mersin |
| 19 | Asi/Orontes | Hatay | Kilis, Gaziantep |
| 20 | Ceyhan | Osmaniye | Kahramanmaras, Adana, Kayseri, Sivas, Adiyaman, Gaziantep, Malatya, Hatay |
| 21 | Firat/Dicle/Euphrates/Tigris | Diyarbakir | Elazig, Gaziantep, Malatya, Sanliurfa, Adiyaman, Van, K. Maras, Erzurum, Erzincan, Bingol, Agri, Mus, Bitlis, Mardin, Kilis, Tunceli, Batman, Hakkari, Siirt, Sirnak, Sivas |
| 22 | Eastern Black Sea | Trabzon | Ordu, Rize, Giresun, Gumushane, Sivas, Artvin |
| 23 | Coruh/Corukh | Artvin | Erzurum, Bayburt |
| 24 | Aras/Araks | Kars | Igdir, Agri, Ardahan, Erzurum |
| 25 | Van Lake | Van | Bitlis, Agri |

## 3. Asi basin management committee

As per the communiqué, the Asi Basin Management Committee and Supreme Committee of the Asi Basin conducted a Management Committee meeting on 05.12.2013, where opinions of Committee Members, the OIZ representative, university representatives and representatives of NGO's active in the field of water management were consulted. Nominated members were unanimously elected and organization of the Asi Basin Management Committee was established as specified in Table 2.

**Table 2 – Head and Members of the Asi Basin Management Committee**

| | |
|---|---|
| | **Head of the Management Committee**<br>**Governor of Hatay (Coordinating Governor for the Asi Basin)** |
| 2 | Mayor of Gaziantep Metropolitan Municipality-Gaziantep |
| 3 | Mayor of Hatay Metropolitan Municipality-Hatay |
| 4 | Mayor of Kilis Municipality-Kilis |
| 5 | Rector of Mustafa Kemal University-Hatay |
| 6 | Rector of Gaziantep University-Gaziantep |
| 7 | Rector of Kilis 7 Aralik University-Kilis |
| 8 | General Directorate of Water and Sewage Administration (GASKI)-Gaziantep |
| 9 | General Directorate of Water and Sewage Administration(HATSU)-Hatay |
| 10 | General Secretary of Special Provincial Administration-Kilis |
| 11 | Director of DSI 6thRegion-Adana |
| 12 | Director of DSI 20thRegion-Adana |
| 13 | Director of 7thRegion, Ministry of Forestry and Water Affairs-Adana |
| 14 | Director of 15thRegion, Ministry of Forestry and Water Affairs-Malatya |
| 15 | Regional Director of Forestry-Kahramanmaras |
| 16 | Director of Meteorology, 6thRegion-Adana |
| 17 | Provincial Director of Environment and Urban Planning-Hatay |
| 18 | Provincial Director of Environment and Urban Planning-Gaziantep |
| 19 | Provincial Director of Environment and Urban Planning-Kilis |
| 20 | Provincial Director of Food, Agriculture and Livestock-Hatay |
| 21 | Provincial Director of Food, Agriculture and Livestock-Gaziantep |
| 22 | Provincial Director of Food, Agriculture and Livestock-Kilis |
| 23 | Provincial Director of Science, Industry and Technology-Hatay |
| 24 | Provincial Director of Science, Industry and Technology-Gaziantep |
| 25 | Provincial Director of Science, Industry and Technology-Kilis |
| 26 | Provincial Director of Culture and Tourism-Hatay |
| 27 | Provincial Director of Culture and Tourism-Gaziantep |
| 28 | Provincial Director of Culture and Tourism-Kilis |
| 29 | Regional Director of Provincial Bank of Adana (ILBANK) A.S.-Adana |
| 30 | Regional Director of Provincial Bank (ILBANK) A.S.-Gaziantep |
| 31 | General Secretary of East Mediterranean Development Agency-Hatay |
| 32 | General Secretary of Silkroad Development Agency-Gaziantep |
| 33 | Representative of the Ministry of Energy and Natural Resources (Representative of the General Directorate of Renewable Energy)-Ankara |
| 34 | East Mediterranean Regional Director of Mineral Research and Exploration-Adana |

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**Table 2 – Head and Members of the Asi Basin Management Committee (continued)**

| | **Head of the Management Committee**<br>**Governor of Hatay (Coordinating Governor for the Asi Basin)** |
|---|---|
| 35 | Director of Public Health-Hatay |
| 36 | Director of Public Health-Gaziantep |
| 37 | Director of Public Health-Kilis |
| 38 | Chairman of Yarseli Irrigation Union-Hatay |
| 39 | Officer of General Directorate of Water Management-Ankara |
| 40 | Chairman of Antakya Chamber of Commerce and Industry-Hatay |
| 41* | Representative of Hatay Branch of Turkish Natural Conservation Association-Hatay |
| 42* | Head of the Department of Biosystem Engineering, Faculty of Agriculture, Mustafa Kemal University-Hatay |
| 43* | Head of the Department of Environmental Engineering, Faculty of Architecture, Kilis 7 Aralik University-Kilis |
| 44* | Head of Antakya OIZ-Hatay |
| 45 | Provincial Director of Disaster Relief and Emergency Management-Hatay |
| 46 | Provincial Director of Disaster Relief and Emergency Management-Gaziantep |
| 47 | Provincial Director of Disaster Relief and Emergency Management-Kilis |
| 48 | Representative of the Ministry of Foreign Affairs (Representative of the General Directorate of Multilateral Economic Affairs)-Ankara |
| 49 | Chairman of Yesilkent Ground Water Irrigation Cooperative, Erzin-Hatay |
| 50 | Dean of the Faculty of Maritime Sciences and Technology, Mustafa Kemal University, Iskenderun-Hatay |
| Secretary | Director of DSI 6th Regional Directorate-ADANA |

* Committee members unanimously elected by the Head and Members of Asi Basin Management Committee.

**Figure 1 – Overall Plan for the Asi Basin (Asi Basin, Basin Protection Action Plan)**

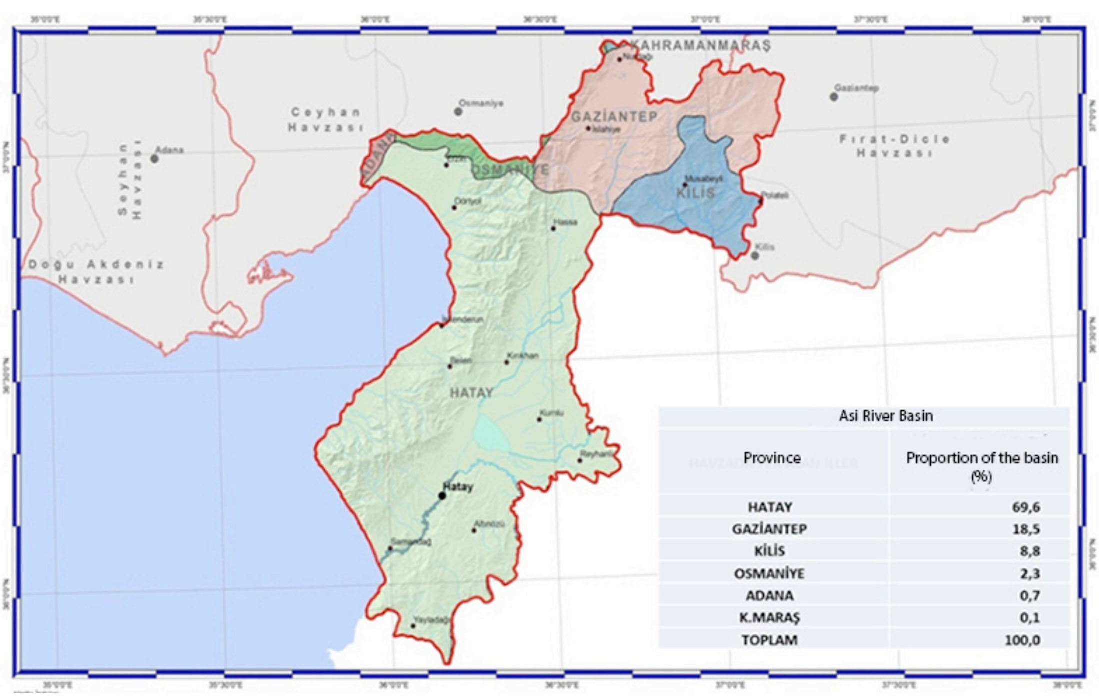

**Table 3 – Task Schedule and Monitoring Tables for the Asi Basin Protection Action Plan**

| Action No | Action |
|---|---|
| 1 | ESTABLISHING LEGISLATIVE AND INSTITUTIONAL BASIS |
| **1.1** | **Establishing Legislative Basis** |
| **1.1.1** | **Laws** |
| | Adoption of the Water Law |
| | Revision of the Law on Environment |
| | Revision of the Law on Aquaculture |
| | Law on Establishing Provincial Water and Sewage Administration Bodies in Provinces other than Metropolitan Municipalities |
| **1.1.2** | **Regulations to be Revised** |
| | Revision of the Regulation on Water Pollution |
| **1.1.3** | **Regulations Required to be Adopted** |
| | Regulation on Preservation of Drinking Water Basins |
| | Regulation on Detection and Prevention of Leakages and Illegal Uses in Drinking Water Networks |
| | Regulation on Monitoring of Surface and Ground waters |
| | Regulation on Determining Dangerous Substances |
| | Regulation on Effective Use of Economic Instruments for Water Management and Adoption of Cost Effective Tariffs |
| | Regulation on Reuse of Treated Wastewater |
| | Regulation on Issuing and Implementation of Flood Management Plans |
| | Regulation on Preservation of Water Quality for Sustainability of Habitats of Trout and Carp |
| **1.1.4** | **Communiqués to be Adopted and Revised** |
| | Communiqué on Management of Membrane Concentrate Flows for Receiving Environments |
| | Communiqué on Sampling and Analysis Methods under the Regulation on Water Pollution Control |
| | Communiqué on Determining Environmental Quality Standards |
| | Communiqué on Protection of Still Inland Waters against Eutrophication |
| **1.2** | **Establishing Institutional Infrastructure** |
| | Supreme Board of Water Management |
| | Basin Water Allocation Committee |
| | Forming Basin Management Committees |
| | Completing formation of BMC's for 25 Basins as per the Relevant Communiqué |
| | Establishing Provincial Water and Sewage Administrations |
| 2 | STRATEGIES AND ACTIONS |
| **2.1** | **Following the National Basin Management Strategy Document** |
| **2.2** | **Issuing River Basin Management Plans** |
| **2.3** | **Implementing Basin Protection Action Plans** |
| 2.3.1 | Urban Wastewater Management |
| 2.3.2 | Industrial Wastewater Management |
| 2.3.3 | Solid Waste Management |
| 2.3.4 | Nonpoint Pollution Management and Control |
| 2.3.5 | Reforestation, Flood and Erosion Control |
| 2.3.6 | Treatment Sludge Control |
| 2.3.7 | Working on Determining Special Provisions for Potable Water Basins |
| 2.3.8 | Flood Managements |
| 2.3.9 | Drought Management |
| 2.3.10 | Working on the Monitoring, Inventory and Water Information System |
| 2.3.11 | Water Investments |
| 2.3.12 | Reuse of Treated Wastewater |
| 2.3.13 | Control of Impacts of Climate Change on Water Resources |
| 2.3.14 | Industrial Allocation Plans |
| 2.3.15 | Solutions to be Introduced for Hot Spots |

The “Basin Protection Action Plan for the Asi Basin”, which was prepared by SYGM and The Scientific and Technological Research Council of Turkey (TUBITAK) Marmara Research Center, was completed in 2014 with contributions of the relevant institutions and organizations. Actions included in the Basin Protection Action Plan for the Asi Basin were planned for the short (3 years), medium (6 years) and long term (10 years) for the scales of Lower Asi Sub-basin and İskenderun Bay Sub-basin.

A maximum of 78 parameters had been observed in the Asi Basin by the end of 2014 through the surface and groundwater observation stations, that were established by the DSI General Directorate in accordance with various irrigation purposes. In line with the new basin management approach formed within the framework of Strategic Environmental Assessment, a meeting was held under coordination of SYGM on April 14, 2014, in the Meeting Hall of DSI 63rd Regional Directorate among the DSI General Directorate, Ministry of Food, Agriculture and Livestock and the Ministry of Environment and Urban Planning. During the meeting, water bodies and typologies were determined in order to ensure monitoring of surface water quality, and 37 Water Quality Monitoring Stations were decided to be established for the Asi Basin. Out of these, 6 of them would be located in Protected Areas (Figure 2). As of January 1, 2015, observational and conservational monitoring to be carried out at these stations, which are based in the vicinities of streams, creeks, ponds, transitional waters and coastal waters, will cover approximately 250 physiochemical, hydro-morphologic, bacteriologic and biologic parameters. Observational monitoring studies will be reiterated every 6 years. Following 1 year of observational and conservational monitoring, operational monitoring will be carried out at the 10 stations determined by SYGM in 2014. The final number of these stations, however, is yet to be finalized in 2015.

**Figure 2 – Location of the water quality monitoring stations**

As per the relevant communiqué, the "Basin Management Workshop" was held by the Basin Management Committee Secretariats and the DSI General Directorate in DSI 6th Regional Directorate, Adana on April 24-26, 2014. Participants included all relevant DSI Regional Directorates and authorities from SYGM. The "Draft Communiqué on Organization, Duties, Working Procedures and Principles of Basin Management Committees", which was prepared by SYGM, was presented by SYGM on the occasion of this workshop. Opinions of DSI Regional Directorates about the draft were consulted through official correspondences and the final opinion of DSI General Directorate was later communicated to SYGM. SYGM is still in the process of revising the Communiqué.

Basin Protection Action Plans have been prepared for 25 basins with the participation of all relevant stakeholders for the purpose of conserving basins, reducing pollution and improving the pollution status. Performing and monitoring the actions listed in the task schedules and monitoring tables issued as part of the aforementioned plans has great importance. Conducting regular meetings throughout the year having committee secretariats keep meeting minutes at such meetings has also great importance so as to make sure that the tasks listed in the Communiqué on Organization, Duties, Working Procedures and Principles of Basin Management Committees are realized.

The current Basin Management Committees have been established in a format that removes the disadvantages of moving beyond provincial boundaries, which is a consequence of the present administrative organizational structure. They promote an administrative approach at basin scale for a better understanding of the concept of basins. Furthermore, the committees gather together all basin stakeholders at the same place, promote understanding among upstream and downstream stakeholders for fair usage, and enable discussion of pollution-induced impacts at upstream level. Thus, they ensure transition from provincial inventories that contains drought action plans to inventories issued at basin level.

DSI Regional Directorates that are in charge of Secretariat services for Basin Management Committees, prepare the task schedule that includes the 2015 meeting schedule as well, in accordance with the instructions of our Coordinating Governors. In line with this schedule, stakeholder meeting invitations will be sent to Basin Management Committee Members for Basin Management Committee Meetings, which will be led by the Coordinating Governors who are also Heads of the relevant committees.

The task schedule and monitoring table results to be collected from Basin Management Committee members will be entered into monitoring tables, which will be regularly submitted to the Ministry of Forestry and Water Affairs via e-mail. Minutes of Basin Management Committee meetings will also be submitted to the Basin Steering Board following each meeting.

DSI Regional Directorates, in charge of Secretariat services for Basin Management Committees, will act as committee members in addition to their secretariat functions; contribute to Basin Protection Action Plans, Basin Management Plans and Basin Management Committee Activities with their relevant experience; and follow decisions made by the Water Management Coordination Council and adapt their own activities to such decisions in order to coordinate the required level of cooperation and collaboration among the various stakeholders of Basin Management Committees.

Management Committee Meetings for Asi Basin will involve any required revisions in the relevant Basin Protection Action Plan as per the Communiqué on Organization, Duties, Working Procedures and Principles of Basin Management Committees, and be conducted as regularly per year as the relevant legislation requires. Meeting agendas will include the following: 1- Opening speech by the Head of the Committee; 2- evaluation of the process of entering data into the task schedules and monitoring tables of the Basin Protection Action Plan number 19 of the Asi Basin Stakeholders within every three months, review of accurate data entry as well as of basin monitoring and application activities in line with the schedule/plan; A- task schedule and monitoring tables for the process of establishing the legislative and institutional basis; B- task schedule and monitoring tables for strategies and actions; 3- discussion items proposed by the head of the committee and members prior to the meeting; and 4- discussion of outcomes and suggestions among the head of the committee and members, which is to be followed by the closing.

The Asi Basin Supreme Management Committee will also, follow regular committee meetings, conduct routine meetings in order to evaluate and approve suitability of decisions made by the Basin Management Committee.

Coordinating Governors will execute as the Head of the Committee and Supreme Committee, while secretariat services will be provided by the DSI Regional Directorates, which are in charge of the province of the relevant Coordinating Governorate.

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# Land-use and Land-cover Changes in Amik Plain, Hatay

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→ Kilic, S., "Land-use and Land-cover Changes in Amik Plain, Hatay", in *Water Resources Management in the Lower Asi-Orontes River Basin: Issues and Opportunities*, Geneva: Graduate Institute of International and Development Studies; Istanbul: MEF University, 2016, p. 57–62.

## 1. Introduction

Human-induced disturbances such as land use/land cover (LULC) changes, pollution of air, water and soil, and losses of productive lands and biodiversity are increasingly threatening ecosystem productivity and health on local, regional and global scales (Wali et al. 1999). Land use/land cover changes are the most common cause of loss of biological productivity and biodiversity in aquatic and terrestrial ecosystems. Increases in population density, water use intensity, and droughts are putting water resources under pressure and calling for sustainable and adaptive ecosystem management strategies if escalating land use conflicts are to be avoided and environmental degradation is to be reversed.

About 80% of all wetlands in some areas of Europe, and *ca.* 50% of all wetlands in the United States have been lost or destroyed (Gibbs 2000). Globally, *ca*. 1000 bird species many of which are particularly dependent on aquatic habitats including wetlands are on the verge of extinction. Sustainable management of natural resources requires that ecological goods and services be used to meet both current and future generations' needs by recognizing and adapting to the inevitable biophysical limitations and interdependencies. This is even as multi-temporal high-resolution, remotely sensed data and geographic information systems (GIS) have facilitated the derivation of ecological inventories and the monitoring of LULC changes on the local, regional and global scales. There is a lack of quantification and identification of LULC changes in ecologically productive and hotspots of the study region: Amik Plain, Hatay, Turkey (Kilic et al. 2003; Kilic et al. 2004).

Sustainability of vital ecosystems in the region are threatened by increased rates of population growth, consumption and waste disposals, and the keen competition among LULCs for both rate-limited ecological services and stock-limited natural resources. The main objective of this study was to reconstruct past LULC changes over the last 28 years at the scale of the province of Hatay, Turkey, based on a time series of Landsat imagery acquired from 1972, 1987, and 2000.

## 2. Methodology

### 2.1. Study region

The study region, Amik Plain, is located in the province of Hatay (Turkey) (35° 47′-36° 24′ E; 35° 48′-36° 37′ N) and has a total area of *ca.* 3930 km$^2$ with an elevation range from sea level up to 2100 m (Figure 1).

Figure 1 – Location of the study region in Turkey


The prevalent climate regime in the Amik Plain is Mediterranean climate characterized by a mild winter during which about 67% of the annual precipitation of 1,124 mm falls, and a hot dry summer. Average annual temperature reaches a maximum of 44°C in the summer and a minimum of –15°C in the winter, with an average annual temperature of 18°C. Parent materials in the study region consist mostly of sedimentary rocks of highly calcareous clays, limestone, dolomites, and sandstones. The major soil orders include entisols, inceptisols, vertisols, mollisol, and alfisol (Kilic 1999).

## 2.2. Data processing

The following remotely sensed cloud-free data was used in the classification of LULCs in the province of Hatay through ERDAS Imagine and TNTmips software: Landsat MSS of December 15, 1972, Landsat-5 TM of October 1, 1987, and Landsat-7 ETM+ of June 22, 2000. The images were geometrically corrected and geo-coded to the Universal Transverse Mercator (UTM) co-ordinate system, using 1:25.000 scale topographic maps and aerial photographs taken in 1992. Approximately 45 evenly distributed ground control points were selected from each image. The acquired Landsat images were classified using a maximum likelihood classifier method of ERDAS Imagine and TNTmips software. A supervised maximum likelihood classification was performed with 2682, 11689 and 8107 pixel training data sets, and the images were classified into 6 (1987 and 2000) and 7 (1972) LULC classes.

## 3. Results and discussion

Based on a time series of the Landsat images, LULCs of the study region were classified into seven categories: evergreen forest, shrublands-orchards, the Amik lake and its related wetlands, croplands, water bodies, settlements, and bareground (Table 1).

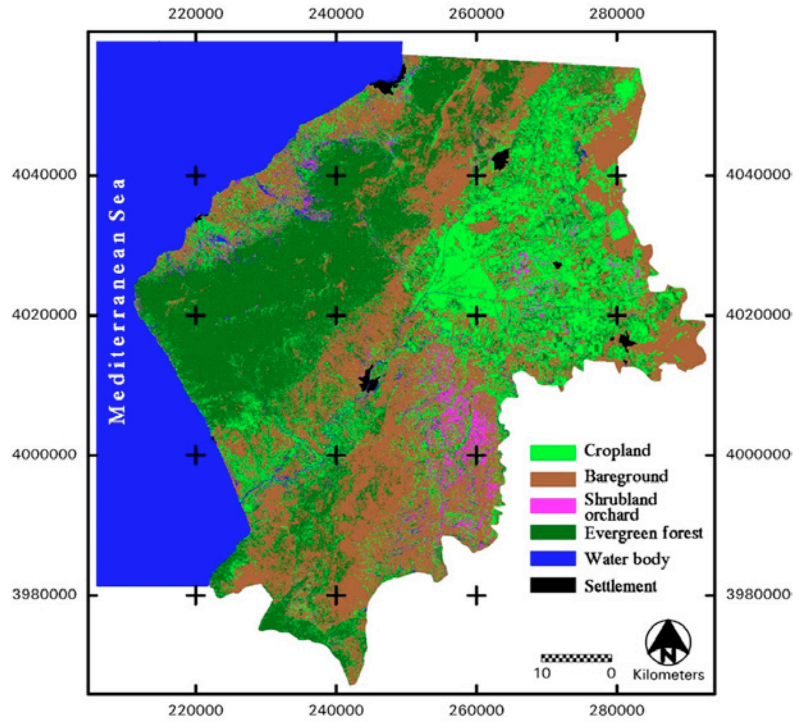
**Table 1 – Detection of 28-year changes in land uses/covers (LULC) in the province of Hatay, based on time series satellite images of 1972, 1987, and 2000**

| Land use/land cover | Land area (ha) | | | Rate of change in LULC (ha $yr^{-1}$) | | | Amount of change in LULC (%) |
|---|---|---|---|---|---|---|---|
| | 1972 | 1987 | 2000 | 1972–1987 | 1987–2000 | 1972–2000 | 1972–2000 |
| Amik lake & wetlands | 5325 | – | – | – | – | – | –100 |
| Croplands | 46,658 | 92,098 | 127,883 | 3029 | 2753 | 2901 | 174 |
| Evergreen forests | 110,417 | 141,904 | 125,964 | 2099 | –1226 | 555 | 14 |
| Shrublands & orchards | 74,057 | 12,193 | 41,130 | –4124 | 2226 | –1176 | –44 |
| Settle-ments | 2090 | 2276 | 4297 | 12 | 155 | 79 | 106 |
| Bareground | 154,424 | 144,500 | 93,696 | -662 | –3908 | -2169 | –39 |
| Total area* | 392,970 | 392,970 | 392,970 | 392,970 | 392,970 | 392,970 | – |

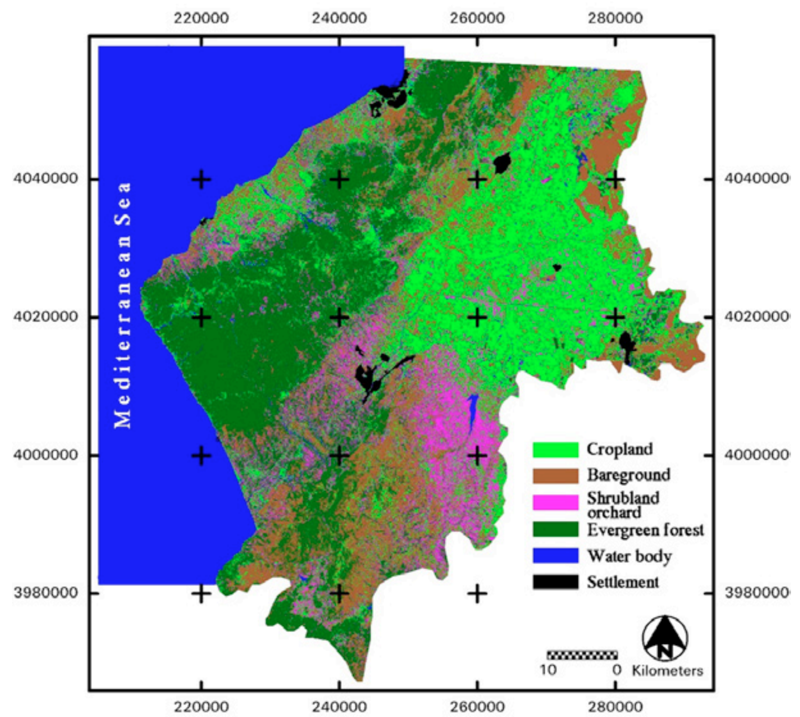
The annual rates and cumulative amounts of LULC changes were estimated over the two periods: 1972 to 1987 (period 1), and 1987 to 2000 (period 2). Land use/cover changes were of highest amount in croplands, evergreen forests, shrublands-orchards, and the Amik lake-related wetlands in the first period and in settlements and bareground in the second period. In both periods, bareground decreased, while croplands and settlements increased. In the first period, the rate of change of the Amik Lake-its related wetlands, and shrublands-orchards was negative, whereas the rate of change of evergreen forests was positive. In order to determine the accuracy of the image classification, the stratified random sampling method (Jensen 1996) was used to generate reference points. For each of classified images, 300 reference points were obtained. The resulting overall classification accuracy was 91%, 88%, and 85% with Kappa values of 0.89, 0.85, and 0.81 for the three images of 1972, 1987, and 2000, respectively. With the initiation of a large-scale campaign to increase the amount of croplands used for food production in the Amik plain in the 1940s, the Amik Lake was channeled into the Orontes River. The increase in croplands took place at the expense of the irreversible losses of the lake and its related wetlands used to provide vital ecosystem goods and services for the region. In both periods, croplands and settlements increased in parallel to the decrease in bareground. Settlements and baregrounds were negatively correlated ($r = -0.9$; $p < 0.05$). The increase in settlements occurred mostly to the detriment of croplands. There was a significantly negative correlation between evergreen forest-orchards and shrublands ($r = -0.9$; $p < 0.05$) Figure 2.

**Figure 2 – Classification of land use/cover (LULC) in the province of Hatay based on time series satellite images of (a) 1972, (b) 1987, and (c) 2000**

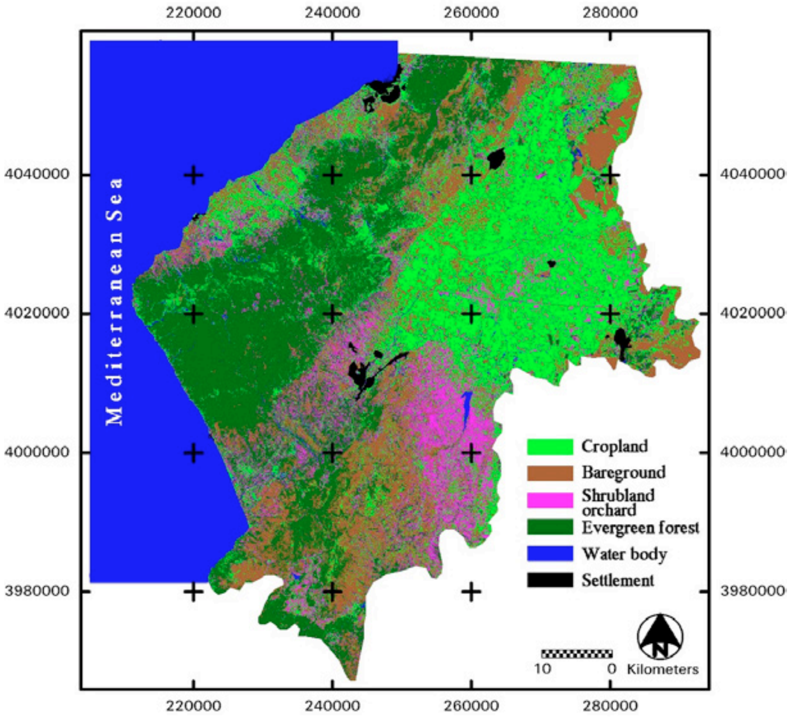
1972




1987

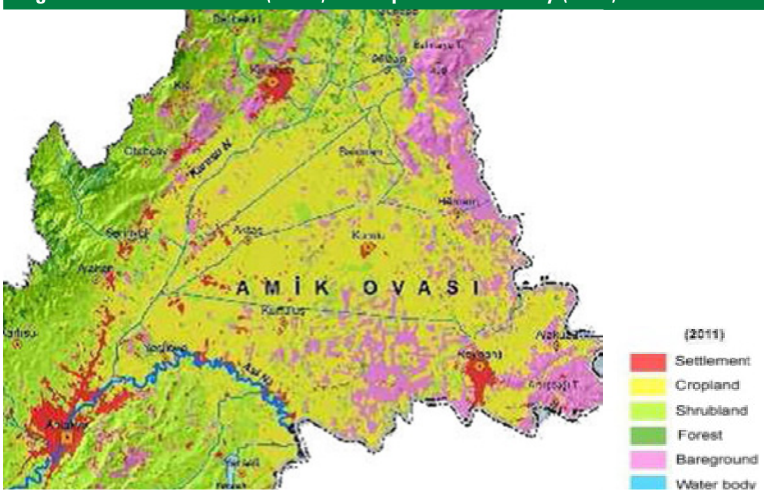


2000




Özsahin and Atasoy (2014) studied Land use and Land cover (LULC) change of Amik plain in 2011 (Figure 3). In that study, Land use and Land cover (LULC) change was analyzed through Landsat satellite images and various maps. As a result of the study, soil erosion raised 10 % between 1990 and 2011. There were significant negative changes in forest and shrubland. Agricultural areas in the Amik basin were occupied by the expansion of settlements. Agricultural lands and forest areas have been invaded in the last 20 years.

**Figure 3 – Land use/cover (LULC) in the province of Hatay (2011)**




(Özşahin and Atasoy, 2014)

Understanding of ecosystems requires historical reconstructions of LULC dynamics. The integration of ecosystem management and economic development can only be achieved by a holistic, interdisciplinary, goal-oriented and participatory approach. This approach should aim at having people recognize that their well-being is dependent upon the sustenance of ecological goods and services and at improving coordination among related administrative and institutional bodies.

The magnitude of uncertainties associated with the quantification of the LULC changes needs to be reduced and integrated with dynamic process-based models in order to enable management and planning institutions and public to make informed decisions. The intensive drainage and cultivation of Lake Amik and its related wetlands with rich, fertile soils and abundant supply of water are the kind of the environmental challenges that many rural communities face across the world. The impacts of the need for more agricultural land, and prevailing land use policy on life support ecosystem functions are evident from the presented results. Unsustainable LULC changes result in loss of wetlands, falling groundwater levels, reducing agricultural production, disappearance of natural wetland vegetation, invasion of non-native species, and $CO_2$ emissions with local-to-global linkages of global climate change.

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# Sustainable Land Use Planning of Lower Asi River Basin


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## 1. Introduction

Sustainable development, although a widely used phrase and idea, has many different meanings and therefore provokes many different responses. In broad terms, the concept of sustainable development is an attempt to combine growing concerns about a range of environmental issues with socio-economic issues. Sustainable development has the potential to address fundamental challenges for humanity, now and into the future. However, to do this, it needs more clarity of meaning, concentrating on sustainable livelihoods and well-being rather than well-having and long term environmental sustainability, which requires a strong basis in principles that link the social and environmental to human equity (Hopwood et al 2005).

Land resource inventories to determine land suitability have become a standard part of planning analysis at many scales. Any attempt to review, compare, evaluate, or improve upon the myriad of case studies, many only partially documented and in limited circulation, suffers from the lack of reference to a common framework (Hopkins 2007).

Sustainable land use planning requires an in depth analysis of the existing resources (localization, features, sensitivity to development) and an understanding of development characteristics (resource needs and collateral effects) in order to identify the use for the natural resources in a way that will not prejudice future development (Van Lier et al. 1993).

Land suitability is the ability of a given type of land to support a defined use. The process of land suitability classification is the evaluation and grouping of specific areas of land in terms of their suitability for a defined use. The main objective of the land evaluation is the prediction of the inherent capacity of a land to support a specific land use for a long period time without deterioration, in order to minimize the socio-economic and environment costs (De La Rosa 2000).

Geographical Information Systems (GIS) is the tool for input, storage and retrieval, manipulation and analysis, and output of spatial data (Marble et al 1984; Prakash 2003). GIS functionally can play a major role in the spatial decision-making. Considerable effort is involved in information collection for the suitability analysis for crop production. This information should present both opportunities and constrains for the decision-maker (Ghafari et al. 2000). GIS has the ability to perform numerous tasks utilizing both spatial and attribute data. In multi-criteria evaluation many data layers are to be taken, which can be achieved conveniently using GIS (Prakahs 2003).

Multi-criteria decision analysis (MCDA) is an umbrella approach that has been applied to a wide range of natural resource management situations. The general definition three dimensions of MCDA are: (1) the formal approach, (2) the presence of multiple criteria, and (3) that decisions are made either by individuals or groups of individuals. Invariably these dimensions are the main reasons why MCDA has been one of the most widely applied models in land use planning, because they manifest some of the major river basin management issues, namely: (1) the need for a structured and rational management approach that can integrate many of the key river basin management elements, (2) the multi-functional or multiple uses of the river basin, and (3) the presence of multiple stakeholders and interest groups each with their own views, goals, and demands on how the river basin should be managed (Mendoza and Martins 2006).

Some of Turkey's wetlands, which are of international importance, have been under protection under the Ramsar Convention. Before it was drained the Amik Lake could have been protected by the Ramsar Convention (Varnaci 2008). It covered about 220 km² of marshes before drainage canals were built to drain the lake. At the beginning of the 1980s drainage was completed and transformed the former lake area into a plain. Soon after, intensive agricultural activities began. But these agricultural activities produced intensive salinity. Salinization has been on the rise year after year contributing to geological decay. Agriculture has been severely affected by salinization. Unless necessary measures are taken, salinization will reach serious proportions (Zor 2000).

Under these developments, the lower Asi River Basin has been transformed from a natural structure to an industrial and an urban structure that adversely affected the ecological structure. This current situation requires new ecological database for sustainable planning and maintenance. Therefore some precautions have to be taken, such as; allocating some lands to ecological land use planning for natural resources utilization in a rational manner, preserving natural resources for future generations.

Hence, the aim of this study is to determine sustainable land use planning of the lower Asi River Basin by using ecological and social factors in resolving the above problems.

## 2. Materials and methodology

### 2.1. Study area and materials

#### *2.1.1. Study area*

The lower Asi River Basin, a region with a typical complex Mediterranean landscape in the southern part of Turkey in Hatay province, is chosen as the study area. It is located in the southern part of Turkey (36° 31¹- 36° 01¹ N and 35° 54¹ - 36° 41¹ E) and covers 146.199,80 ha. The study region is limited by Syria in the east, by Amanos Mountain up to border of 250 m high in the west, by Kirikhan in the north, by Antakya and Samandag province to the south. It is border to the Mediterranean Sea. Asi River and Afrin, Muratpasa and Karasu Streams are located in the central part of the study area. The entire Amik plain is located in the study region.

**Materials:** Topographic maps (1/100.000), Topographic maps (P35-c2, P35-c3, P36-a1, P36-a2, P36-a3, P36-a4, P36-b1, P36-b2, P36-b3, P36-b4, P36-c1, P36-c2, P36-d1, P36- d2, P36-d4, P37-a1, P37-a3, P37-a4, P37-d1, P37-d2), Landsat (2001), ALOS (2008) ve Aster (2009) imagery, map of land capability classes, map of major soil groups (obtained from TUGEM), erosion map, Asi River Basin Hydrogeology study report (for geology), Turkey geology maps (1/100.000), meteorological data (1975-2011), forest maps, socio-economic data. Arc GIS 9.3, Erdas Imagine 9.1 and Auto CAD software was used during to GIS stage.

***2.1.2. Methodology***

A "Linear Combination Model" was used as one of the multiple criteria decision-making approach analysis model in the study. So the study comprises 4 stages: (1) obtaining data, (2) analysis, (3) evaluation and (4) conclusion.

**(1) Obtaining data:** The stage consists of literature survey about the subject, obtaining data, determining the current status of the research area. Current status includes ecological and socio-economic factors. Ecological factors were divided as biotic and abiotic factors. Biotic factors consist of flora and fauna, while abiotic factors consist of topographic structure (slope, aspect, elevation), geology (geological structure and seismicity), hydrology, soil structure (land capability classes, major soil groups, erosion) and meteorological factors (temperature, precipitation, humidity, wind). All data was converted to digital data using ArcGIS 9.3 software. All kinds of base maps were obtained to get optimum sustainable maps. Remotely sensed data were used in the classification of Land Use in the research area through Erdas Imagine 9.1 software: ALOS-AVNIR 2 (2008), ASTER (2009). The images were geometrically corrected and geocoded to the Universal Transverse Mercator (UTM-WGS 84, zone 37) coordinate system. A minimum of 20 regularly distributed ground control points (GCPs) were selected from the images. Resampling was performed using a nearest neighbor algorithm. The transformation had a root mean square (RMS) error of <0.5 pixels indicating that the image was accurate to within one pixel. "Maximum Likelihood Classification" performed for classification the area. Pixel resolution was 30 cm used in the study.

**(2) Analysis:** Potential sustainable land use maps were created for each land use classes in this stage. Linear combination model was used to produce these maps.

**Linear Combination Method:** The most frequent response to this understanding of the measurement assumptions of the ordinal combination method has been to play the weighting game. The types within each factor are rated on separate interval scales. Then a multiplier - often identified as an importance weight - is assigned for each factor. The ratings for each type are multiplied by the weight for the factor. The "suitability rating" is made for a particular region then the sum of the multiplied ratings, or in mathematical terms, the linear combination (Hopkins 1977).

**Suitability Rating (Standardization of the Criteria Map):** In the land suitability analysis, a map represents each evaluation criterion with ordinal values (like S1, S2, N1, N2 etc.) indicating the degree of suitability with respect to a criterion (Seghal 1996; Prakash 2003). These classes have to be rated, according to importance of the class S1 with respect to particular criteria in contributing to the final goal or objective. This process of setting the relative importance of the classes of criteria is called standardization. Criteria standardization is normally done from 0 to 1 scale. Pairwise comparison technique can be used for the purpose of rating or standardizing these ordinal values (Malczewski 2004). In this particular land suitability analysis the criteria are mainly related to topographic structure, geology, hydrology, soil structure and meteorological factors, flora, fauna, socio-economic, environment and infrastructural facilities. Some of them can be represented by the GIS layer and some are non-spatial. These criteria at the lowest level have different suitability classes are standardized on 0 to 3 scales. S means suitable, N means non suitable in the stage, S1 "most suitable", S2 "suitable", N1 "little suitable" and N2 "non suitable". So S1 get highest rate as 3, while N2 get lowest rate as 0 (Table 1).

**Suitability weights (Assessing the weights):** At higher levels of hierarchy, the criteria are required to be evaluated according to effects of determining land use potential.

**Table 1 – Suitability criteria for agriculture, settlement, industry, forest, meadow, protected area, recreational area**

| Land Use Type | Criteria | Suitability Rating | | | | Suitability weight (SW) |
|---|---|---|---|---|---|---|
| | | 3 (Most suitable) | 2 (Suitable) | 1 (Little suitable) | 0 (Non suitable) | |
| | | S1 | S2 | N1 | N2 | |
| **Agriculture** | Soil Capability Class | I- II | III-IV | V-VI | VII-VIII | 1 |
| **Settlement** | Soil Capability Class | VII-VIII | V-VI | III-IV | I-II | 0,40 |
| | Geological Structure | Basalt, Conglomerate | Basalt, Conglomerate | Alluvion, dayk complex, limestone, marl, tectonic | Alluvion, dayk complex, limestone, marl, tectonic | 0,30 |
| | Slope | % 6-12 | %12-20 | %2-6 | %0-2 ,>20 | 0,20 |
| | Vegetation | Outside of forest, shrubs, dunes, wetlands, crops (olive, citrus) and pasture | Outside of forest, shrubs, dunes, wetlands, crops (olive, citrus) and pasture | Forest, shrubs, dunes, wetlands, crops (olive, citrus) and pasture areas | Forest, shrubs, dunes, wetlands, crops (olive, citrus) and pasture areas | 0,10 |
| **Industry** | Soil Capability Class | VII-VIII | VI | V | I-II-III- IV | 0.25 |
| | Geological Structure | Basalt, Conglomerate | Basalt, Conglomerate | Alluvion, dayk komplex, limestone, marl, tectonic | Alluvion, dayk komplex, limestone, marl, tectonic | 0.21 |
| | Slope | % 6-12 | %12-20 | %2-6 | %0-2, >20 | 0.11 |
| | Vegetation | Outside of forest, shrubs, dunes, wetlands, crops (olive, citrus) and pasture | Outside of forest, shrubs, dunes, wetlands, crops (olive, citrus) and pasture | Forest, shrubs, dunes, wetlands, crops (olive, citrus) and pasture areas | Forest, shrubs, dunes, wetlands, crops (olive, citrus) and pasture areas | 0.18 |
| | Erosion | Non or little | Moderate erosion | Severe erosion | Very severe | 0.04 |
| | Settlement | Non-residential | Non-residential | Residential areas | Residential areas | 0.14 |
| | Accessibility to road (km) | 0.5-2 | 2-5 | 5-10 | 10> | 0.07 |
| **Forest** | Soil Capability Class | VI-VII | V | IV | I-II-III-VIII | 0.20 |
| | Slope | %12-30 | > %30 | %6-12 | %0-6 | 0.10 |
| | Vegetation | Forest | Forest | Outside of forest | Outside of forest | 0.40 |
| | Erosion | Severe | Moderate | Very severe | Little | 0.30 |
| **Meadow** | Soil Capability Class | IV-V | VI | III | I-II-VIII | 0.40 |
| | Slope | % 1-12 | %12-20 | %20-30 | >%30 | 0.10 |
| | Vegetation | Outside of forest, shrubs, dunes, wetlands, crops (olive, citrus) and pasture | Outside of forest, shrubs, dunes, wetlands, crops (olive, citrus) and pasture | Forest, shrubs, dunes, wetlands, crops (olive, citrus) and pasture areas | Forest, shrubs, dunes, wetlands, crops (olive, citrus) and pasture areas | 0.30 |
| | Erosion | Non or little | Moderate | Severe | Very severe | 0.20 |
| **Protected Area** | Sensitive Biotopes | Coast areas, wetland, forest, scrubs | Plated areas | Bare soil, meadow | Industry, residential area | 0.33 |
| | Protected Areas | Natural Conservation Area, Site Area | Natural Conservation Area, Site Area | Wildlife Development Area | Non | 0.67 |

→

**Table 1 – Suitability criteria for agriculture, settlement, industry, forest, meadow, protected area, recreational area (continued)**

| Land Use Type | Criteria | Suitability Rating | | | | Suitability weight (SW) |
|---|---|---|---|---|---|---|
| | | 3 (Most suitable) | 2 (Suitable) | 1 (Little suitable) | 0 (Non suitable) | |
| | | S1 | S2 | N1 | N2 | |
| **Water Based Recreation** | Soil Capability Classes | VI-VII-VIII | IV-V | III | I-II | 0.23 |
| | Slope | % 1-6 | %6-12 | %12-20 | >20 | 0.08 |
| | Accessibility to wetland (km) | 0-1 | 1-2 | 2-5 | 5> | 0.30 |
| | Current Land Uses | Shores, Wetlands | Shores, Wetlands | Agriculture, Residential, Industry, Meadow | Agriculture, Residential, Industry, Meadow | 0.33 |
| | Erosion | Non or little | Moderate | Severe | Very severe | 0.06 |
| **Non-Water Based Recreation** | Soil Capability Classes | VI-VII-VIII | IV -V | III | I-II | 0.23 |
| | Slope | % 1-6 | %6-12 | %12-20 | >20 | 0.08 |
| | Accessibility to forest (km) | 0-1 | 1-2 | 2-5 | 5> | 0.30 |
| | Current Land Uses | Forest | Forest | Agriculture, Residential, Industry, Meadow | Agriculture, Residential, Industry, Meadow | 0.33 |
| | Erosion | Non or little | Moderate | Severe | Very severe | 0.06 |

Here the criteria weights need to be summed up to 1, so the well-established rank sum method was used (Dragan 2009). In this way the criteria over the hierarchy are obtained. Standardized criteria maps are multiplied with these criteria weights at each level.

**Suitability Score:** Suitability score for each pixel was calculated according to following formula for each kind of land use (Table 1).

SSn=SRn * SWn
TSS=SS1 + ….. + SSn

(SS: Suitability score, SR: Suitability Rating, SW: Suitability Weights, TSS=Total Suitability score)

As a result of the calculation, all land uses of proposed potential suitability map were classified as "most suitable", "suitable", "less suitable" and "not suitable". After that, "non suitable" areas are ignored for each potential suitability land uses. Than the differences between highest value and lowest value divided to triplicate for each pixel, after that the pixel get the highest score to determine its suitability rate. This process is implemented for each proposed land uses. Afterwards, four grade potential suitability maps are obtained for each land use. These entire maps intersected to create potential suitable map for each land use. Priority is given to forest, protected area and residential places to maintain sustainability.

**(3) Evaluation:** Evaluation of the research was done after analyses. Whole potential land use map created by intersection all potential land use maps. After that land use map overlaid with this map, and then contradiction maps created for each land uses.

**(4) Conclusion:** Optimal land use planning is created as a result of the study. This map is created by using potential suitability map, in addition to socio-economic structure of the area with the target of sustainability. Some recommendations were developed to reduce conflict between the results and land uses.

## 3. Results and discussion

Natural and social structure of study area is evaluated with a method based on ecological basis to determine the suitability of potential uses in this study. As a result of a detailed inventory of site, potential land uses were defined as agriculture, settlement, industry, forest, meadow pasture, protected area, and recreational area.

"Potential suitability" maps, which are created for each land use intersected to create "potential suitable map" for all type of land use. Some pixels become suitable for more than one land uses during the process. Forest, protected area and current settlement land are considered as priority areas to resolve conflicts. Conflicts were determined after intersected current land use map and potential suitable map. All these process were carried out by using GIS.

Finally, an "optimal land use map" was created to eliminate contradictions between "potential suitable map" and "current land use map" (Figure 1, Table 2). The potential suitable land use map is used as a base map during the process, which included ecological criteria to maintain sustainability. For example Amik Lake was drained about 40 years ago. When intersected all ecological criterion maps Amik Lake occur again, and then it is proposed in the final map to reconstitute it. The same situation occurred for Samandag dunes. Samandag dunes are one of the most important dunes in all Mediterranean coastal regions. So it suggested as a protected area in the final map (Samandag dune doesn't appear on the map because of the scale. But appears when zoom in to Mediterranean coast).

**Figure 1 – Optimal land use map of the lower Asi River basin**

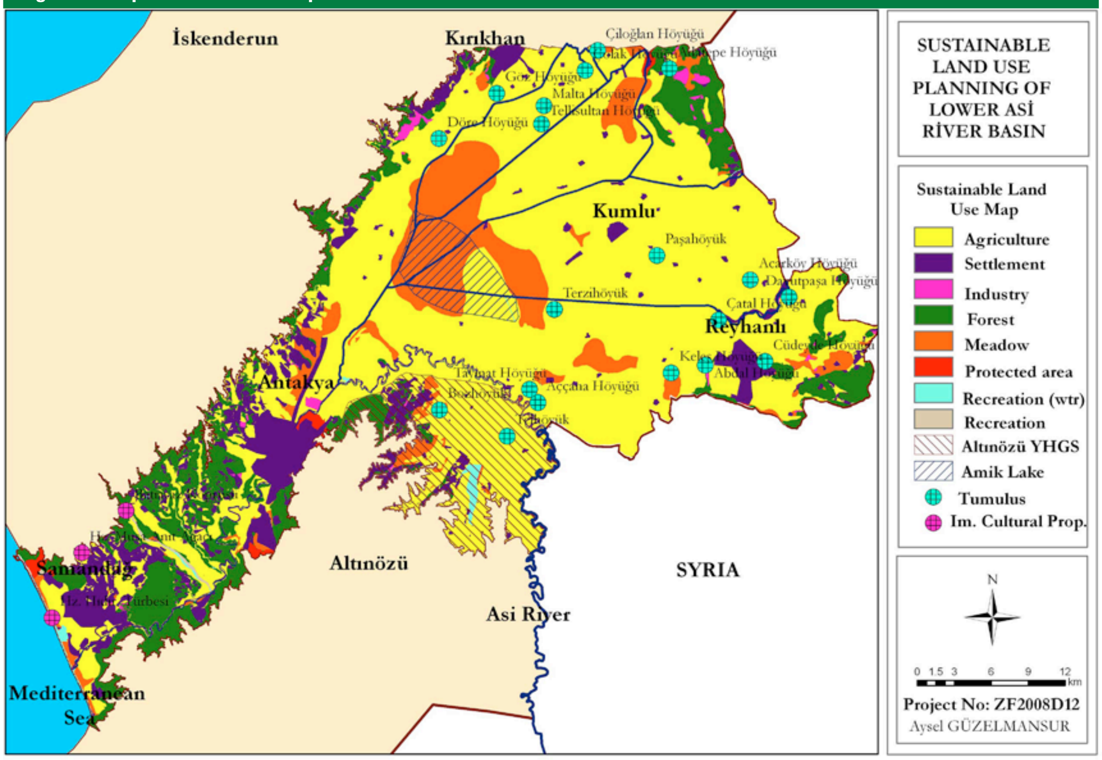

**Table 2 – Current land uses types, potential sustainability and optimal land use area (ha) and rate**

| Land Use Type | Current Land Uses | | Potential Sustainability | | Optimal Land Uses | |
|---|---|---|---|---|---|---|
| | Area (ha) | Rate (%) | Area (ha) | Rate (%) | Area (ha) | Rate (%) |
| Agriculture | 112.261,48 | 76,79 | 93,294,90 | 63,81 | 93.294,90 | 63,81 |
| Settlement | 12.111,47 | 8,28 | 14,142,69 | 9,67 | 13.909,14 | 9,51 |
| Industry | 775,89 | 0,53 | 556,74 | 0,38 | 854,64 | 0,58 |
| Forest | 11.841,44 | 8,10 | 19.506,35 | 13,34 | 20.047,34 | 13,71 |
| Meadow | 6.290,26 | 4,30 | 15.795,36 | 10,80 | 15.791,76 | 10,80 |
| Protected area | 1.232,46 | 0,84 | 1.930,14 | 1,32 | 1.412,19 | 0,97 |
| Recreation | 1.686,80 | 1,15 | 973,62 | 0,66 | 889,83 | 0,61 |
| Total | 146.199,80 | 100,00 | 146.199,80 | 100,00 | 146.199,80 | 100,00 |

Based on optimal land use results, 63,81% of land is suggested for agriculture, 9,51% of land for settlement, 0,58% for industry, 13,71% for forest, 10,80% for meadow pasture, 0,97% for protected area, 0,61% for recreational activities.

## 4. Conclusion

Land degradation caused major problems like the draining of the Amik Lake. It also caused other problems i.e. migratory bird's biotopes were destroyed, wetland vegetation were completely cleared away, and fishing area was destroyed. In addition, migration birds changed their incubation and nesting areas. Thus, the basin has been affected not ecologically but also economically. Fishing communities had to immigrate to other places, local people had to change their livelihoods after the Lake was drained. Additionally, agricultural productivity decreased year after year. However, it was possible to overcome all these problems with sustainable use. Therefore, it was recommended to bring the Amik Lake back into the basin. But to accomplish this, geology structure, geomorphology, climatology, hydrogeology structure should be analyzed as well as socio-economic dynamics.

Cost of restoration of the Lake and social problems of private ownership of land expropriation should also be considered.

Hatay airport was constructed on the drained Amik Lake. So, in winter season, the airport flooded because of rainwater. Additionally, Caliskan (2008) recommended that the Amik Lake should be brought back because of it is an incubation and nesting area of migration birds.

Besides the unfavorable ecological dimensions of the drained Lake, it also has some problems because of the airport built on the drained lake area. The airport could not be used during the winter season of 2011 and 2012 due to heavy flooding. Hence, passengers who use the airline were in a lurch. After that, some precautions were taken including opening of a deep drainage canal to avoid flooding. The airport may have to move to a more suitable area according to the result of feasibility and ecological studies. Considering all available data, we recommend to bring the Amik Lake back into the basin.

The second proposal of this contribution is to designate the Samandag as a protected area because its dunes. Samandag dunes are under the regulation of the "Coastal Law" number 3830 and the "Regulation on the Implementation of the Coastal Law "and are not currently protected. But the dunes are very significant ecologically, in addition, there is habitat of *Caretta caretta*, *Chelonia mydas, Trionyx triunguis,* and it has very high floristic biodiversity. So it is important to get the dunes under protection as suggested by scientific studies (Ozhatay et al. 2003).

Agricultural area covers 63,81% of the area in the optimal land use map, while current agricultural land corresponds to 76,79%. It is clear that 13% of non-agricultural land is used for agricultural purposes. To illustrate some forest areas used for agriculture. But this situation differs for settlement area. 9,51% of the research area is suitable for settlement while this rate is 8.28% on the land use map. So, the approximately 1,3% of the area is suggested for settlement development. Industry approximately has the same rate for optimal land use and current land use map; 0,58%, 0,53% respectively. The two figures are close but the location of industrial activities is different. Industry is currently located in three sites; in west part of Antakya city center, in Antakya industrial district, and around the E-91 highway from Antakya to Serinyol province. In the potential land use suitability map locates industrial sites in different areas. The current forest area consists of 8,10% while optimal land use it is 13,71%. This is also the case for meadow areas currently covering 4,30% of the area while optimal land use map allocates 10,80% of the area to meadows. The meadow area needs to be increased because of livestock activities in the basin. The rate of protected areas currently of 0,84% should be increased to 0,97 % according to the optimal land use map. It is in this context that we suggest including Samandag dunes in protection zones. Recreational areas are divided as water related recreation and non-water related recreation. Current water related recreation areas cover 1,15% while the optimal land use map gives 0,41%. On the other hand, the rate of optimal non-water related recreation is 0,20%. The reason for this lower rate is that Lake Amik is accepted as a recreational area in the current land use map.

The aim of the study was to determine ecological bases of sustainable land use planning of the lower Asi River Basin. There was seven land use types: agriculture, settlement, industry, forest, meadow, protected area and recreational area. Optimal land use map created for these seven types of land uses in the river basin. All ecological maps like; soil, geology, meteorology, hydrogeology, flora, fauna were used to create the map. Additionally, social and economical structures were considered during the process. Thus, sustainable land use map developed for Asi River basin, hosting different confessions, ethnic groups and cultures, ensures the sustainable use of land resources without negatively affecting ecological and social structure. Recommendations from the study intend to contribute to restore the sustainability of the river basin.

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# Assessment of Groundwater Pollution Parameters in the Amik Plain


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## 1. Introduction

Water is one of the most important natural resources to sustain life. Ascertaining its quality is very crucial before it is used for drinking, agricultural and industrial purposes and by aquatic life. However, all available water bodies are not suitable for all different uses (Khan et al. 2003). Freshwater is one of the basic necessities for life sustenance, human consumption, and habitats. But only 2.5% of all waters on Earth are freshwater. Because, nearly 70% of freshwater is frozen in the ice-caps of Antarctica and Greenland, only 1% of world's freshwater is also accessible for direct human uses. This is the water found in lakes, rivers, reservoirs and those underground sources (Ebrahimi et al. 2011). Groundwater is the major source of freshwater for drinking, irrigation, and industrial uses. For its sustainable use, both the quantity and quality issues have to be addressed together (Kumari et al. 2014).

The water quality used for irrigation is very important for agricultural production and to ensure environment protection. Water contains some salts as dissolved ions. Excessive amounts of dissolved ions in irrigation water can affect plant growth, and the physical and chemical properties of the agricultural soil. It also reduces soil fertility and crop yields (Ayers and Westcot 1994).

Groundwater is one of the major sources of exploitation in arid and semi-arid regions (Khasei-Siuki and Sarbazi 2015). Groundwater quality can be affected by numerous types of human activity such as agricultural, residential, industrial and municipal activities (Nas and Berktay 2010). The variety and extent of groundwater chemical composition could also be influenced by natural processes such as evaporation, dissociation of minerals, mixing of water, rock weathering, and human activities. The geochemistry of soil and the geological history of rocks have a significant impact on the chemical contamination of groundwater. Therefore, any groundwater suitability assessment for agriculture should include their chemical composition (Narany et al. 2014). Agricultural, industrial and domestic activities degrade the quality of groundwater supply (Anonymous 1979).

According to the Turkish General Directorate of State Hydraulic Works (DSI), the available surface water potential of Turkey totals 98 billion $m^3$ while total annual groundwater resource is approximately 14 billion $m^3$. The total usable annual surface and groundwater potential of Turkey is 112 billion $m^3$. 37% of the groundwater is used for irrigation, 24% for industrial purposes and 39% domestic purposes. In Turkey, uses of groundwater for irrigation take place to a great extent on lands where irrigation network is inadequate. As of 2012, a total agricultural land area of 667.080 ha is irrigated by groundwater (DSI 2013).

Contamination of groundwater by domestic and industrial effluents and agricultural activities is a serious problem faced by developing countries. The industrial wastewater, sewage sludge and solid waste materials are currently being discharged into the environment indiscriminately. These materials enter subsurface aquifers, resulting in the pollution of irrigation and drinking water (Ebrahimzadeh and Boustani 2011).

All over the world, wherever nitrogenous fertilizers have been used extensively to increase the agricultural productivity, the groundwater shows a high nitrate level. Often, nitrate contamination of groundwater may be also associated with point sources such as domestic sewage, industrial waste, livestock feeding operations and septic tanks, etc. Various physical, chemical, and biological processes in the soil zone and groundwater determine the nitrate level in groundwater (Johnsson et al. 2002). Agricultural systems also contribute to excessive phosphorus (P) additions that are adversely affecting water sources worldwide (Webb et al. 2004).

## 2. Evaluation of pollution parameters in groundwater in the Amik plain

The Amik plain is situated in the Asi basin and has an area about 75000 ha (Figure 1). It is surrounded by the Amanos Mountain to the west, the Syrian border and the town of Reyhanli on the east, Antakya and Altınözü cities to the south, and the towns of Hassa and Kirikhan to the north. The area has a Mediterranean climate with annual average temperature rainfall and relative humidity 18.8°C 1124 mm and 69% respectively (Gün and Erdem 2003). Parent materials of the Amik Plain consist mostly of alluviums and lacustrine. Lacustrine is relatively flat and often has parent materials with uniform properties. Amik plain is one of the most productive agricultural lands in Turkey. Main crops in the plain are cotton, maize, and wheat (Kilic et al. 2008).

The most important formations bearing groundwater in the Amik plain are quaternary alluvium, Pliocene, Miocene, Sandstone, and conglomerate marl and limestone. Alluvial exist together with hillside rubbles in the eastern parts of Antakya-Kirikhan highway. The groundwater recharge occurs through infiltration from precipitation and from surface runoff and while discharge occurs through evapotranspiration and the flow from springs. Groundwater recharge and discharge capacity is in equilibrium at $57.5x10^6 m^3$/year. The amount of groundwater that can be taken safely from alluvial aquifer in the Amik plain is $9.5x10^6$ $m^3$/year (DSİ 1975; Karatas and Korkmaz 2012). The depth of the well from the surface range from 35 m to 140 m (mean 92 m).

In the studies conducted by Agca (2014) and Agca et al. (2014), a total of 92 groundwater samples were collected from drilled wells in the Amik plain in June 2012 to evaluate pollution parameters. The groundwater samples were analyzed for electrical conductivity (EC), total dissolved solids (TDS), pH, major cations [sodium ($Na^+$), potassium ($K^+$), calcium ($Ca^{2+}$) and magnesium ($Mg^{2+}$)] and major anions [carbonate ($CO_3^{2-}$), bicarbonate ($HCO_3^-$), chlorine ($Cl^-$) and sulfate ($SO_4^{2-}$)], dissolved oxygen, ammonium (DO), ($NH_4^+$), Nitrate ($NO_3$), phosphorus (P) and heavy metals (Cd Co, Cr, Cu, Fe, Mn, Pb, Ni, and Zn) contents were determined the groundwater in the Amik plain In addition, sodium adsorption ratio (SAR), residual sodium carbonate (RSC) and total hardness (TH) were calculated from measured data to evaluate groundwater quality and classification.

In order to evaluate the contamination of groundwater regarding physicochemical variables and heavy metal pollution, their concentration were compared with World Health Organization standards (WHO 1997 and 2004), Classification of Turkish Water Pollution Control Regulation (TWPCR 2008) and FAO standards (Ayers and Wescot 1994).

**Figure 1 – Asi River basin**


https://www.water-security.org/article/the-orontes-a-complex-river

According to results of Agca (2014), among the parameters, the coefficients of variations (CV) were the highest for $Ca^{2+}$ (113.63%) and the lowest for pH (3.59). Usually, CV<10% represents low variability, 10%≤CV≤100% means moderate variability, and CV>100% means high variability (Zhou et al. 2011). According to this classification, all the groundwater parameters except pH, $Ca^{2+}$ and $Cl^{-}$, have the moderate variability. The pH value has weak variability while $Ca^{2+}$ and $Cl^-$ have the strong variability. Low CV values indicate a homogeneous distribution of soil variables, while high CV values indicate a non-homogenous distribution of variables in the study area. For example, the mean pH values in both seasons were close to that of median values. In other words, the range of pH values were fewer variables than the range of other parameter values.

$Na^+$ ion (average content of 183.0 mg $L^{-1}$) dominates while $K^+$ ion (average content of 3.62 mg $L^{-1}$) has minimum value among the cations. $Mg^{2+}$ and $Ca^{2+}$ are between $Na^+$ and $K^+$. The $SO_4^{2-}$ ion (average content of 303.2 mg $L^{-1}$) has maximum average value while $CO_3^{2-}$ + $HCO_3^-$ have minimum value among the anions. $Cl^-$ and $HCO_3^-$ are between $SO_4^{2-}$ and $CO_3^{2-}$. In the bed of the old Amik Lake, EC, $Cl^-$ and $SO_4^{2-}$ concentration in groundwater are very high in comparison with other parts of the region (Agca 2014). This is because of the deposits in this region and the soils that are formed on these deposits. The soils in this region have very high salts and gypsum (DSI 1989; Agca et al. 2000; Kilic et al. 2008. Agca et al. 2006) were found high concentration of EC, $Cl^-$ and $SO_4^{2-}$ in the groundwater in the same area.

According to results of Agca et al. (2014), Fe (Iron) had the highest mean concentration in the groundwater, followed by Mn, Ni, Cr, Cu, Zn, Co, Cd and Pb. The highest Co value was determined as 21.10 µg/L. The 83 of 92 groundwater samples exceeded the permissible limit of Co content (10 µg/L) set by the Turkish Water Pollution Control Regulation (TWPCR) (2008). The highest Cr value was recorded as 353.60 µg/L. 54 of 92 groundwater samples were below the permissible limit of Cr concentration (20 µg/L) set by TWPCR (2008). The highest Cu content was 54.90 µg/L. According to these results, 31 out of 92 groundwater samples exceeded the permissible limit of Cu concentration (20 µg/L) set by TWPCR (2008). The highest Fe value was found as 657.10 µg/L in wells. In this study, 15 of 92 groundwater samples exceeded the permissible limit of Fe concentration (300 µg/L) set by TWPCR. The highest Mn value was recorded as 1026.10 µg/L). A total of 26 groundwater samples exceeded the permissible limit of 100 µg/L set by TWPCR (2008). The highest Ni values in groundwater samples in Amik plain were found to be 161.80 µg/L. Only in 6 out of 92 groundwater samples, Ni contents were below the permissible limit of 20 µg/L set by TWPCR. Pb could not be detected in any of the groundwater samples. Therefore, Pb in all the groundwater samples was below the limit of 10 µg/L set by TWPCR (2008). The highest Zn value in the Amik plain was recorded as 193.90 µg/L. In this study, Zn concentrations of all the groundwater samples were below the permissible limit of concentration (200 µg/L) set by TWPCR (2008).

## 2.1 Assessment of groundwater quality for drinking purpose

According to results of Agca (2014), in the Amik plain, the pH values varied from 7.10 to 8.37 with an average value 7.79, indicating the slightly alkaline nature of groundwater. All the groundwater pH values in the study area were within the desirable limits (7.0-8.5) prescribed by WHO (1997). Electrical Conductivity (EC) measures the salt concentrations of water and provides indication of ionic concentrations. The EC in 1.1 % of the total samples is lower than the maximum desirable limit of 750 µS/cm and is more than highest permissible limit of 1500 µS/cm in 52.2 % of the total groundwater samples. Higher EC values in the study area indicate the enrichment of salts in the groundwater. Approximately 98.9 % of the samples are above the maximum desirable limit of 500 mg/L of TDS which can be used for drinking without any risk and 29.3% of the total groundwater samples have more than the highest permissible limit of 1500 mg/L of TDS. All the samples are more than the maximum desirable limit of 100 mg/L of TH that can be used for drinking without any risk and TH in 73.9 % of the total groundwater samples are lower than the highest permissible limit of 1500 mg/L. On the other hand, according to the total hardness classification recommended by Sawyer and Mcartly 1967 (Alam et al. 2012), 2.2% of the water samples fall in hard class (150-300 $mgL^{-1}$ total hardness as $CaCO_3$) and 97.8% of the samples also fall in the category of very hard class (<300 $mgL^{-1}$ total hardness as $CaCO_3$).

$Na^+$ in 12% of total samples are below the most desirable limit of 50 mg/L that can be used for drinking without any risk, while $Na^+$ content in 66.3% of all the samples are below the maximum allowable limit of 200 mg/L. On the other hand, all the groundwater $K^+$ values in the study area were below the recommended value of 100 mg/L. $Ca^{2+}$ in 92.4% of the samples were below most desirable limits of 75 mg/L, however only 2.2% of the samples exceed maximum allowable limit of 200 mg/L. All the groundwater $Mg^{2+}$ contents in the study area were between the most desirable limit of 30 mg/L and maximum allowable limit of 150 mg/L. $HCO_3^-$ in 65.2% of total samples were below the desirable limit of 200 mg/L while $HCO_3^-$ in all the groundwater were below the maximum allowable limit of 600 mg/L. In 67.4% of the samples, $Cl^-$ contents are below the most desirable limit of 250 mg/L. However $Cl^-$ in 9.8% of samples exceed maximum allowable limit of 600 mg/L. $SO_4^{2-}$ in 33.7% of total groundwater samples are below the most desirable limit of 200 mg/L while only $SO_4^{2-}$ contents of 9.4% of samples are determined above the maximum allowable limit of 600 mg/L.

According to Agca et al. (2014), in the groundwater of the Amik plain, the temperature values in the groundwater ranged from 18.7 to 33.0 $^0C$. In 73.0% of the samples exceeded the permissible limit of $25^0C$ suggested for very high quality classes by TWPCR (2008). Dissolved oxygen (DO) varied from 08.9 to 13.18 mg/L. The DO concentration in only 5 samples were found to have higher than the permissible limit of 8 mg/L for high quality classes (TWPCR 2008). Nitrates are the end product of aerobic stabilization of organic nitrogen and a product of conversion of nitrogenous material, and as such occur in polluted water. The highest $NO_3^-$ concentration recorded as 300 mg/L and lowest as 0.38 mg/L in this study. The desirable limit of nitrate for drinking water is specified as 50 mg/L recommended by WHO (2004). In this study, only 12 of the 92 groundwater samples from the study area exceeded the desirable limit of 50 mg/L.

P values in groundwater ranged from 0.021 mg/L to 0.250 mg/L. There are no health-based guidelines on P values for water prescribed by the WHO, however, the Food Standards Agency (2003) has determined the guideline value for P in drinking water. According to the Food Standards Agency (2003) PO4-P limits is 2.2 2.0 mg/L.

In this study, all the groundwater samples taken from wells had higher Cd concentration than the guideline value for drinking water of 3 $\mu gL^{-1}$ recommended by the WHO (2004). In the 7 of 92 samples, Cr concentration exceeded the guideline limit of 50 µg/L while the Cu concentrations of all the groundwater samples were below the guideline limit of 2000 µg/L by WHO. The Fe concentrations of all the groundwater samples were also below the guideline limit of 300 µg/L. In 3 of 92 samples, Mn concentration exceeded the guideline limit of 400 $\mu gL^{-1}$ while Ni concentrations in a total of 23 samples exceeded the guideline limit of 70 µg/Lby WHO. This situation also results from Ni content of the fertilizers containing P expand, since phosphorus fertilizers a lot of Ni content (Koleli and Kantar 2005). In all the groundwater samples, Zn concentration did not exceed the guideline limit for drinking water of 4000 µg/L suggested by WHO (2004). The cadmium and nickel concentrations exceeded the maximum allowable limit also recommended by WHO in 24% and 70% of sample locations, respectively.

## 2.2 Assessment of groundwater quality for irrigation purpose

The evaluation of groundwater quality for irrigation is based on pH, EC and TDS values and calculation of chemical index like sodium adsorption ratio (SAR) and residual sodium carbonate (RSC), nitrogen, phosphorus and heavy metals.

Despite the pH values varied from 7.10 to 8.37 with an average value of 7.79 in the two periods, pH values varied between 7.10 and 7.50 in 19.6% of the samples, between 7.5 and 8.0 in 55.4% and between 8.00 and 8.35 in 25%. These results show that approximately 80% of groundwater is suitable for irrigation with respect to pH values. It is doubtful whether the remaining water is suitable for irrigation or not. This is because its pH values are close to 8.5 which is the highest limit for soil alkalinity (Richards 1954). But, research by Keskin et al. (1999), Agca et al. (2000) and Kilic et al. (2008) have not found alkalinity problems in the Amik plain, until now.

Electrical conductivity (EC) is routinely used to measure salinity (Richards 1954). Electrical conductivity (EC) is a good measure of the salinity hazard to crops as it reflects the TDS in groundwater as well as other water resources. The EC values of groundwater in the study area have very large variation from 456.9 to 13112.0 µS/cm. The large variation in EC is mainly attributed to geochemical processes prevailing in this region.

The US salinity laboratory diagram (Richards 1954) was used to evaluate the suitability of groundwater for irrigation purposes by Agca (2014). According to this classification, 3.3% of the groundwater samples in the study area fall in the C4S4 that has very high salinity and very high sodium hazard. These waters have very high salinity and very high sodium hazard. Therefore these waters are not suitable for irrigation under ordinary conditions. Nearly 4.3% of the groundwater samples fall in the C4S3 class. These waters have very high salinity and high sodium hazard. This water is not also suitable for irrigation. Because, these water have very high amount of salt and high amount of $Na^{+}$. 17.4% of the groundwater samples fall in the category C4S2 that has very high salinity and medium sodium hazard. This water is not suitable for irrigation, since the water has a very high amount of salt and induces a potential hazard dues sodium in fine-textured soils having cation exchange capacity. As much as 3.3% of the groundwater samples in the study area fall in the C4S1 having very high salinity and low sodium hazard. In fact, this water could be suitable for irrigation with respect to sodium adsorption ratio (SAR) values, but because of limiting of very high salt content, is not suitable for irrigation. About 4.3% of the water samples fall in the C3S2. This water has high salinity and medium sodium hazard. This water cannot be used on fine-textured soils with restricted drainage. If drainage is adequate or soils have coarse textured it may be used for irrigation on salt tolerant crops. As much as 66.3% of the water samples fall in the C3S1 having high salinity and low sodium hazard. This water can be used almost all soils with little danger of the development harmful levels of exchangeable sodium with respect to SAR values. However, even then this water cannot be used on soils with restricted drainage. If drainage is adequate or soils have coarse textured it may be used for irrigation on salt tolerant crops.

The residual sodium carbonate (RSC) values of the groundwater samples in the study area were found between -40.6 and 2.39. In all the water samples, the RSC of almost all the water samples have less than 1.25 me/L confirming that the water in the area is suitable for irrigation with respect to RSC. Moreover, RSC values all groundwater samples except 4 samples have negative RSC values. These results indicated that $Ca^{2+} + Mg^{2+}$ did not precipitate completely $Ca^{2+}$ and $Mg^{2+}$ as carbonate. Because the excess of $CO_3^{2-} + HCO_3^{-}$ over $Ca^{2+} + Mg^{2+}$ may cause complete precipitation of $Ca^{2+}$ and $Mg^{2+}$ as carbonate.

The NO3-N values in the groundwater changed between 0.09 mg/L and 67.74 mg/L. In the 12 water samples, The NO3-N values are bigger than the maximum recommended concentration for irrigation water of 10 mg/L NO3-N (44 mg/L$NO_3^{-}$) proposed by Ayers and Westcot (1994). NH4-N concentrations in groundwater samples were found to vary between 0.11 mg/L and 163.72 mg/L. In 34 of 92 samples, NH4-N contents were higher than maximum permissible limit for irrigation water of 5 mg/LNH4-N (6.1 mg/L$NH_4^{+}$) recommended by Ayers and Westcot (1994). FAO determined the maximum recommended concentration for P in irrigation water.

According to FAO (Ayers and Westcot 1994), a PO4-P limit is 2.0 mg/L. None of the groundwater samples in this study exceeded P limit.

All the Co, Cu, Fe, Ni and Pb and Zn values in groundwater were below recommended maximum concentration values of 50, 200, 5000, 200 and 5000 µg/L respectively, for irrigation set recommended by FAO (Ayers and Westcot 1994). Cadmium concentration of 76 groundwater samples is higher than recommended maximum concentration of 10 µg/L suggested by FAO. This situation results from phosphorus fertilizers since their Cd contents are very high (Koleli and Kantar 2005). Chromium content of 89 groundwater samples was lower than recommended maximum concentration of 100 µg/L for irrigation water proposed by FAO. Only in 5 groundwater samples, Mn concentrations exceeded the recommended maximum content of 200 µg/L set by FAO. None of the groundwater samples in this study exceeded P limit.

## 3. Evaluation of pollution parameters in Asi River

The Asi River is one of the most important surface water sources in the Middle East and is the most important surface water for the Amik plain. Asi River is trans-boundary rivers in the Middle East region. It rises in Lebanon and passes through three countries' territories. These counties are Lebanon (upstream), Syria (mid-stream) and Turkey (downstream). The Asi discharges into the Mediterranean Sea at the southern edge of Samandag, Hatay in Turkey (Scheumann et al. 2011). The total length of this river is approximately 400 km, the section in Turkey being about 88 km. It is presently used for the irrigation of 12.000 ha land on Amik plain and another 50.000 ha is being planned to be irrigated (Altunlu 2002). The main flow rate of the Asi River ranged annually between 2.39 (in July) and 22.96 $m^3$ $s^{-1}$ (in February) according to the data of the period during 1995-2002 (Eie 2003).

In the research by Agca et al. (2009), 12 sampling sites were selected along the Turkish section of the Asi River (Fig. 2). The samplings from these sites were carried out at six different times: starting in October 2004, and continuing in January, May, July, September and November in 2005. Water samples were analyzed for temperature (T), electrical conductivity (EC), pH, Na, K, Ca, Mg, Al, Ba, Cd, Co, Cr, Cu, Fe, Mn, Ni, Pb, Zn, P, $CO_3$, $HCO_3$ and Cl were volumetrically determined. In addition, sodium adsorption ratio (SAR) was calculated from Na, Ca and Mg values.

### 3.1. Evaluation of physicochemical parameters

The electrical conductivity (EC) and sodium adsorption ratio (SAR) values changed between 745.5- 1699.6 S $cm^{-1}$ and 0.75–1.71, respectively, during the study period. According to the classification of USSL (Richards, 1954), irrigation water quality class of the Asi River was C3S1 (with high salinity and low sodium hazard) within all sampling sites and at all times. Similar results were also reported by Agca et al. (2006) and Odemis et al. (2006). The differences in EC values among the sampling times were found to be statistically significant ($p<0.01$). The EC values were the highest in January and the lowest in November. Intensive agricultural activities on the Amik plain elevated the use of fertilizers and other chemicals. The Amik plain has water table (Anonymous 1986) that enables upward transport of salts mainly Na and Mg chlorides in dry summer seasons. These salts are leached away by means of surface run off to the Asi River with winter precipitations. In addition, starter fertilizers applied in wheat sowing can leach, to some extent, with winter rainfall as well. Therefore, leaching of the soil by winter precipitation caused an increase in the values of EC, Na, Mg and Cl at the sampling time of January 2005. The EC values were relatively low from May to September, which is the irrigation season in the study area. This outcome may be considered advantageous for irrigation. But, the EC values of the river were still high for various management. In fact, in a research related to the salinization tendency of the soil, about 28130 ha land was classified as slightly saline and around 2600 ha as saline in the Turkish part of the Asi River basin (DPT 1997). The temperature values of the river water vary significantly within the sampling times. This parameter under the influence of the climate of the region peaked in July and decreased during winter months. The temperature variations within the sampling times, indicated by the standard error values, were the lowest in May and September. Regarding the chemical properties, the highest levels except for K were recorded in January, whereas the lowest pH, Na, and Cl values were measured in November. All of the aforementioned parameters were significantly different within the sampling times ($p<0.01$). Phosphorus was recorded as a potentially hazardous element to aquatic life and water quality. The P content ranged from 13.64 to 1097.70 µg L-1 during the study period, in general being very low in winter months; but started increasing in May 2005 and attained its maximum in July 2005.

**Figure 2 – Sampling sites on the Asi River**


The spatial changes in physico-chemical properties of the river water were not statistically significant, except for the pH. The variations of the pH values among sampling sites were significant ($p< 0.01$) also. The EC values increased from Demirköprü towards Antakya city center because of discharges from nearby cities and inclusion of drainage water from the drainage channels. The lowest EC values were recorded at sites 1 and 12. Little creeks and streams that flow into the Asi River at sites 10 and 11 decreased salt content of the river water. The highest Cl values were measured at site 12 (Figure 2) along the river. This situation is probably related to the mixing of the river water with the seawater. Measured temperature values of the river water did not differ significantly within sampling sites but it was higher, on average, at site 12 than the other sites (Agca et al. 2009). This situation was probably related to broader river-bed and shallower water depth at this site since the temperature in rivers changes in accordance with the altitude, climate, atmospheric conditions, flow rate, and structure of the river-bed (Cirik and Cirik 1995). The P concentrations of river water were very high at sampling site 8 through 12. For example, in July, the P concentrations at the points 8 and 9 (Antakya city center) were 1061.8 and 1097.7µ g L-1, respectively. The reasons for such an increase in P content of the river may be the addition of drainage waters from agricultural lands, sewage sludge discharges from nearby cities and the inevitable decline in the water content of the river during summer months. In fact, agricultural and urban activities are considered as the major sources of P additions to aquatic ecosystems (Wu 2005; Rogel et al. 2006). Earlier reports showed that detergents are one of the most important factors in the P enrichment of natural surface water resources (lakes and rivers) in Turkey (Sengül 1991).

### 3.2 Evaluation of heavy metal contents

All metal contents of the Asi River during the study period were found to be considerably lower than the allowed maximum concentration of trace elements in irrigation water recommended by FAO (Pais and Jones 1997). In other words, there was no metal pollution in the river during the period of the investigation. This situation is most likely related to the small number of industrial plants in Turkish part of the Asi River basin. The reports in various basins reveal that the elevated water pollution is related to the regional industrial development and technological levels of the industrial plants. For example, in the Southern Thrace, which is one of the most important industrial centers in Turkey, it was reported that Hg, Cd and Zn contents were low whereas Cr and Pb were high in the surface water owing to automotive, dyeing and textile industry in the region (Aksoy 1993). Until recently, rivers have been utilized as the easiest and cheapest means for the disposal of municipal wastes without proper treatment, especially near highly populated cities. Therefore, organic contaminants and P contents of the rivers have been higher near the cities. Some significant differences were detected between the sampling times for all metal concentration except for Ni ($p<0.01$). When the mean concentrations of metals were compared, sampling times 3 and 4 (May and July) yielded significantly higher concentration than the other sampling times. The concentrations of Cr, Fe and Mn increased markedly at sampling time 4 and they were the lowest at sampling times 2, 5 and 6. Among the metals, the highest variation in concentration was observed for Al. However, there was no significant seasonal difference in Ni concentration. The remaining metals could be placed in two or three statistically different groups. The spatial differences in metal contents were not statistically significant except for Ba ($p>0.05$). When the mean values were considered, metal contents except for Cd, Cr, Ni, and Fe were lower at the sites 1, 2 and 3 (on the Syria-Turkey borderline) than those of the other sampling sites. But, the Cd, Cr, Ni, and Fe contents were also found to be relatively high at these sites. In general, it was observed that heavy metal concentrations were high near Antakya city center (sites 8 and 9) because of small industrial estate and leather industry (Agca et al. 2009).

The order of heavy metal was found to be Fe>Mn> Cu > Ni > Cr >Pb> Co > Cd for all water samples. The contents of Cd, Co, Cu, and Pb in all samples and Cr, Fe, Mn and Ni in 90% of all samples were found to be below the limits for class one (high quality) according to Water Pollution Control Regulation (Anonymous 1988). In other words, there was no heavy metal pollution in the water resources investigated. It is most likely that this situation resulted from no intensive industrial and domestic activities in the study area. Because, industrial and domestic activities may degrade the quality of underground water supply (Anonymous 1979).

## 4. Conclusion

Inadequate rainfall in Amik plain area makes the irrigation requirement peak in the summer. Surface and groundwater are the main sources of the irrigation in the Amik plain. But, drainage water is also used when other sources became inadequate. In addition, local people use well water for drinking purposes. Because of these reasons, groundwater quality is very important in the Amik plain.

The results of Agca et al. (2006) indicated that groundwater in the Amik plain have dominance of physiologically neutral salts such as NaCl, $Na_2SO_4$, $MgCl_2$ and $MgSO_4$. Therefore, these salts cannot increase pH of the water environments because such salts do not hydrolyze in water. The pH values of all groundwater sources being below 8.5 (the limit values of alkalinity) supported this situation. The most of the groundwater samples of RSC values were found negative. In addition, the most of the samples of SAR values were lower than 10. Therefore, most of the groundwater can be safely used for irrigation considering alkalinity. Nearly 29% of the total groundwater is not suitable for irrigation because of high and very high EC values (>2250 µS/cm). Other water can be used for irrigation if adequate leaching occurs and plants that can be resistant to salts grow. The results of studies of the groundwater in Amik plain indicated that the number of wells with high $NH_4^+$content is more than that of with $NO_3^-$. But there was no $NO_3^-$, $NH_4^+$ and $PO_4^{3-}$ pollution in the groundwater of Amik plain. Temperature and salt content seemed to be problems in some of the groundwater, but dissolved oxygen deficiency were the main problem in all the examined groundwater in the Amik plain.

The metal concentrations showed a dominance in the order of Fe >Mn> Ni> Cr> Cu> Zn> Co> Cd>Pb in the groundwater in the Amik plain. They all had much higher Cd concentration than the guideline value for drinking water while the Cu and Fe concentrations of all the groundwater samples were below the guideline limit recommended by the WHO. Physicochemical properties and heavy metal studies of Amik plain indicated that the main sources of nitrogen and some heavy metal pollution in the study area, are because of the agricultural activities. There were no industrial activities or heavy traffic in and around Amik plain.

The Asi River water has a slightly – moderately alkaline reaction ranging from pH 7.47 to 8.57. Therefore, also considering the relatively low SAR values, the river water is not expected to cause sodicity. According to the EPA, optimum pH values of fresh water can be between 6.5 and 9.0. As a concluding remark, it can be stated that content please qualify are soluble salts and P are the most critical parameters, for treating aquatic life and agriculture in the lower Asi River basin. As stated earlier, the quality of the Asi River water is C3S1; thus its use without consideration of soil parameters (i.e. ECe, ESP) and plant requirements (i.e. ECw tolerance) for irrigation and without proper allowances for leaching requirements may cause rapid degradation of the soil. Further, keeping this mind, irrigation methods with minimum water consumption such as drip irrigation should be preferred instead of the conventional methods to minimize the rate of salt accumulation in the soil and save water.

Higher quality surface water resources instead of groundwater resources should be used to prevent increasing soil salinity and protect human health. For this purpose, The Turkish State Hydraulics Work has been constructing dams in the Amik plain. Besides, groundwater and Orontes river quality must be continuously monitored.

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# Water Quality Issues in the Asi River Basin

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## 1. Introduction

In ancient times, Asi-Orontes River was the chief river of the Levant, also called Draco, Typhon and Axius. The modern name: *'Āṣī* ("rebel") is given because the river flows from the south to the north unlike the rest of the rivers in the region (Anonymous 2014). The Asi River has a total length of 380 km. Nearly 40 km of the river is located in Lebanon, 159 km in Syria, 88 km in Turkey. The Asi Basin which has a total water potential of 2,8billion $m^3$, derives 0,3 billion $m^3$ from Lebanon, 1,2 billion $m^3$ from Syria and 1,3 billion $m^3$ from Turkey (Korkmaz and Karatas 2009).

The Asi River is crucial for ecology, human use including, agriculture, aquaculture and industry. The objective of this contribution is to review the studies related to water quality and pollution in the Turkish portion of the Asi River basin and the impact of water quality changes on the aquatic organisms. Hence, this contribution intends to contribute to prospective studies on the management and monitoring of the basin.

## 2. Asi River and water quality studies

Bulut et al. (2006) worked on the issue of water quality of the Asi River. According to their study, the quality of surface and groundwater in the basin varies, mainly depending on the level of agricultural activity. Water quality of the Orontes is affected by agricultural, urban and industrial activities. Basic problem in the basin is monitoring and management of environmental pollution. Bulut et al. (2006) measured the water quality parameters in Demirkopru and Antakya for a long time period and arrived at the results shown in Table 1.

**Table 1 – Parameters of Water Quality of Asi River from Demirkopru and Antakya Stations**

| | Water Quality at Demirkopru (1995–2005) | Water Quality at Antakya (1997–2005) |
|---|---|---|
| | Mean | Mean |
| Flow $m^3\ s^{-1}$ | 14.80 | 45.3 |
| Water Temp. $^0C$ | 17.50 | 17.4 |
| pH | 8.20 | 8.37 |
| EC µs $cm^{-1}$ | 954.00 | 975 |
| Na meq $L^{-1}$ | 2.16 | 2.23 |
| K meq $L^{-1}$ | 0.099 | 0.08 |
| Ca+Mg meq $L^{-1}$ | 7.94 | 8.25 |
| $CO_3^{-2}$ meq $L^{-1}$ | 0.26 | 0.50 |
| $HCO_3^{-1}$ meq $L^{-1}$ | 3.74 | 4.20 |
| Cl meq $L^{-1}$ | 2.12 | 2.10 |
| $SO_4^{-2}$ meq $L^{-1}$ | 4.08 | 3.75 |
| Total Anions and cations meq $L^{-1}$ | 10.20 | 10.06 |
| Na changeable % | 21.50 | 20.7 |
| SAR | 1.09 | 1.08 |
| Harness French scale | 39.70 | 41.3 |
| Total salt mg $L^{-1}$ | 611.00 | 624 |
| Boron mg $L^{-1}$ | 0.15 | 0.13 |

(Bulut et al. 2006).

Tasdemir and Goksu (2001) have carried out a research entitled "Water Quality Criteria of Asi River" in the wetlands of Hatay, in order to examine various water quality criteria. This research was completed within a period of 12 months and during this period the samples were taken 12 times from the Asi River, between September 1996 and August 1997. Determined stations were Canal of Asi, the area of Guzelburc, entrance to Antakya and the Samandag area. The sampling points are given in Figure 1. Water quality parameters, namely DO, pH, Temperature, Conductivity, COD, Ammonia nitrogen, Nitrite nitrogen, Nitrate nitrogen, Suspended solids, Phosphate, Silica, Hardness have been measured and given below (Table 2) (Tasdemir and Goksu 2001).

**Table 2 – Water quality parameter of the Study**

| Mont. | Temp (°C) | pH | DO Mg$^{-1}$ | Cond (µohms/cm) | $NO_2^-$-N (mgl-1) | $NO_3$-N (mgl-1) | $NH_4^+$-N (mgl-1) | $PO_4^{-3}$-P (mgl-1) | $Si_2O_2$-Si (mgl-1) |
|---|---|---|---|---|---|---|---|---|---|
| Sept. | 24.1 | 8.18 | 6.40 | 700 | 0.04 | 2.00 | 0.09 | 0.06 | 7.43 |
| Oct. | 21.2 | 8.34 | 7.00 | 340 | 0.01 | 1.79 | 0.66 | 0.79 | 1.95 |
| Nov. | 17.0 | 7.83 | 7.80 | 720 | 0.02 | 1.46 | 0.95 | 0.08 | 6.75 |
| Dec. | 17.1 | 8.11 | 8.66 | 910 | 0.06 | 3.57 | 0.58 | 0.18 | 6.61 |
| Jan. | 9.8 | 8.21 | 9.04 | 810 | 0.05 | 3.30 | 1.31 | 0.29 | 6.43 |
| Feb. | 12.3 | 8.16 | 9.24 | 700 | 0.02 | 3.54 | 1.28 | 0.02 | 7.61 |
| Mar. | 16.6 | 7.95 | 7.94 | 640 | 0.03 | 4.13 | 1.32 | 0.07 | 6.45 |
| Apr. | 18.3 | 8.06 | 8.44 | 690 | 0.02 | 3.40 | 0.96 | 0.14 | 4.04 |
| May | 21.6 | 8.00 | 7.90 | 670 | 0.03 | 2.64 | 0.43 | 0.14 | 8.91 |
| Jun | 29.1 | 8.37 | 7.60 | 830 | 0.06 | 2.20 | 0.29 | 0.14 | 6.04 |
| Jul. | 27.1 | 7.98 | 6.62 | 950 | 0.04 | 0.86 | 0.35 | 0.42 | 8.37 |
| Aug. | 26.4 | 7.91 | 6.54 | 790 | 0.16 | 1.50 | 0.22 | 0.18 | 6.82 |

(Tasdemir and Goksu 2001)

**Figure 1 – Sampling sites**

Results of the study show that the temperature values of station IV are higher than other stations. Because this situation affects the oxygen solubility, lot of aquatic organisms have also been affected. The basic reason of sharp temperature changes is due to the fact that the river gets wider and shallower in this area. Also, domestic discharges caused lower oxygen levels. Owing to contamination of agricultural chemicals to the river N, P and COD values increased.

According to the results of this research, it has been suggested that, Asi River might be under a risk of pollution.

Karatas and Korkmaz (2012) have worked on "water potential of Hatay City and its sustainable management". They updated the parameters of water quality of the Asi River in Demirkopru and Antakya (Tables 3-4)

**Table 3 – Chemical analyses results of water from Asi River**

| | Seasons | PH | EC (µS/cm) | Na (mg/l) | K (mg/l) | Ca+Mg (mg/l) | co3 (mg/l) | $HCO_3$ (mg/l) | $Cl_2$ (mg/l) | $SO_4$ (mg/l) |
|---|---|---|---|---|---|---|---|---|---|---|
| Demirkopru | Jan. 1995 | 8.32 | 1.091 | 2.35 | 0.1 | 9.40 | 0.55 | 3.59 | 2.46 | 5.24 |
| | Jul. 1995 | 8.13 | 690 | 1.86 | 0.15 | 5.20 | 0.24 | 2.96 | 1.80 | 2.21 |
| | Jan. 1999 | 8.26 | 1.095 | 2.68 | 0.15 | 9.10 | 0.32 | 3.23 | 2.89 | 5.49 |
| | Jul. 1999 | 8.08 | 953 | 2.12 | 0.13 | 8.22 | 0.08 | 5.20 | 1.96 | 3.23 |
| Antakya | Jan. 1998 | 8.30 | 1.390 | 4.17 | 0.11 | 10.20 | 0.52 | 4.40 | 3.80 | 5.76 |
| | Jul. 1997 | 8.00 | 930 | 2.34 | 0.17 | 7.50 | 0.10 | 5.20 | 2.00 | 2.71 |
| | Jan. 1999 | 8.41 | 1.141 | 2.65 | 0.08 | 10.11 | 0.34 | 4.50 | 2.75 | 5.25 |
| | Jul. 1999 | 7.75 | 878 | 2.12 | 0.25 | 7.20 | <0.1 | 5.58 | 1.74 | 2.25 |

(Karakilcik and Erkul 2002)

**Table 4 – Amounts of Heavy metal in water from Asi River**

| Place | Time | DO2 % | $NH_4^+$-N mg/l | $NO_2$-N mg/l | Zn mg/l | K mg/l | EP mg/l | pH |
|---|---|---|---|---|---|---|---|---|
| Demirkopru Karakolu | Feb. 2006 | 65.6 | 6.1 | 0.13 | 0.005 | 4.26 | 0.40 | 8.09 |
| | Aug. 2007 | 73.5 | 2.8 | 0.06 | 0.009 | – | <0.50 | 8.00 |
| Before the Sea Conjuction | Feb. 2006 | 74.0 | 5.2 | 0.11 | 0.018 | 4.37 | 0.50 | 8.28 |
| | Aug. 2007 | 155 | 2.3 | 0.03 | 0.013 | – | <0.50 | 8.61 |
| Limit Values for Rivers | | 40 | 0.5 | 0.05 | 0.003 | 2.00 | 2.0 | 6-9 |

(T.C. Cevre ve Orman Bakanligi 2007)

## 3. Fisheries in the Asi River

Fisheries in the Asi River have an economic importance. So the water quality and pollution come into prominence for fisheries in addition to its importance for ecology and the environment.

Demirci and Demirci (2009) carried out a study to determine catching methods and fishermen profiles. Records of Hatay Provincial Directorate of Ministry of Food, Agriculture and Livestock were used for the catch amount estimated. Fishermen profiles were made by in person interviews in different areas of the River. Fishing gears used in the region were illustrated according to catalogues of FAO standards. Groups of catch species such as Catfish (*Clariaslazera),* family of Cyprinidae (*Cyprinuscarpio, Capoetacapoeta*, *Capoetatrutta*, *Capoetadamascina*, *Capoetabarroisi*) and Eel fish (*Anguilla anguilla)* are frequently caught in the basin.

Fishing is carried out with different nets, various types of fishing lines and local traps. Most of the people, who were engaged in fishing activity in the river, do not have licenses of amateur or professional fisherman even though they derive an income from this activity.

In the delta of the Asi River, there was in the 1990s an annual total catch of 148,000 kg (Munsuz et al. 1999) including mostly African catfish (Clariasgarie-pinus), Himri (Carasobarbusluteus) and other fish such as European eel (Anguilla anguilla) in addition to Cyprinids and Cobitis (Yalcin 1997). But recent research shows that there is a crucial decrease in total catch amount on Asi River (Table 5).

**Table 5 – Certain Species Catch Amount in River Asi**

| Species | Amount of Catch (Kg) | |
|---|---|---|
| | 2006 | 2007 (6 months) |
| Catfish | 16.200 | 4.050 |
| Eel fish | 13.250 | 1900 |

(Demirci and Demirci 2009)

## 4. Water pollution and aquatic organisms

Natural waters are increasingly affected by various anthropogenic and geological sources. Human activities have elevated the levels of heavy metals in freshwaters, and, under certain environmental conditions, these metals may accumulate to reach toxic concentrations in aquatic animals' tissues and cause ecological damage (Karadede and Unlu 2000; Yilmaz 2003; Henry et al. 2004).

Marine organisms, among them fish, may accumulate heavy metals through direct absorption or via their food chain and pass them to human beings, by consumption, causing chronic or acute diseases (Chen et al. 2000; Calza et al. 2004).

The bioaccumulation in fish, as a result of higher metal concentration also causes biochemical or pathological effects in individual fish, resulting in the decrease of their population, their fecundity and their survival. Therefore, fish have been extensively used in marine pollution monitoring programs.

Two main objectives are being pursued in these programs,

(i) to determine contaminant concentrations in fish muscle in order to assess the health risk for humans, and
(ii) to use fish as environmental indicators of aquatic ecosystems quality (Adams 2002).

Yilmaz and Dogan (2008) carried out a study to determine the bioaccumulation of heavy metals in himri (*Carasobarbusluteus*) in the Guzeburc region in the Asi River basin, by taking samples seasonally between October 2003 and July 2004. (Figure 2).

The concentrations of heavy metals (Ag, Cd, Cr, Cu, Fe, Ni, Pb and Zn) were measured in running water and in tissues (muscle, liver, gill, skin and gonads) of one commercially valuable fish species (*Carasobarbusluteus*) in the Asi River (Table 6-7).

**Figure 2 – Study area**


**Table 6 – Some physic-chemical parameters of the Asi River**

| | Turkish Environmental Guidelines (TSE-266). (1988). | | | | | | |
|---|---|---|---|---|---|---|---|
| | Class I | Class II | Class III | Oct. 2003 | Jan. 2004 | Apr. 2004 | Jul. 2004 |
| Temperature (°C) | 25 | 25 | 30 | 24.20 | 15.80 | 19.30 | 23.10 |
| D.O. (mg/L) | 8 | 6 | 3 | 6.40 | 7.68 | 7.76 | 6.92 |
| pH | 6.5 8.5 | 6.5 8.5 | 6 9 | 7.60 | 7.25 | 7.33 | 7.10 |
| Hardness (Fr) | <10 | 10-22 | 22< | 30.80 | 78.80 | 53.60 | 48.00 |

(Yilmaz and Dogan 2008)

**Table 7 – Heavy metal concentrations of water in the Asi River**

Mean heavy metal concentrations and their standard deviations (Mean ± S.D) of Orontes River (Guzelburcstation) for four seasons (concentration unit is in µ.g $1^{-1}$) and Turkish Environmental Guideline (µ.g $l^{-1}$)

| | Class I | Class II | Class III | EPA | October | Jan. | Apr. | Jul. | Average conc. |
|---|---|---|---|---|---|---|---|---|---|
| **Metals** | | | | (µg $l^{-1}$) | (2003) | (2004) | (2004) | (2004) | (µg $l^{-1}$) |
| **Ag** | | | | – | $0.48\pm0.04^{a*}$ | $0.63\pm0.02^{a}$ | $0.97\pm0.06^{b}$ | $0.37\pm0.11^{a}$ | 0.61 |
| **Cd** | 3 | 5 | 10 | – | $7\pm0.06^{a}$ | $8\pm1.02^{a}$ | $11\pm2.02^{b}$ | $18\pm6.06^{b}$ | 11.0 |
| **Cr** | 20 | 50 | 200 | – | $12\pm5.02^{a}$ | $7\pm3.35^{a}$ | $3\pm0.03^{a}$ | $39\pm4.13^{b}$ | 15.3 |
| **Cu** | 20 | 50 | 200 | 1.3 | $40\pm1.07^{a}$ | $38\pm3.08^{a}$ | $39\pm5.10^{a}$ | $44\pm4.23^{b}$ | 40.3 |
| **Fe** | 300 | 1000 | 5000 | 0.3 | $68\pm3.37^{a}$ | $117\pm9.19^{b}$ | $102\pm9.33^{b}$ | $108\pm8.58^{b}$ | 98.8 |
| **Ni** | 20 | 50 | 200 | – | $20\pm2.07^{a}$ | $19\pm2.28^{b}$ | $21\pm3.07^{b}$ | $30\pm2.01^{a}$ | 22.5 |
| **Pb** | 10 | 20 | 50 | – | $32\pm5.07^{c}$ | $40\pm3.21^{c}$ | $16\pm2.01^{b}$ | $20\pm3.03^{a}$ | 27.0 |
| **Zn** | 200 | 500 | 2000 | 5 | $37\pm7.08^{a}$ | $44\pm4.23^{b}$ | $39\pm6.06^{a}$ | $36\pm3.05^{a}$ | 39.0 |

*Means in the same line with different superscripts were significantly different ($P<0.05$) between the seasons.
(Yilmaz and Dogan 2008)

The results found that the levels of metal concentration in the water, were at the highest concentration in the context of national and international water quality guidelines such as those prescribed by WHO, EC and EPA. Further, Cd, Cu, Ni and Pb were found to exceed permissible level of drinking water in national criteria TSE-266 whereas Fe, Zn and Cr concentrations were within the permissible levels for drinking (Yilmaz and Dogan 2008).

The study showed a significant seasonal variation ($p<0.05$) in the concentration of those metals whose concentrations were examined, in the selected tissues, except gonads ($p>0.05$), which showed seasonal variation of only Zn ($p<0.05$) (Table 8).

While maximum concentrations of Ag, Cd, Cr and Pb were detected in the gonads followed by liver, gill, skin and muscle, maximum concentrations of Cu, Fe, Ni and Zn were detected in the liver followed by other tissues. Concentrations of heavy metals in the muscle of C. luteus were below the permissible limit for human consumption, level of Cu being very close to the permissible limit. Consequently, continuous monitoring of heavy metal concentration in edible freshwater fish are needed in Asi River (Yilmaz and Dogan 2008).

Reference to the study, putting in order the amount of metal accumulation in tissues is as given below;

**Silver**: Gonads > Liver > Gill > Skin > Muscle
**Cadmium**: Gonads > Liver > Gill > Skin > Muscle
**Chromium**: Gonads > Liver > Gill > Skin > Muscle
**Copper**: Liver > Gonads > Gill > Skin > Muscle
**Iron**: Liver > Gill > Gonads > Skin > Muscle
**Nickel**: Liver > Gonads > Gill > Skin > Muscle
**Lead**: Gonads > Liver > Gill > Skin > Muscle
**Zinc**: Liver > Skin > Gill > Gonads > Muscle

**Table 8 – Heavy metal concentrations of selected tissues of himri *(Carasobarbus luteus)* in Asi River**

Mean concentrations (µg metal.w.w.) and associated standard deviations (Mean±S.D) of heavy metals (Ag, Cd,Cr, Cu, Fe, Ni, Pb and Zn) in the liver (L), gill (G), skin (S), muscle (M) and Gonads (O) of *Carasobarbus luteus* collected for four seasons in the Asi River (Guzelburc).

| Heavy metals | Tissues | October (Mean ± S.D.)* | January (Mean ± S.D.) | April (Mean ± S.D.) | July (Mean ± S.D.) |
|---|---|---|---|---|---|
| Ag | L | 0.36±0.22[a]** | 0.37±0.26[a] | 1.72±1.33[d] | 0.19±0.11[a] |
| | G | 0.38±0.24[a] | 0.24±0.27[a] | 1.25±0.49[d] | 0.16±0.14[a] |
| | S | 0.11±0.09[a] | 0.02±0.01[a] | 0.77±0.32[d] | 0.07±0.04[a] |
| | M | 0.04±0.02[d] | 0.03±0.02[d] | 0.16±0.01[a] | 0.05±0.02[d] |
| | O | 1.60±0.75[a] | 6.61±1.60[a] | 3.22±1.68[a] | 5.61±2.24[a] |
| Cd | L | 2.35±1.06[a] | 3.22±1.11[a] | 2.22±1.15[a] | 3.41±0.91[a] |
| | G | 1.28±1.03[a] | 1.64±0.93[a] | 2.14±1.01[d] | 1.98±0.23[a] |
| | S | 1.22±0.19[a] | 2.26±1.10[d] | 2.02±0.91[d] | 1.15±0.16[a] |
| | M | 0.15±0.11[a] | 0.08±0.05[a] | 0.16±0.12[a] | 0.09±0.02[a] |
| | O | 6.62±2.31[a] | 5.52±3.44[a] | 6.77±2.02[a] | 5.79±2.23[a] |
| Cr | L | 1.22±0.16[a] | 1.56±0.45[a] | 2.07±0.86[d] | 2.57±1.80[d] |
| | G | 1.40±1.13[d] | 1.31±0.97[d] | 0.49±0.32[a] | 1.16±0.30[d] |
| | S | 0.26±0.10[a] | 0.43±0.27[a] | 0.15±0.22[a] | 1.61±0.51[d] |
| | M | 0.16±0.28[a] | 0.14±0.04[a] | 0.04±0.03[a] | 0.81±0.07[a] |
| | O | 7.72±4.31[a] | 3.70±1.34[a] | 5.46±0.76[a] | 6.85±2.16[a] |
| Cu | L | 73.84±5.57[c] | 27.14±4.50[a] | 61.93±1.86[d] | 19.97±9.3[a] |
| | G | 14.10±2.89[d] | 9.34±5.19[a] | 6.63±2.96[a] | 7.02±5.07[a] |
| | S | 12.71±1.93[d] | 6.69±1.98[a] | 4.07±0.92[a] | 3.12±0.35[a] |
| | M | 5.23±4.34[d] | 4.96±2.86[ad] | 4.93±1.07[ad] | 3.06±1.41[a] |
| | O | 25.84±6.98[a] | 20.94±6.08[a] | 21.19±6.95[a] | 21.33±8.35[a] |
| Fe | L | 354.12±2.39[d] | 330.68±1.7[d] | 150.51±3.80[a] | 174.15±2.21[a] |
| | G | 388.05±31.1[d] | 244.91±8.11[d] | 179.75±4.17[a] | 170.86±1.71[a] |
| | S | 51.60±3.82[a] | 72.91 ±4.47[d] | 31.63±7.32[a] | 27.47±1.01[a] |
| | M | 17.95±6.21[a] | 19.60±8.02[a] | 13.15±5.91[a] | 12.01±7.05[a] |
| | O | 31.87±10.51[a] | 70.97±12.22[a] | 75.39±19.49[a] | 47.52±11.02[a] |
| Ni | L | 3.31±2.13[d] | 4.15±1.17[d] | 2.01±0.16[a] | 2.23±1.21[a] |
| | G | 1.87±1.72[d] | 1.32±0.77[d] | 0.38±0.22[a] | 0.89±0.60[ad] |
| | S | 0.68±0.47[a] | 0.88±0.35[a] | 0.32±0.21[a] | 0.44±0.12[a] |
| | M | 0.29±0.16[a] | 0.52±0.33[d] | 0.19±0.06[a] | 0.12±0.10[a] |
| | O | 2.70±0.25[a] | 2.34±0.81[a] | 2.80±1.98[a] | 2.11±2.12[a] |
| Pd | L | 1.30±0.34[a] | 2.22±0.86[d] | 1.73±0.66[ad] | 0.94±0.50[a] |
| | G | 0.88±0.66[a] | 0.88±0.66[a] | 0.88±0.66[a] | 0.46±0.26[a] |
| | S | 0.57±0.29[a] | 0.44±0.18[a] | 0.74±0.89[a] | 0.35±0.28[a] |
| | M | 0.17±0.09[a] | 0.11±0.05[a] | 0.07±0.08[a] | 0.13±0.07[a] |
| | O | 4.66±0.86[a] | 6.42±2.66[a] | 3.69±2.68[a] | 3.35±2.14[a] |
| Zn | L | 101.21±3.84[d] | 97.21 ±3.4[d] | 88.11±1.77[a] | 71.81±7.33[a] |
| | G | 47.31±3.82[a] | 64.77±2.45[a] | 49.01±3.61[a] | 41.82±5.80[a] |
| | S | 64.59±1.54[a] | 73.66±1.32[a] | 57.46±5.87[a] | 52.84±13.20[a] |
| | M | 13.03±4.04[d] | 15.10±7.90[d] | 6.87±1.84[a] | 4.56±1.27[a] |
| | O | 30.99±8.10[a] | 52.25±25.13[d] | 46.39±24.21[d] | 34.97±8.66[a] |

(Mean ± S.D.) *Mean concentrations (µg metal.g 1 w.w.) and associated standard deviations
**Means in the same line with different superscripts were significantly different (P<0.05) between the seasons
(Yilmaz and Dogan 2008).

This study was carried out to provide information on heavy metal concentrations in water and himri (*C. luteus*) in the Asi River. Selected metals were found to exceed permissible level of drinking water in international criteria namely WHO, EC and EPA. Although levels of some heavy metals are not particularly high, a potential danger may emerge in the future depending on domestic sewage, industrial wastes and agricultural activities in this region.

Rather high levels of Ag, Cd, Cr and Pb were found in the gonads of himri. Liver was the main tissue in which Cu, Fe, Ni and Zn accumulated, in the samples collected. The himri was did not seem to have a high concentration in its muscle and was within the safe limits for consumption by human (Yilmaz and Dogan 2008), according to the studies conducted.

Another study that was carried out to determine the heavy metal accumulation in Orontes River is a thesis for Master of Science by Caliskan (2005).

Seasonal concentrations of Cd, Co, Cr, Cu, Fe, Mn, Ni, Pb, and Zn were investigated in the samples of water, sediment, and African catfish (*Clarias garepinus*) when received between October 2003 and July 2004,. The sampling area in which the stations were located includes the border of Syria, Guzelburc, city centre of Antakya, and Samandag (figure 3).

**Figure 3 – Sampling points**


In this study, one of the stations (4th station, Tahtakopru, undomestic area) differed from the working stations mentioned so far in this paper. Some water quality parameters and heavy metal values in water from this station are given in table 9.

**Table 9 – Water quality parameters and heavy metals in water, Tahtakopru station**

| | Autumn | Winter | Spring | Summer |
|---|---|---|---|---|
| Tempetature (⁰C) | 21,10 | 14,80 | 19,30 | 22,60 |
| S.O. (mg/L) | 6,80 | 8,24 | 7,75 | 6,51 |
| pH | 8,00 | 7,55 | 7,20 | 7,36 |
| Hardness (Fr) | 33,60 | 36,70 | 26,40 | 32,80 |
| Heavy metals (ppm) | | | | |
| Ag | –* | – | – | – |
| Cd | 0,002±0,02[ab]** | 0,002±0,01[b] | 0,007±0,02[a] | 0,019±0,01[c] |
| Cr | 0,001±0,03[a] | – | – | 0,037±0,04[b] |
| Cu | 0,038±0,07[a] | 0,040±0,01[a] | 0,038±0,07[a] | 0,042±0,11[a] |
| Fe | 0,065±0,80[a] | 0,117±0,20[b] | – | 0,102±0,15[b] |
| Ni | 0,011±0,07[b] | 0,022±0,01[b] | 0,006±0,07[a] | 0,002±0,01[a] |
| Pb | 0,051±0,40[b] | 0,040±0,04[b] | 0,015±0,04[a] | 0,014±0,02[a] |
| Zn | – | – | – | – |

*: not to determined
**: Different letters (a,b,c) point out that the differences are important (P<0,05).

Accumulations in sediments were higher (except Cd in water), compared to water and fish. The highest Cd accumulation was in water. The Cr and Ni levels were found as fish<water<sediment although the other element concentration levels were found water<fish<sediment. Amount of accumulations of heavy metals in fish, which caught from Tahtakopru station, are given in table 10 (Caliskan 2005).

The values of Cd, Co, Cr, Cu, Fe, Mn, Ni, Pb, and Zn in the samples of water, sediment and fish (except Cd in water) are found to be lower than the acceptable limits. It may be said that the Asi River does not have a risk as a result of the concentrations of the examined metals, that seems to threaten the environment during the study period.

**Table 10 – Distributions of heavy metals in tissues of fish, caught in Tahtakopru region**

| µg/g | Tissues | Autumn | Winter | Spring | Summer |
|---|---|---|---|---|---|
| Ag | L | 0,09±0,05[a]** | 0,66±0,59[b] | –* | – |
| | G | 0,07±0,07 | – | – | – |
| | S | – | – | – | – |
| | M | 0,02±0,01[ab] | 0,03±0,33[b] | – | – |
| Cd | L | – | – | 0,14±0,08[a] | 0,53±0,19[b] |
| | G | – | – | 0,15±0,01[a] | 0,25±0,10[b] |
| | S | – | – | 0,13±0,03[a] | 0,25±0,10[b] |
| | M | – | – | 0,07±0,01[a] | 0,18±0,01[b] |
| Cr | L | 0,48±0,53[b] | 0,31±0,31[ab] | 0,12±0,04[ab] | – |
| | G | 0,70±0,53[b] | 0,22±0,09[a] | 0,16±0,10[a] | – |
| | S | 0,30±0,10[a] | – | – | 0,27±0,05[a] |
| | M | 0,11±0,07[a] | – | 0,03±0,02[b] | – |

→

**Table 10 – Distributions of heavy metals in tissues of fish, caught in Tahtakopru region (continued)**

| | | | | | |
|---|---|---|---|---|---|
| Cu | L | 61,32±2,83[b] | 33,23±28,4[a] | 14,05±3,90[a] | 14,72±1,84[a] |
| | G | 10,80±4,49[b] | 4,23±2,28[a] | 3,75±1,31[a] | 7,91±5,55[ab] |
| | S | 6,08±4,50[ab] | 13,88±19,2[b] | 2,80±0,88[a] | 4,01±1,80[a] |
| | M | 4,11±1,26[a] | 5,74±3,20[a] | 3,08±0,93[a] | 3,72±1,22[a] |
| Fe | L | 252,14±57,8[ab] | 446,37±34,6[b] | 174,81±4,10[a] | 194,19±36,2[a] |
| | G | 133,59±97,7[b] | 78,28±18,6[a] | 131,26±12,5[b] | 36,81±15,8[a] |
| | S | 45,01±57,80[a] | 23,34±5,71[a] | 28,01±16,2[a] | 79,68±10,47[b] |
| | M | 8,76±0,70[a] | 5,83±1,01[a] | 7,30±1,26[a] | 17,27±11,8[b] |
| Ni | L | 1,59±1,58[ab] | – | 1,36±1,02[ab] | 2,25±2,33[b] |
| | G | 2,53±1,40[ab] | 1,05±0,68[b] | 0,95±0,58[a] | 3,01±1,95[b] |
| | S | 2,54±1,66[b] | – | 0,95±0,68[ab] | 3,01±1,01[ab] |
| | M | – | 1,67±0,34[ab] | 0,56±0,56[bc] | 1,19±0,12[c] |
| Pb | L | – | 0,22±0,41[ab] | 0,92±0,44[b] | 5,14±0,96[c] |
| | G | – | – | 1,50±1,43[a] | 1,71±0,49[a] |
| | S | – | 1,53±0,21[a] | 1,50±0,31[b] | 1,71±0,67[c] |
| | M | – | 0,17±0,08[a] | 0,75±0,11[a] | 1,81±0,16[b] |
| Zn | L | 81,11±35,0[c] | 51,11±11,1[b] | 11,62±13,1[a] | 10,85±0,49[a] |
| | G | 23,42±5,69[b] | 30,51±2,31[c] | 10,89±4,7[a] | 11,85±0,54[a] |

*: Not to be determined.
**: Different letters (a,b,c) point out that the differences are important (P<0,05).
(Caliskan 2005).

At the end of the study, it has been determined that metal concentrations were significantly different between seasons ($p<0,005$). Generally, the increased accumulation in fish and water samples were measured in summer, and higher accumulation is measured in sediment samples in winter.

Further, among fish tissues that showed accumulation, generally the highest was in the liver but the highest Cr and Mn concentrations were found in the gills, and the highest Zn levels were found in the skin. The minimum Cd, Cu, Mn, Pb accumulations were measured in skin tissues, and Co, Cr, Fe, Ni, Zn accumulations were measured in muscle tissues (Caliskan 2005).

## 5. Conclusion

Sediments and fish tissues with a high amount of anthropogenic pollutants prove that water of the Asi River is highly contaminated by heavy metals Most of the research emphasizes the necessity of long-term monitoring and a close collaboration between people, industry and politicians. In addition, projects focusing on adaptation options by using water risk management-based prediction models for policy makers should be improved and applied.

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# Sustainable Agricultural Water Management in the Asi Basin

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## 1. Introduction

This study aims at determining the present situation of agricultural water management and measures required for sustainable agricultural production in the Turkish portion of the Asi transboundary basin. Erzin Dortyol, Samandag, Arsuz and Amik Plains in this basin are the most productive agricultural lands regionally and nationally. The prevailing climate is Mediterranean in the basin and water requirement increases significantly in the summer. The widespread growing of crops with high irrigation demand has recently caused significant issues in the irrigation period. No success has been made in terms of reductions in agricultural water demands despite the intensive efforts by the state, irrigation associations, and non-governmental organizations. However, no or little efforts have been made to protect soil and water quality, and even some state-owned investments have led to soil and water pollution at the basin scale. Industrial facilities built or to be built in the Erzin-Dortyol District – the most significant production area of Turkey in terms of citrus species, in particular – and the thermal power plants will cause the district to be subjected to acid deposition in foreseeable future.

## 2. General geographical characteristics of Asi basin

Asi Basin is located in the provincial boundaries of Hatay in the eastern Mediterranean Region (35º 47′– 36º 24′ E; 35º 48′– 36º 37′ N). Within the basin lie the Amik, Dortyol-Erzin, Arsuz and Samandag Plains (Table 1).

Asi basin is under the influence of Mediterranean climate with hot and semi-arid summers and warm and rainy winters. Given the long-term mean annual rainfall of 774 mm in the Mediterranean Region, the basin received 1032 mm in 2012 and 625 mm in 2013. Observed rainfall was below by 19% in 2013 relative to the basin-specific long-term mean value and by 39% relative to 2012. 67% of rainfall is received during the winter period, and mean annual air temperature is about 18ºC (Anonymous 2014).

**Table 1 – Plains in the lower Asi River basin**

| Plain Name | Area (ha) |
|---|---|
| Amik | 119350 |
| Dortyol-Erzin | 34920 |
| Arsuz | 6840 |
| Samandag | 3200 |
| **Total** | **164310** |

The prevailing soil structure in the basin is alluvium and lacustrin. Alluvial soils are abundant along the important rivers of the basin such as Asi, Afrin, and Karasu. Lake Amik is situated in the northwest section of the basin and has an area of about 53 $km^2$ (Kilic et al. 2004). The biggest contribution to usable water potential in the basin is from rivers and streams. Chiefly, Asi River, Afrin, Muratpasa, Karasu, Little Karacay, Big Karacay, and Tomruk Water constitute significant surface water resources of the basin. The most important groundwater resources are located in Amik and Arsuz Plains in north of Erzin District.

## 3. Agricultural production potential of the Asi basin

The area of the agriculturally productive lands in the basin is about 275578 ha. Majority of the basin is irrigated from different water resources. The land area that is not suitable for irrigation is 69025 ha, while the total irrigable land area is of 206553 ha. About 30038 ha of the latter land are not under irrigation for various reasons (Table 2). The total land area irrigated across the basin is of 176515 ha. Out of the total land area, 51% is not arable. The most extensive agricultural area in the basin is the Amik Plain covering 119350 ha (Table 2).

**Table 2 – Hatay total and irrigated area**

| Agriculturally Productive Area (ha) | Economically Non-irrigable Area (ha) | Total Irrigable Area (ha) | Irrigable Area not in Use (ha) | Total Irrigated Area (ha) |
|---|---|---|---|---|
| 275578 | 69.025 | 206.553 | 30.038 | 176.515 |

(Anonymous, 2013)

Main crop categories in the basin are field crops, fruits, and vegetables (Table 3). The main field crops in the basin are wheat, cotton, corn, potatoes, and chickpeas. The main vegetable crops are tomatoes, green peppers, cucumbers, carrots, and cabbages. The most produced fruits in the basin are oranges and tangerines.

Especially, Erzin-Dortyol Plains meet about 20% of the national citrus production. The aforementioned district has the agricultural land with the highest sum of sunshine hours across Turkey. Majority of population in the district earn their income from citrus orchard production. Similarly, Arsuz Plain is the place where citrus and orchard production is concentrated. The most intensive and extensive production of field crops takes place in the Amik Plain, which includes agricultural land around the towns of Kirikhan, Hassa, Reyhanli, and Antakya where wheat, cotton, and corn are mostly grown.

**Table 3 – Yields of field crops, fruits, and vegetables mostly grown in the basin in 2013**

| Field Crops (1374961 da) | | Fruits (843787 da) | | Vegetables (329052 da) | |
|---|---|---|---|---|---|
| **Name** | **Yield (ton)** | **Name** | **Yield (ton)** | **Name** | **Yield (ton)** |
| Wheat | 313000 | Orange | 302000 | Tomato | 158000 |
| Cotton | 203000 | Tangerines | 277000 | Pepper | 55000 |
| Corn | 214000 | Olive | 158000 | Cucumber | 58000 |
| Potato | 44000 | Grape | 72000 | Carrot | 60000 |
| Chickpea | 715 | Lemon | 38000 | Cabbage | 16000 |

(TUIK 2013)

## 4. Rainfall and evapotranspiration attributes of the basin

The most influential climatic factors on management of agricultural irrigation demand are the rainfall regime and evapotranspiration. Long-term mean annual rainfall of the basin is estimated to be 896.7 mm (Table 4). Mean monthly values measured in the basin between 1970 and 2010 were as follows: 173 mm (Jan), 160.2 mm (Feb), 141.2 mm (Mar), 101.6 mm (Apr), 88.1 mm (May), 17 mm (Jun), 10.8 mm (Jul), 3.4 mm (Aug), 37 mm (Sep), 74.2 mm (Oct), 114.3 mm (Nov), and 171.9 mm (Dec) mm.

Stochastic irregularities observed recently in the amount and spatial distribution of rainfall has led to drought spells common across the basin at the time of irrigation. A nation-wide review of all the basins in Turkey revealed that the greatest decline in rainfall was experienced in 2012 for the Asi basin (Anonymous 2014). The decline is by 30.5% as far as mean values are concerned and by 47.6% when 2012 was used as the baseline year. These decline rates of rainfall in the Asi basin are higher than the mean decline values of Turkey and Seyhan and Ceyhan basins, which neighbor the Asi basin.

Asi basin is under the influence of semi-arid climate. The maximum amount of evaporation occurs in the summer months during which irrigation demand peaks. Annual evaporation ($ET_o$) measured in the basin between 1981 and 2010 varied between 1000 and 1198 mm (Figure 1-4).

**Table 4 – Precipitation (agricultural season: 1 October 2013 – 30 September 2014)**

| Basin No | Basin Name | Precipitation (mm) | Normal (mm) | Last year (mm) | Increase – Decrease Rate | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | According to Normal (%) | | According to Last year (%) | |
| 1 | Meric | 836.6 | 603.3 | 820.5 | 38.7 | Increase | 20.0 | Increase |
| 2 | Marmara | 735.8 | 729.9 | 760.4 | 00.8 | Increase | –3.2 | Decrease |
| 3 | Susurluk | 849.5 | 706.4 | 690.7 | 20.3 | Increase | 23.0 | Increase |
| 4 | North Ege | 652.7 | 601.2 | 923.5 | 80.6 | Increase | –29.3 | Decrease |
| 5 | Gediz | 538.9 | 576.8 | 735.0 | –6.6 | Decrease | –26.7 | Decrease |
| 6 | Little Menderes | 578.7 | 612.2 | 740.9 | –5.5 | Decrease | –21.9 | Decrease |
| 7 | Big Menderes | 514.3 | 565.8 | 723.3 | –9.1 | Decrease | –28.9 | Decrease |
| 8 | West Akdeniz | 803.6 | 826.7 | 989.0 | –2.8 | Decrease | –18.7 | Decrease |
| 9 | Antalya | 749.2 | 752.9 | 780.1 | –0.5 | Decrease | –4.0 | Decrease |
| 10 | Burdur | 455.1 | 441.8 | 394.7 | 30.0 | Increase | 15.3 | Increase |
| 11 | Akarcay | 431.4 | 470.2 | 419.1 | –8.3 | Decrease | 20.9 | Increase |
| 12 | Sakarya | 484.1 | 471.1 | 417.9 | 20.8 | Increase | 15.8 | Increase |
| 13 | West Karadeniz | 886.5 | 875.3 | 785.1 | 10.3 | Increase | 12.9 | Increase |
| 14 | Yesilirmak | 399.3 | 497.9 | 518.0 | –19.8 | Decrease | –22.9 | Decrease |
| 15 | Kizilirmak | 417.1 | 444.6 | 429.9 | –6.2 | Decrease | –3.0 | Decrease |
| 16 | Konya | 390.4 | 382.6 | 386.5 | 20.0 | Increase | 10.0 | Increase |
| 17 | East Akdeniz | 443.3 | 638.8 | 716.2 | –30.6 | Decrease | –38.1 | Decrease |
| 18 | Seyhan | 426.7 | 625.4 | 608.6 | –31.8 | Decrease | –29.9 | Decrease |
| 19 | ASI | 623.1 | 896.7 | 1.189.0 | –30.5 | Decrease | –47.6 | Decrease |
| 20 | Ceyhan | 477.2 | 677.2 | 786.1 | –29.5 | Decrease | –39.3 | Decrease |
| 21 | Firat Dicle | 418.1 | 572.3 | 589.4 | –26.9 | Decrease | –29.1 | Decrease |
| 22 | East Karadeniz | 1.202.3 | 1.353.8 | 1.177.6 | –11.2 | Decrease | 20.1 | Increase |
| 23 | Coruh | 466.8 | 509.2 | 399.7 | –8.3 | Decrease | 16.8 | Increase |
| 24 | Aras | 423.7 | 461.3 | 457.6 | –8.2 | Decrease | –7.4 | Decrease |
| 25 | Van | 394.6 | 540.7 | 456.5 | –27 | Decrease | –13.6 | Decrease |

(Anonymous 2014)

**Figure 1 – Long-term mean annual evaporation (mm)**

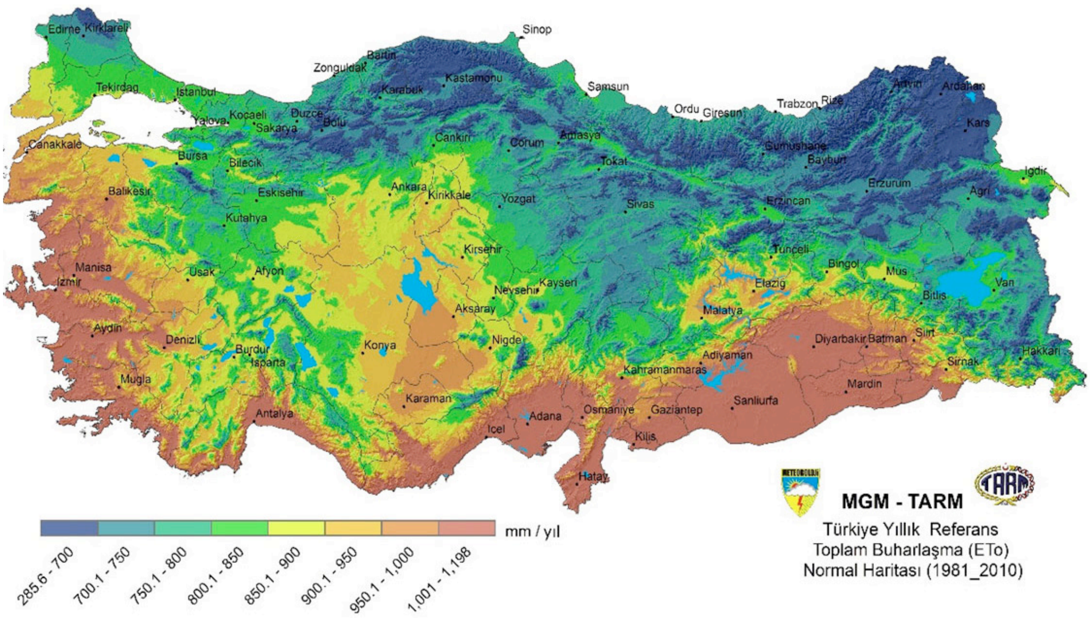



**Figure 2 – Mean annual evaporation (Eto, mm) in June (1981–2010)**

**Figure 3 – Mean annual evaporation (Eto, mm) in July (1981-2010)**

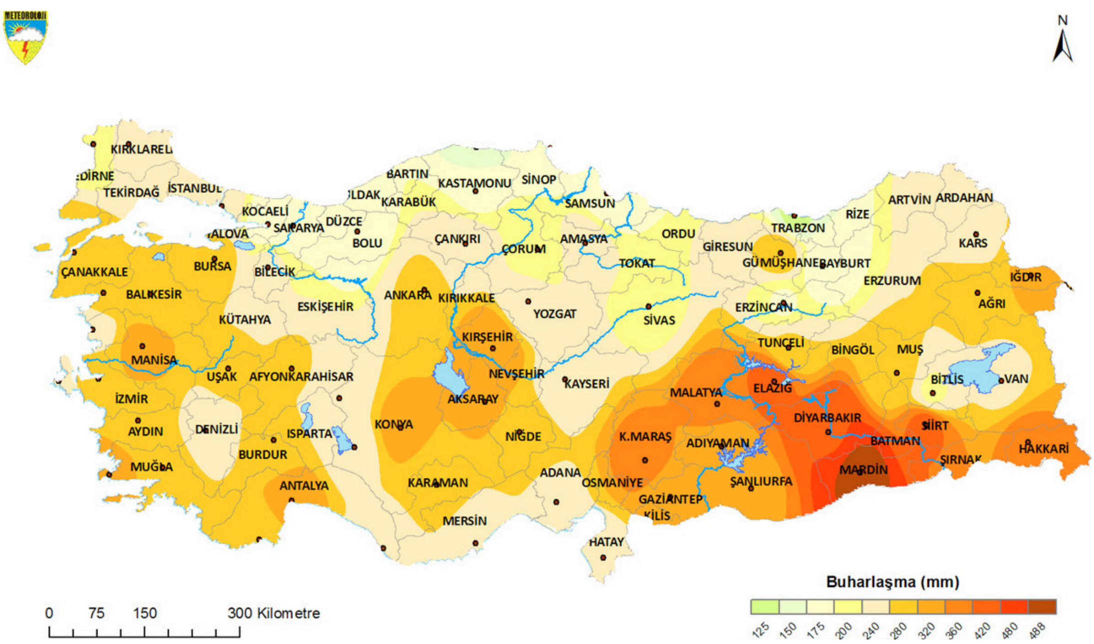
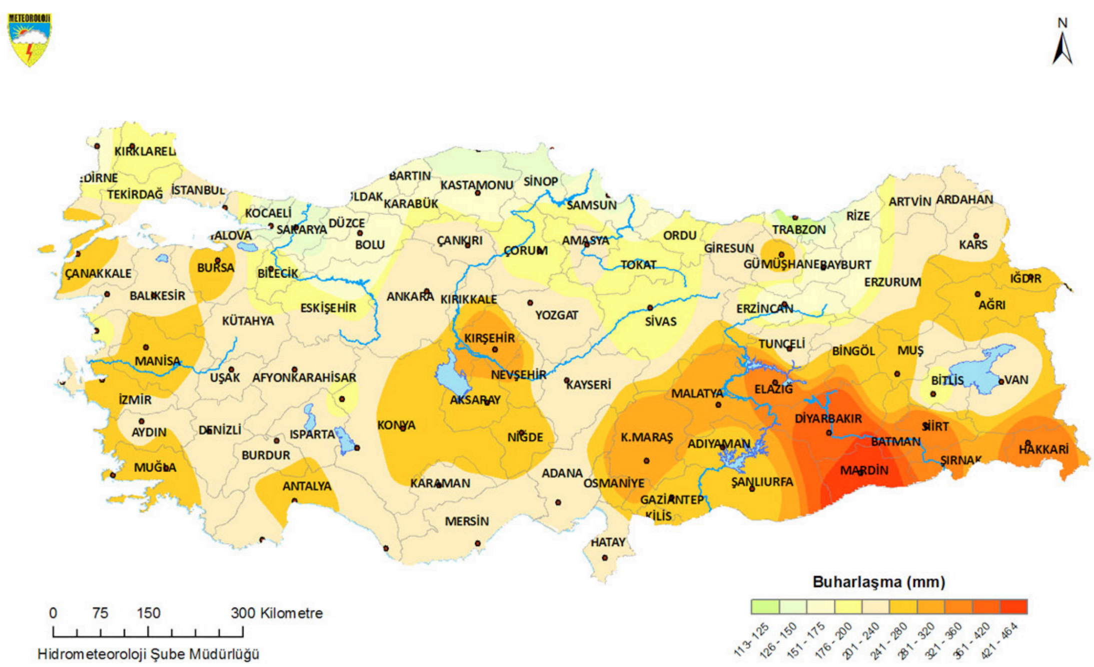



**Figure 4 – Mean annual evaporation (Eto, mm) in August (1981-2010)**



## 5. Agricultural irrigation demand in the Asi basin

Irrigation water demand in the Asi basin changes inter-annually. In the early 1960s irrigation demand was initially met with water from the streams and creeks intensively, but then more water was extracted from the wells due to decreased water table depth in the Amik Plain. Even though the State Hydraulic Works (DSI) built an irrigation channels), local farmers mostly utilize water from wells and streams directly (Table 5).

| Table 5 – Land area irrigated by different sources | |
|---|---|
| State-Invested Irrigation | 47 005 ha |
| Land Irrigated from Wells | 80.000 ha |
| Land Irrigated from Rivers, Streams & Creaks | 49.510 ha |

(Anonymous 2013)

Mostly produced agricultural crops and their annual water consumption are presented in Table 6. Corn, cotton, orange, and tangerine are the most water demanding crops. The different spatial distribution of the aforementioned crops across the basin plains is the primary factor in determining irrigation demand in the basin. Similarly, farmers' adoption of different crops, and hence, water management practices results in diverse irrigation applications in terms of irrigation type, timing, amount, frequency and duration both within the same plains and among the different plains.

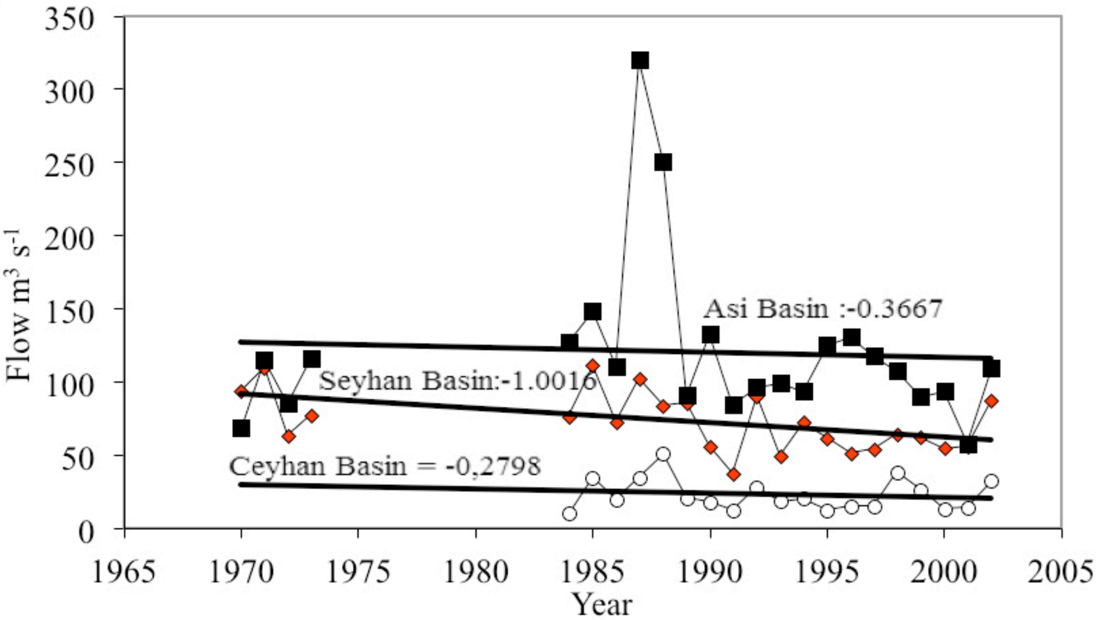
Table 6 – Field crops, orchards and vegetables area and production in the lower Asi River basin

| Crop type | Area (da) | Production in 2013 (ton) |
|---|---|---|
| **Field crops** | 1374961 | 972914 |
| **Orchards** | 843787 | 963292 |
| **Vegetables** | 329052 | 744061 |

(TUIK 2013)

Amik Plain as the biggest plain of the Asi Basin, is also the most important agricultural production area of the Eastern Mediterranean Region. The Asi River as the most significant water resource of the plain is of strategic importance to the regional provinces. Despite its capacity to irrigate an area of 50000 ha, the Asi River is presently irrigating an area of only 12000 ha (Altunlu 2002). Recent decreases in water level of Asi River escalate drought conditions observed in Amik Plain during the irrigation period. Measurements of water level and water quality in Demirkopru and Antakya observation stations across the Asi River, show that not only water level has decreased but also water pollution has increased significantly in the last two decades (Odemis et al. 2007). As a result of withdrawals of scarce river water by pumping stations in the region between Demirkopru and Antakya, which has the largest farmlands of the Amik Plain, the city center of Antakya suffers from severe water scarcity.

**Figure 5 – Changes in flow of the Asi River**




(Odemis et al. 2007)

High water consumption is the common property of crops grown widely across the plain. Intensive water requirement during the irrigation period for corn and cotton was previously met using surface water resources; however, wells have recently been in demand as the source of irrigation. In Turkey, the ratio of total withdrawal from groundwater to the existing reserve is on average 0.70, while this ratio is greater than unity for West Black Sea Region, Burdur Lake, Akarcay, Closed Konya Basin, East Mediterranean, and Asi Basin. This ratio in the Asi Basin rose between 1991 and 1995 to 0.99, 1.02, 1.03, 1.04 and 1.10, respectively (DIE 1998).

Although the operational groundwater reserve of the plain is 120.000.000 $m^3$, the amount of water quite above this level-150.000.000 $m^3$-was reported to be withdrawn (Altunlu 2002). Related to the number of deep wells in the Hatay Province, the number of subscribers to TEDAS Province Directorship increased to 5289, 6967, 7252, 7546, and 7515 from 1997 to 2001, respectively (Onder 2002).

The number of deep wells, which were 1830 in 1997 rose to 2600 in 2001. The rise in the number of wells results in a decreasing trend in the level of groundwater table with each passing year. A couple of years ago, water was extracted from a well depth of 70-80 m below ground, wells of 400-450 m in depth is recently encountered to reach water.

According to the DSI official records, there were 3,168 registered wells in the Amik Plain in 2013 (Anonymous 2013). Out of these wells, 99 belong to DSI. However, about 15,000 wells are recently suspected to exist unregistered. Withdrawal of groundwater through wells from 400 m below the ground in some parts of the plain leads to a significant increase in agricultural production costs. Water scarcity urged the farmers to adopt rain-fed cultivation in Altinozu and Yayladagi districts of the plain, and thus, allows for such crops as tobacco, wheat, barley, lentil, and chickpea to be grown.

In addition to water scarcity, another issue experienced in the plain is flooding events caused by increased water level of rivers and streams depending on spring and winter rainfalls. Especially opening of dam gates on the Syrian side without warning, during those periods caused most lands to be inundated. A cultivated land of about 700,000 da was flooded in Hatay alone between 2001 and 2006 due to the water policy adopted by Syria in the Asi River (Anonymous 2006).

As for the groundwater quality, EC values in the vicinity of Amik Lake, which was drained in the early 1960s, vary between 363.2 and 18877 µmhos $cm^{-1}$, with irrigation water quality being classified as $C_2S_1$ and $C_4S_3$. pH and SAR values were in the range of 7.55 to 8.24 and 0.21 to 9.29, respectively (Sangun et al. 2007). Heavy metal concentrations of well water (Cd, Co, Cr, Cu, Fe, Mn, Ni, Pb) do not exceed the limits set by the FAO (Agca et al. 2006). Another study by Sangun et al. (2007) about the plain reported that EC and pH were in the range of 347 to 2510 µmhos $cm^{-1}$ and 6.86 to 8.75, respectively, based on samples from a total of 59 wells. Thus, Sangun et al. (2007) stated that the use of water from the wells as the source of agricultural irrigation poses an important threat to environmental and human health.

The intensive use of well waters results in the issue of increased salinization in the plain. About 3073-ha area of the plain is set to face the issue of secondary salinization out of which 2813 ha have slight salinity (2 dS $m^{-1}$ < $Ec_e$ < 4 dS $m^{-1}$), and 260 ha have high salinity ($Ec_e$ > 4 dS $m^{-1}$) (DPT 1997).

Onder (2003) did not find significant changes in mean electrical conductivity of soil (EC), exchangeable sodium percentage (ESP) and soil organic matter of the plain soils between 2001-2002 and 1983-1984 ($p > 0.05$). In the same study, pH, cation exchange capacity (CEC) (to a depth of 30 to 60 cm) and calcium content of the soils were reported to decline over time, whereas Ca+Mg amount was reported to increase over time ($p < 0.05$). The area with poor drainage (to a depth of 0 to 2 m) grew from 96.3% to 98.8%. pH of groundwater increased from 7.5 to 7.8r ($p > 0.05$). Mean K, Ca+Mg, $CO_3$, $HCO_3$, Cl, and SAR values of groundwater significantly varied temporally. The same study concluded that drainage channels set up for draining Lake Amik is not capable of serving the purpose. The old lake area has drainage outlets which also impede cultivation activities.

## 6. Erzin-Dortyol plains

In Erzin-Dortyol Plains where orange and tangerine are grown mostly, the main water resources are water from wells. The use of wells along the coastal areas is the main cause of salinization. Light- or medium-textured soils of the plain partially buffer the adverse effects of salt accumulation during the irrigation period. However, increasingly declining winter rainfall amplifies the impact of salinization. Furrow and border irrigation applications in light- or medium-textured soils of the plain cause an increase in deep seepage. Despite the fact that drip irrigation systems are used intensively in this plain relative to the other plains of the basin, irrigation systems built by unprofessional people fail to reach significant water savings and conservation in the district. Considering that 70% (about 24500 ha) of Erzin-Dortyol Plain of 35000 ha is suitable for agriculture, and that water consumption of widespread citrus plantations is about 1000 mm $yr^{1}$, annual irrigation water demand can be estimated at 171.500.000 $m^3$ with 70% efficiency.

## 7. Samandag and Arsuz plains

Arsuz and Samandag plains border the sea coast and are climatically similar to one another. Samandag plain is where parsley and mint are most intensively produced in Turkey (Anonymous 2013). Greenhouse vegetable production and orchards are also widespread in the plains. Irrigation demand of the plain is met mostly from the Asi River. However, during summer period along with inadequate water from the Asi River, farmers of the region obtain necessary irrigation water from the wells. For the prevention of sea water intrusion, there are two drainage channels built in parallel to the coastline (Odemis et al. 2006). The channel on the sea coast serves against the sea water intrusion. The other channel on the land side serves to gather agricultural drainage water and discharge into the sea. The latter drainage channel which goes by greenhouse area is also used for the purpose of irrigation in case well water poses a salinity problem.

Farmers of Samandag utilize water from the drainage channels built in a restricted area with the purpose of overcoming the difficulty ranging from the lack of groundwater quality to surface water scarcity. Odemis et al. (2006) showed that changes in groundwater quality in the Samandag plains during and after irrigation, from 1200 µmhos $cm^{-1}$ to 1400 µmhos $cm^{-1}$. The use of well and drainage waters because of water scarcity and sea water intrusion results in the water table depth reaching as high as 40 cm. This case increases the risk of soil salinization in the plain. Arsuz Plain, like Samandag Plain, has similar issues due to its location near the coastal area. The water demand of crops grown in the mountainous terrain of the district delineated by the range of Mount Amanos is met through wells. In the coastal areas, in addition to wells, water demand is met though Arsuz Creek.

## 8. Effects of environmental issues on agriculture in Asi basin

The Asi Basin has been under the pressure. Air, soil and water pollutants of different structural nature induced by humans have had an impact. The draining of the Amik Lake in the 1960s, in order to clear the land for agriculture and the fight against malaria, has caused the loss of important goods and services from the ecosystem. The ecosystem, in the past, has generated functions as sanctuary, regulation, protection, production and information (e.g. spiritual enrichment, cognitive development, education, scientific references, recreation, aesthetic opportunities, and cultural and historic values). A lake area of 65000 ha was drained into the Asi River through four drainage channels built in 1968, and as a result of a six-year reclamation study, Amik Lake was cleared for agricultural activities (Kilic et al. 2004). Fortunately, since the plain is six meters below the sea level and drainage channels are clogged over time, the old Amik Lake basin reemerges in a pronounced way even after periods of light rainfall.

Inadequately drained rainfall causes the water table to rise and increases the risk of soil salinization across the plain under the effect of capillary movement of water enhanced during the summer. During interviews, farmers have said that excessive irrigation in the plain in parts with fine textured soil leads to moderate soil salinity and a decline in crop quality. Also, the construction of an airport in the Amik Plain after the drainage of Lake Amik adversely affected agricultural characteristics and water management of the plain.

The old Amik Lake was rich in ecosystem services; for example, Hatay–Belen Strait is one of the most important bird migration routes in Turkey. The fact that Amik Lake and its surrounding wetland used to provide safe sanctuaries for birds was a big advantage in many aspects in the region. Following the operation of the drainage in the 1960s, this advantageous state was completely lost to short-term profit maximization. A large number of wetlands in the region are under the pressure from urban sprawl and urbanization.

Another important issue of the basin is that Iskenderun Bay tried to be transformed into a central hub of fossil fuel energy sector. Recently, under the pretext of meeting energy deficit, 12 thermal power plants to be run by natural gas and coal are known to be built in Eastern Mediterranean Region only (EPDK 2015). Considering that Erzin and Dortyol Plains alone contribute to 20% of Turkish citrus production and Amik Plain is one of the most important prime farmlands of Turkey, one can imagine what a big environmental challenge this can be. For example, Su Gozu Thermal Power Plant in operation in Iskenderun Bay with its coal storage area of 960 000 tons and its daily coal consumption of 12000 tons is a source of environmental pollution. Cumulative and interactive impacts of presently operating industrial facilities and the future 12 thermal power plants in the region will harm-fully expose the basic and its surrounding region to wet and dry acid depositions in the near future. This strengthens the evidence that lead concentrations in vegetation, water and soil through which animals are fed are above permissible limits.

## 9. What ought to be done?

In recent years drought has been the largest environmental disaster in the Asi Basin. We suggest that following actions should be taken in order to cope with these problems:

1. DSI provided incentives towards the installation of water-saving irrigation systems, this policy should be continued with a greater magnitude and scale. Institutions providing incentives should approve projects only after a detailed investigation on whether the projects are prepared in accordance with sound scientific criteria. Stochastic regime of groundwater and surface water resources in the region, and the rest of Turkey, necessitates that the existing water resources should be used effectively, rationally and sustainably. Future amount of irrigation water use in the Amik Plain close to Cukurova is expected to rise to 13% for citrus fruits, 11% for fruits and cotton, and 32% for vegetables depending on the projected local impacts of global climate change (Yano et al. 2005). Therefore, there is an urgent need to make it mandatory for farmers to adopt pressured irrigation systems (drip, sprinkler) in the plain with state incentives. It should be noted here that the term "state incentives" is meant to broadly refer to legislative, institutional, technical or financial instruments**.** These govern short-to-long-term behavioral and organizational changes in agricultural water management of the demand and supply sides of qualitative and quantitative irrigation services. Some of the aspects include planning, construction, operation, maintenance, modernization, adequacy, timeliness, equity, efficiency, conservation, dependability, convenience, coordination, decentralization, property rights to the land, the infrastructure, and the water, and quality/quantity-based monitoring. By referring to the prevailing crops of cotton and corn as water-intensive, and given the widespread inefficient irrigation methods, farmers must be informed and made aware of sustainable and best management practices.
2. The root causes of anthropogenic threats to sustainable agricultural production of the Amik Plain are the lack of ecologically sensitive and compatible land use planning, and unsustainable management practices. For example, soil salinity resulting from poor drainage conditions is a major problem since 70% of Amik Plain has fine textured soils (Agca et al. 2000). Rapid population growth, and uncontrolled urban sprawl in the last 30 years threaten the prime farmlands of the plain (Kilic et al. 2003). Therefore, scientifically sound and socially acceptable land use planning should be adopted urgently.
3. Draining operations for the Amik Lake were not fully completed. Even at the end of a half century after the drainage, the old Amik Lake basin reemerges with rainfall events due to ineffective drainage channels. This causes farmers in the neighboring region to suffer from significant economic losses. The rehabilitation of the destroyed Amik Lake should be attempted for the well-being and health of this ecosystem and its surroundings.
4. Observations and analyses of the groundwater table near the old Amik Lake basin show that the use of groundwater for irrigation in this vicinity should be approached cautiously. Otherwise, the land area at initial stages of salinization, will become worse, as a result of excessive use of groundwater for irrigation.
5. The Asi River is the most important source of agricultural water in the region. To prevent water pollution caused by industrial wastewater discharges and agricultural run-off into the Asi River water from both Antakya and the neighboring districts should be discharged into the river once treated only. In this context,

the minimum assurance of proper and effective operation of treatment facility in the city center will greatly benefit the prevention of lower basin and sea against water pollution.

6. Samandag district is the most significant hub of the region for vegetable production. There also exists an intensive greenhouse production in the district. The inadequate irrigation network provided by DSI causes farmers to use drainage channels. Samandag is the region most adversely affected by the issue of water quantity in Asi River. River water pollution ultimately increases seawater pollution.

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# Sustainable Water Management in Hatay: Hydrographic Planning Approach

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## 1. Introduction

The Asi River Basin corresponds to the drainage area of the Asi River fed through the eastern slopes of Lebanon Mountains in Southwestern Asia and was shaped under the influence of Dead Sea Fault Zone. Total length of Asi River, the main watercourse in the basin, is 556 km (7% (40 km) Lebanon, 66% (366 km) Syria, 1%8 (98 km) Turkey and 9% (52 km) Turkey – Syria border line), and the total area of the basin (the section drained by Asi River) is 24.870 $km^2$ (9% (2.205 $km^2$) Lebanon, 69% Syria (17.110 $km^2$) and 22% (5.552 $km^2$) Turkey) (Korkmaz and Karatas 2009, Al Dbiyat and Geyer 2015) (Figure 1). Many variables such as climate conditions, the amount of population and common agricultural activities cause water resources in the basin to become a part of a serious problem in the supply-demand equilibrium. Therefore, solutions to many of the hydrologic, economic, cultural and strategic problems specific to the basin are closely related to the administration and management of the water potential in the basin through fair and reasonable approaches. Such a water management model can only be successful by ensuring the dominance of a "hydrographic planning" approach, as a human centered planning approach that pays attention to the positive and negative impact degrees of all components of the basin instead of their costs. It is now an obligation to consider many angles of the problem such as geologic, geo-morphologic, hydrologic, social, cultural, strategic and political aspects by guarding and preserving all the elements of the ecosystem rather than focusing on financial consideration based on getting the highest benefit and revenue.

Hatay, located in the lower course of the Asi River Basin, is directly affected by plans and projects that will be implemented in the basin in general. However, unstable regimes in Syria and Lebanon, – the middle and upper course countries in the basin – make it almost impossible to implement common plans and projects that will address the whole basin. Therefore, it is a more realistic approach to implement those projects that have been planned in Hatay, to be based on approaches that will address the whole basin but will be shaped according to the own dynamics of the province (Photo 1).

**Figure 1 – Location and topography of the lower Asi River basin**

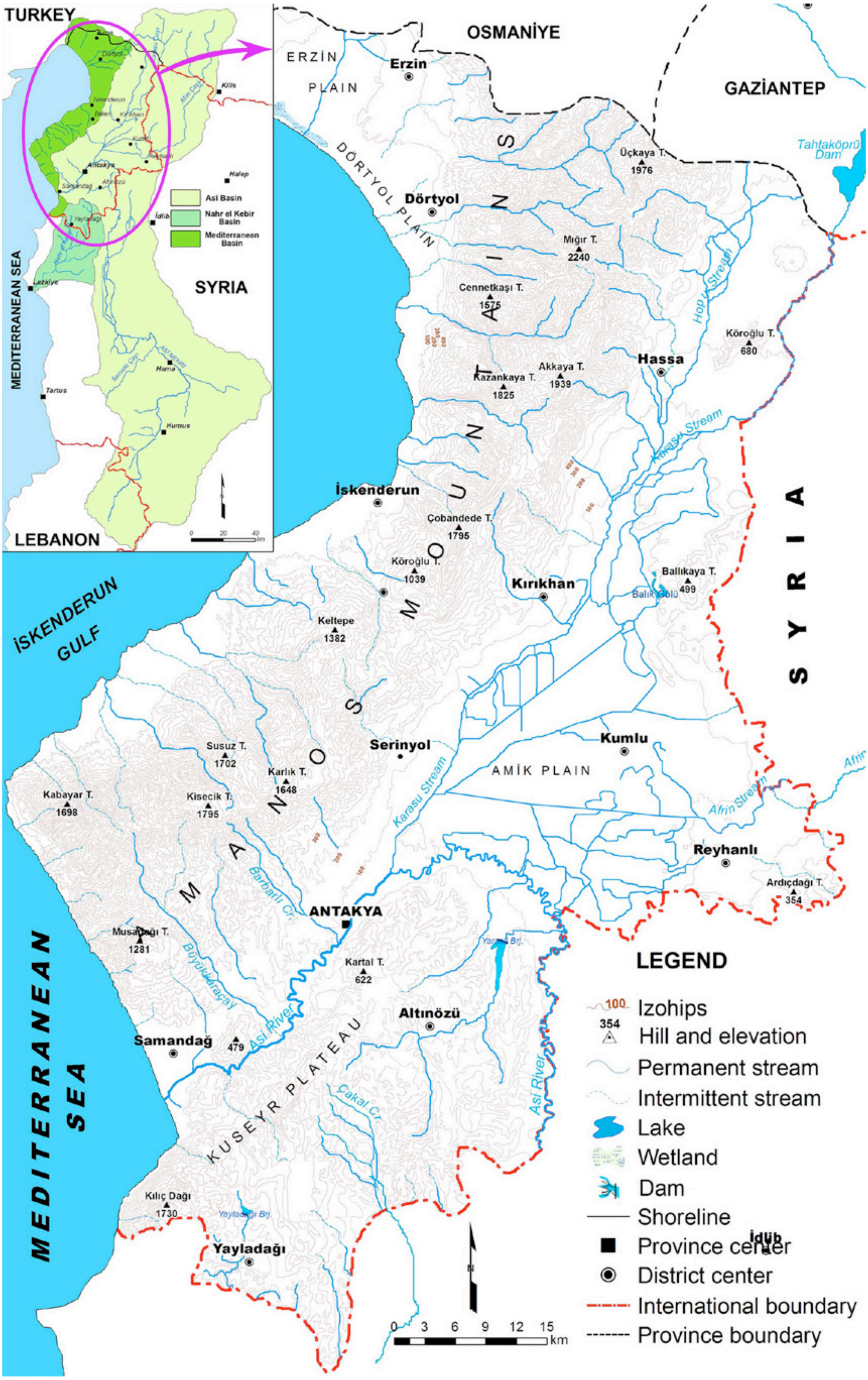
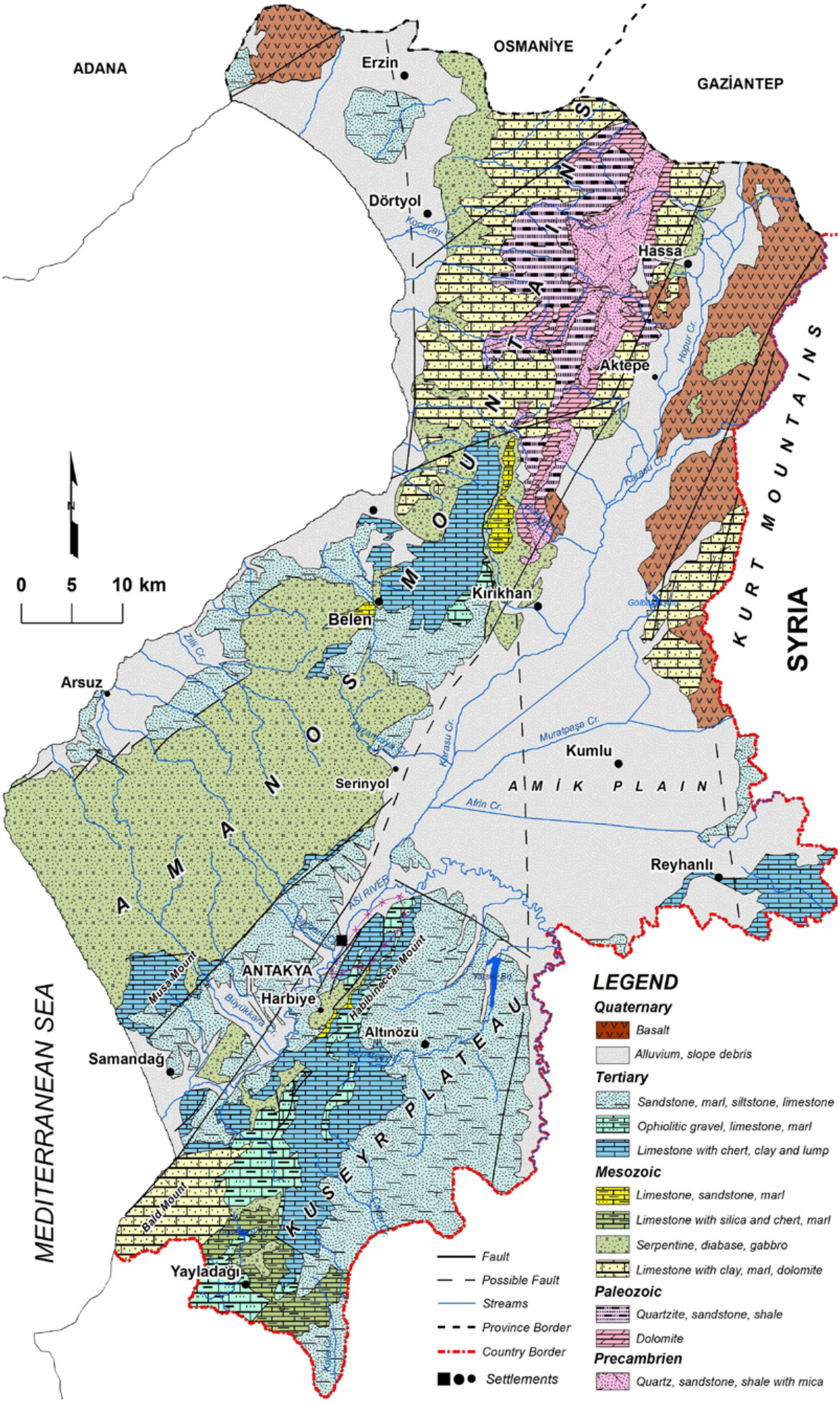


**Photo 1 – Rapid and dramatic change of Asi River in Hatay**


## 2. Geographical features

The first of the two important components of the general geo-tectonic and geo-morphologic structure in the Asi Basin, where the tectonic extension regime (rifting) is dominant, is the high areas that correspond to carbonated rocks and to ophiolites (ocean floor volcanites) and to faulty slopes that separate those from low areas (Herece 2008) (Figure 2). The second component is the bottom of the rift line (separation area between African and Arabian plates) that forms base floors with a large amplitude compared to elevation with anticlinal and horst character on both sides (HGK 2004). Although these base floors sometimes include ridges caused by basic/alkaline magma outflows, alluvial cones and fans settled in and on the sides of alluvial plains. Slopes were fragmentized in the form of deep valleys by the rivers that flow to the rift valley from high ground. No softening has yet been observed in the sharp relief since the impact of neo-tectonic regime is still strong. The general geo-tectonic structure does not change in Hatay. In the high areas, flora is represented by species such as pinus brutia, juniper and quercus (which are adapted to the Mediterranean climate) as well as members of maquis. Zonal soil units represent the high areas where forest soil is common, azonal soil that develops under the impact of alluvial materials exists in the valley floors (KHGM 1998).

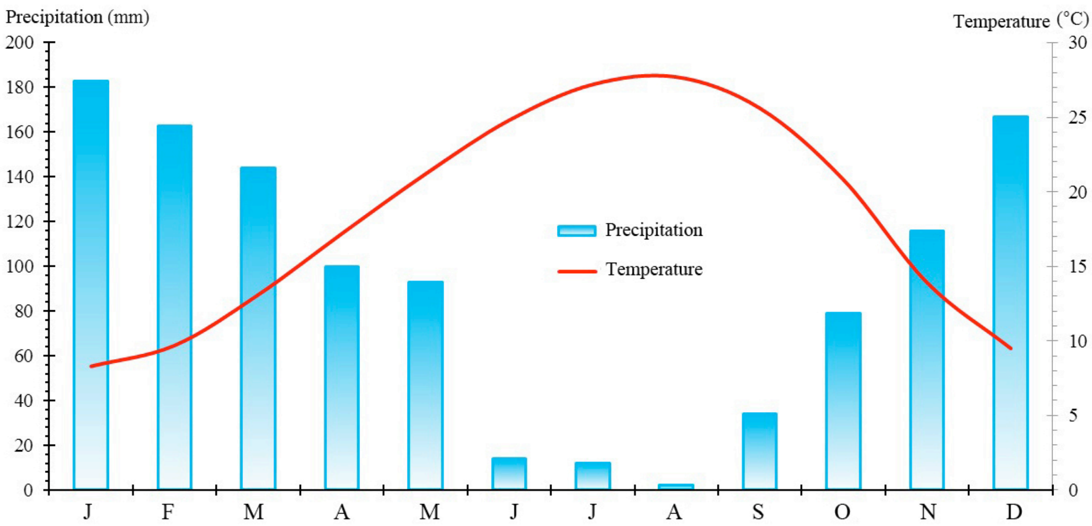
**Figure 2 – Geological and Lithological map of Hatay**




(based on Korkmaz et al. 2011, 2012).

Even though a continental influence can be observed in areas farther from the sea, Hatay is generally included in the Mediterranean climate region. Temperatures in lower altitude which corresponds to base floors vary between 18,2°C (Antakya) and 19,3°C (Kirikhan), whereas temperature gradually drops in higher ground (Karatas and Korkmaz 2012). A similar topographic impact is also observed in precipitation. Total annual average precipitation is 1.120,5 mm in Antakya under the influence of the sea whereas it is about 562 mm in Kirikhan, which has more arid characteristics (MGM 2012) (Figure 3). Increases in elevation have positive impact on precipitation. The hottest months in the year for the province are July and August and the coldest months are January and February. The least amount of precipitation is observed in the hottest months whereas the coldest months are the ones with the highest amount of precipitation (MGM 2012).

**Figure 3 – Annual mean temperature and precipitation in Hatay**




Population density in the province is higher in the floor of the rift valley and decreases in mountainous areas. The situation is completely different on plain floors and alluvial cones and fans (TUIK 2014). Asi River and its tributaries have an impact on the living conditions of approximately one million people living in the province (TUIK 2014). Agricultural activities, which are undertaken on plain floors through irrigation are the leading economic activities. Irrigated agricultural areas included in provincial borders of the basin increased by about 150% in the last 50 years and this fact has escalated the pressure on the water resources (Toma and Akkuyu 2011).

## 3. Groundwater

Both the prevalence of lithologic units and the sinuous and faulted tectonic structure increase the possibility of penetration from surface waters and collection in aquifers. In this context, the existence of not only the carbonated units with high level of permeability but also the ophiolite areas with faults and diaclases (which are crucial in feeding the underground waters) in the high zone creates an advantageous situation (Photo 2). High infiltration level of surface water - supported by intensive precipitation and snow melting during winter seasons - to underground at high degrees is noteworthy in terms of its contribution to the underground water potential of the province. All these positive conditions yield 750 million $m^3$ usable groundwater for Hatay. But excessive consumption has caused the groundwater table to decrease in the province (Karatas and Korkmaz 2012).

Photo 2 – Groundwater withdrawal in Amik Plain

Water infiltrated in these high elevation areas reappears on the surface as a result of cut of water tables by the faults in the graben edge zone and generating tremendous springs in the zonal character. Water located at further depths is stored in aquifers composed of alluvium or basalts in the graben floor and acts as a source for underground water operations. There are more than ten mineral water sources fit for operation, the gifts of geo-tectonic structure, in the province (Oktü et al. 1994).

## 4. Surface water

The average flow of the Asi River, the main water source in Hatay, was 12,7 $m^3$/sec from Lebanon to Syria, 25 $m^3$/sec in the south of Ghab Plain and 35,1 $m^3$/sec (Demirkoprü SGS) in Turkish soil for long years but recently it has been impossible to reach these flow values in Demirkoprü station (EIE 2009) (Figure 4). This situation results from the fact that Syria, receives its share from Lebanon, upstream country (Figure 5). Syria also exploits the water that is supposed to be used downstream by Turkey, and uses it single-handedly in an uncontrolled manner. (DSI 1958, Yetim 2006).

**Figure 4 – Annual mean flow of Asi River in Lebanon-Syria border and Antakya**

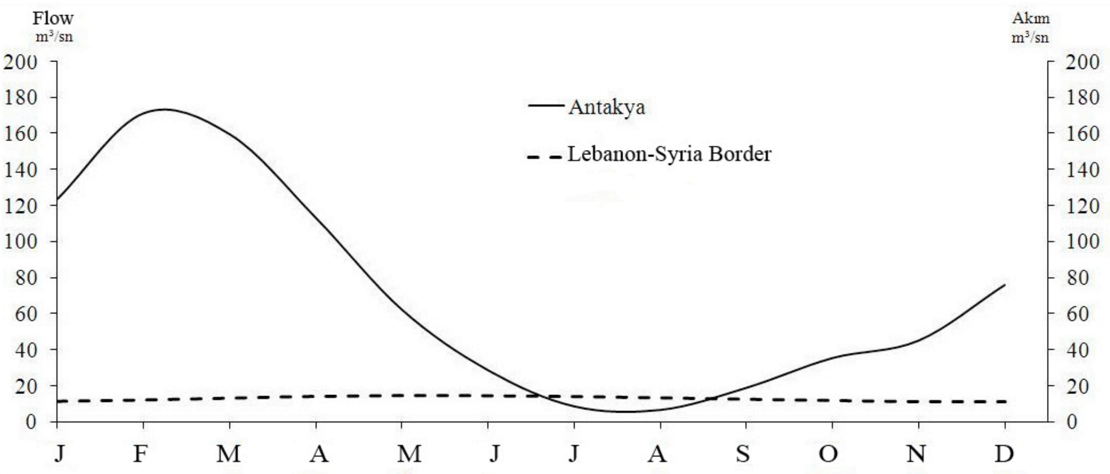



**Table 1 – Lebanon water share according to the 1994 water sharing agreement between Lebanon and Syria**

| **Period of the year** | | **Lebanese share**<br>**Required quantity/million m³** |
|---|---|---|
| 1 | September – October | 10 |
| 2 | November – December – January – February | 10 |
| 3 | March – April | 10 |
| 4 | May – June – July – August | 50 |
| **Total** | | **80** |

(From Syrian Lebanese Higher Council 1994)

A similar situation is valid for the Afrin River whose spring segment is located in Turkey, whose middle course is located in Syria and lower course in Turkey. Average flow of the stream has been 8,8 $m^3$/sec (Müsrüflü SGS) for long years (1950-2005) (EIE 2009). Syria prefers to consume the water based on one-sided plans and implements those via the 17 April Dam (Medanki) built on the river. The Karasu River, the most important tributary of Asi River in Turkey receives its source from Turkey, forms the Turkey-Syria border for 28,1 km and connects with Asi River in the south of Amik Plain. Average flow of this stream is 11,2 $m^3$/sec (Torun Koprüsü SGS) for long periods as well (1950-2005).

The stream is controlled by Turkey and there is no serious interference from Syria. But the amount and quality of water, coming from Syria by the Asi River and the Afrin Dam, has increased because of the Syrian conflict in the last three years. Agricultural and industrial water consumption has decreased in Syria during this period. However it is impossible to define a mean flow amount on three years gauging measurements.

## 5. Water infrastructure

Water infrastructures in the basin such as the dams of Rastan, Mhardeh, Afamia, Yarseli, 17 April and Tahtakoprü, were built mostly in the last 60 years (Korkmaz and Karatas 2009) (Photo 3). The water-holding capacity of the 11 dams in the basin (nine in Syria and two in Turkey) is above 50 million m³ (Korkmaz and Karatas 2009). A total of 49 dams and ponds were built with a total storage capacity of 1.492 million m³. The other important water infrastructures are the drainage canals established to dry the Amik Lake and Al-Ghab swamp and ten thousands wells most of which are unlicensed (Korkmaz and Karatas 2013).

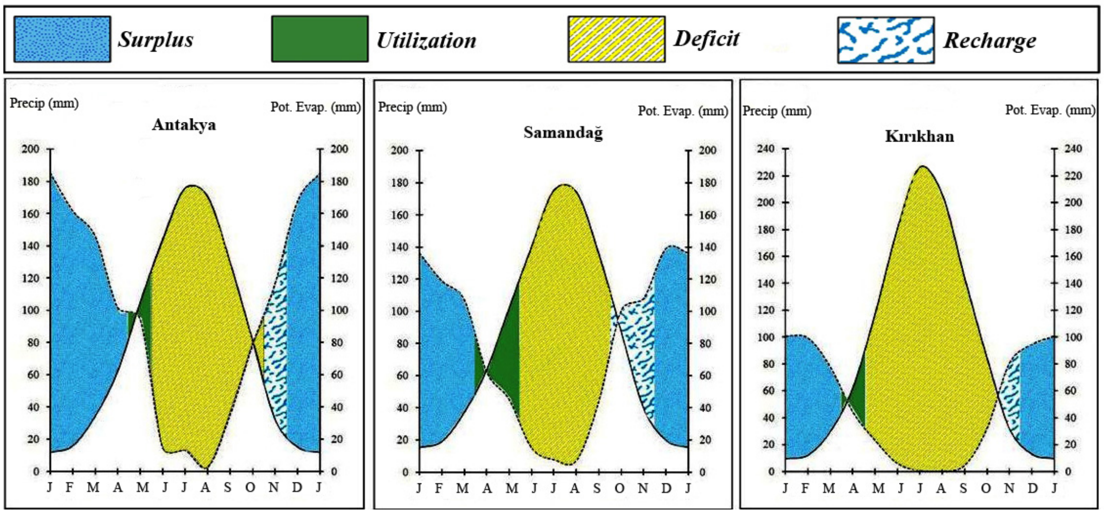
Photo 3 – Yarseli Dam (east of Antakya).

Multitude of the water infrastructures in the basin gives us an idea about the pressure on the water sources in the basin. Results of such an extensive consumption can be observed on the water sources of Hatay with all its negative impacts. Therefore precautions are sought by building new water infrastructures in Hatay (more than 10 reservoirs in the last 20 years) to prevent unstable conditions of decreasing flow and the arbitrary use of water sources. There have been difficulties in water management due to the increase in water infrastructures built without a comprehensive plan and without assessing daily needs.

## 6. Flood and drought

The section of the Asi Basin located along the Hatay borders is subjected to both sides of the problems related to water. On the one hand, the problems caused by insufficient water resources need to be addressed; while, on the other, issues such as flashfloods, overflows and discharge of excess water create unique administrative and catastrophic challenges (DSI 1958, 2007) (Figure 6).

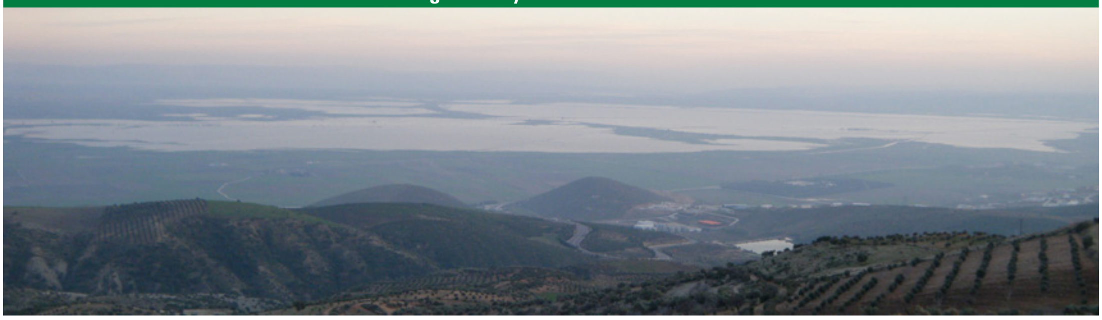
**Figure 5 – Thornthwaite water balance of Antakya, Samandag and Kirikhan**




(Karatas and Korkmaz 2012).

In this context, especially the sudden downpours, deformed natural hydro-geomorphologic structure and unplanned interventions on the soil increase the risk for floods in periods of high flow and acts as a multiplier (Photo 4). On the other hand, some inaccurate plans may also set the stage for such disastrous events as was observed in Hatay Airport flood of January-March 2012 (Korkmaz and Karatas 2013). Therefore, on their own, planned interventions are not sufficient to solve problems related to excess water and planning should be well-directed and to the purpose.

**Photo 4 – Amik Plain and flooded area during January-March 2012 flood**



Another source of hydrologic problems in the province is the threat caused by the insufficiency of water resources. Hot and arid summer season in line with the Mediterranean climate results in decreases in water levels in the summer months. The dimension of the problem grow with the inclusion of some anthropogenic parameters such as the rapid increase in population, the extension of irrigated agricultural areas without noteworthy improvements in irrigation systems, an the increase in evaporation surfaces by building large and shallow reservoirs and the decrease in water quality caused by the use of agricultural and biological wastes (Karatas and Korkmaz 2012) (Photo 5). All these factors point to human activity increase the pressure on water sources. Since oscillations in the climate result in fluctuations in the annual flow and causes high magnitude changes in the basin's water potential, it can be comprehended that current lack of water will be exacerbated in dry years (Karatas 2014).

Photo 5 – Shallow reservoir of Pulluyazi pond south of Antakya at the end of summer period

## 7. Hydrographical planning perspective

The United Nations Conference on Environment and Development held in 1992 in Rio de Janeiro, Brazil declared a body of decisions titled "Agenda 21". Integrated basin management concept, defined in this framework, has been widely accepted and adopted by many organizations, institutions and formal bodies (European Union 2000, Ramsar Convention Secretariat 2007, www.environment-agency.gov.uk/, http://wwf.panda.org). According to this definition, integrated basin management is summarized as "the period of fair coordination of water, soil and related resources, their preservation, management and development and restoration of fresh water ecosystems when necessary to have the best possible economic and social benefits regarding the water resources in a basin" (United Nations 1992, Global Water Partnership 2000). However, as can be observed from the definition, integrated water resources management is the product of an approach to reach the end purpose of "obtaining the best possible economic and social benefits related to water resources". Hence, all elements of the ecosystem are regarded in line with their economic and social benefits and their amelioration, protection and preservation is planned in line with these values. However, based on the fact that the ecosystem is a whole and changes in any one component will have the potential to affect all other elements. It is therefore, necessary to state that planning each unit by assigning the same value to each unit and without taking economic and/or social benefits into consideration is extremely necessary. Hence, preferring "hydrographic planning" concept to "integrated basin management" is a result of the efforts to eliminate these deficits during basin planning. Therefore it would be best to define hydrographic planning as "a human centered planning approach that pays attention to the positive and negative impact degrees of all components of the basin instead of their costs".

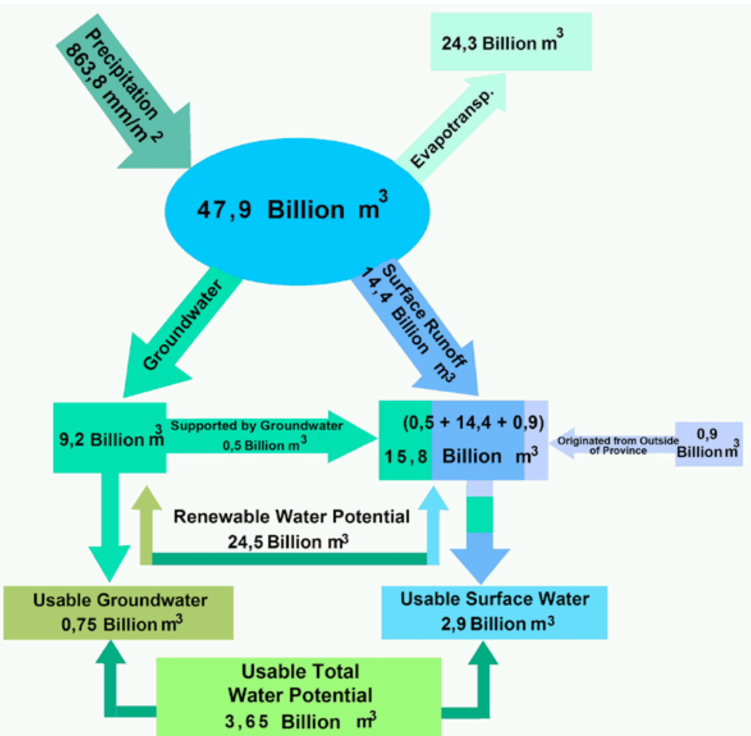
Primarily, ways of effectively using the water excess that is observed in habitual intervals in the framework of hydrographic planning, should be implemented for both in entirety of the Asi River and the segment located inside the Hatay border. It will be possible to prevent flood damages this way as well as shortening the period in which water sources are inefficient.

Main precautions that first come to mind about the issue are as follows: decreasing the flow velocity in the slopes and by constructing slope barriers that will provide positive influence on the amount of penetration, decreasing the land cover that prevents penetration (like asphalt, concrete etc.) and building smaller but deeper reservoirs in areas with suitable hydrographic conditions. Also minimizing leakages in water transport systems such as municipal water systems and irrigation canals, making wider use of irrigation methods that allow productive irrigation with less water, identifying the pollutants that negatively affect the usable amount of water by decreasing water quality and rehabilitating the reasons that cause these problems are crucial.

It is very important to ensure social participation and have local people embrace these steps. Of course, vital importance of the following should be kept in mind in all planning work: continuing flood based siltation in sediment basins, providing enough water for each element of the ecosystem throughout the year, producing projects appropriate for the socio-cultural nature of local public and undertaking very detailed geopolitical and geostrategic assessments. Hence, it is important to identify the hydrologic, kinetic, economic, touristic, hydro-politic and catastrophic potential of the basin and then manage this potential in the best manner possible (Figure 7).

In this context, implementation starts after a detailed assessment of each parameter to ensure that these parameters do not present contradictions in themselves or with the other parameters. Balance with the social and cultural structure is especially critical because it is unwise to expect long term projects that are not in harmony with the social and cultural texture and it may even cause the loss of a stakeholder during implementation when harmony is not observed. Lastly it would be wise to remind that it is necessary to include all elements of the ecosystem in assessment without exception because any negative aspects that will occur in a member of the ecosystem, in which human beings also belong, may create a chain reaction that will affect all other components.

**Figure 6 – Annual mean water balance of Hatay**




(Karatas and Korkmaz 2012)

## 8. Conclusion

Hatay presents variety as well as complexity in terms of its surface and groundwater resources. This situation presents a characteristic structure for all the components related to the planning of water resources. Therefore, it is not possible to talk about planning without accurate and full assessment of the large diversity, and it is not possible to talk about the success and sustainability before ensuring theses variable structures serve the same purpose in an organized manner.

Water resources in Hatay are a part of the larger Asi basin and therefore it is directly affected from the developments and changes in the Asi basin. On the other hand, water management in Hatay province is governed by the management plans that are created by taking into consideration of hydrographic and hydrologic dynamics of the province. However, the best approach would be to follow a two phase approach in which the first phase involves protecting the water sources of the province from the negative impacts generated by out of province influences and the second phase involves detailed planning that will cover all elements of the ecosystem in the province. It should always be kept in mind that water is a substance to which all living things have a right, whose use cannot be abandoned and whose place cannot be filled. It is the responsibility of the human beings to ensure access of this substance for all beneficiaries.

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# The Turkish-Syrian Friendship Dam on the Orontes River: Benefits for All?


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## 1. Introduction

Until at least one decade ago, negotiations between Turkey and Syria over the Orontes River[1] were always linked to issues concerning the Euphrates-Tigris rivers shared between Turkey, Syria and Iraq, and progress of the former was conditional and dependent on progress of the latter. Since the start of negotiations between Turkey, Syria and Iraq, under the mandate of the Joint Technical Committee in the early 1980s, Turkey and Syria adopted conflicting strategies with regard to the subject of negotiation. While Turkey insisted that negotiations would encompass all regional transboundary waters including the Orontes, the Euphrates and the Tigris, Syria refused to formally discuss the Orontes River with Turkey. Syria considered the Turkish province of Hatay, through which the Orontes River flows and where it discharges into the Mediterranean, as Syrian territory, and hence regarded the Orontes River as a "national river". Any negotiation would have been tantamount to acknowledging Turkey's sovereignty over the Hatay region.

This political interlinkage prevailed until Ankara and Damascus signed the Adana Security Protocol in October 1998 (table 1).[2] As a result of this rapprochement, the two riparian countries' relations improved considerably, both politically and economically. On December 22, 2004, they signed the *Agreement on Avoidance of Double Taxation* and *Agreement on Reciprocal Promotion and Protection of Investment* (FERB 2004; FTA 2004). This trade agreement with corresponding assurances to open Syrian trade missions in the province of Hatay was considered by Turkish authorities to de facto imply recognition of the international border including the province of Hatay (Hurriyet Daily News 2005a, 2005b; DSI 2005).

During a visit to Syria in 2004, the then Turkish Prime Minister Recep Tayyip Erdogan proposed a joint multi-purpose dam project to be built on the Orontes River, a proposal that was sealed by the Ministers of Foreign Affairs of both countries. In 2009, the Syrian Minister of Irrigation and the Turkish Minister of Environment signed the *Memorandum of Understanding between the Government of the Republic of Turkey and the Government of the Syrian Arab Republic for*

1 The Orontes River is called "Asi Nehri" and "Nahr al-Asi" in Turkish and Arabic respectively.
2 The Adana Security Protocol (1998) improved the bilateral relations between Turkey and Syria which had long been uneasy due to Syria's logistical support of the Kurdistan Workers' Party (PKK).

*the Construction of a Joint Dam on the Orontes River under the Name "Friendship Dam"*. The agencies responsible (the Turkish State Hydraulic Works (DSI) and the Syrian General Company for Hydraulic Studies (GCHS) that was assigned by the General Commission of Water Resources) then met on January 5-7, 2010, and decided that the feasibility and final design studies should be ready by October 15, 2010 (Special Specification 2008-10). Already on February 6, 2011, the Prime Ministers of both countries celebrated the laying of the foundation stone of the Friendship Dam before the technical specifications and the final design had been made. Negotiations came to a halt with the Syrian crises which started in March of the same year.

**Table 1 – Cooperation record relevant for agreeing on the Friendship Dam**

| Dates | Agreements |
|---|---|
| October 1998 | Ceyhan Agreement (Adana Security Protocol) |
| December 22, 2004 | Agreement on Avoidance of Double Taxation and Agreement on Reciprocal Promotion and Protection of Investment (entered into force on January 1, 2007) |
| May 16-17, 2005 | The Turkish Minister of Environment visited the Orontes basin together with the Syrian Minister of Irrigation |
| October 19, 2007 | Memorandum of Understanding for the Turkish-Syrian cooperation on politics and security, economy and energy and water signed by the Ministers of Foreign Affairs |
| June 27, 2008 | Protocol on Flood Early Warning System |
| September 2009 | Joint Political Declaration on establishing the High-Level Strategic Cooperation Council (HLSCC); first meeting at ministerial level in October in Gaziantep and Aleppo where the Visa Exemption Agreement was signed |
| December 23, 2009 | HLSCC meeting at prime ministerial level in Damascus: *Memorandum of Understanding between the Government of the Republic of Turkey and the Government of the Syrian Arab Republic for the Construction of a Joint Dam on the Orontes River under the Name "Friendship Dam"*, signed by Syrian Minister of Irrigation and Turkish Minister of Environment |
| January 5-7, 2010 | Formation of a joint commission (Turkish DSI & Syrian GCHS) to prepare feasibility and final design studies by October 15, 2010 |
| October 2-3, 2010 in Latakia; October 20-21, 2010 in Ankara | HLSCC meetings at ministerial and prime ministerial levels; 13 additional agreements were signed |
| February 6, 2011 | Turkish-Syrian Prime Ministers celebrated laying of foundation stone of the Friendship Dam |

Source: Compiled by authors.

The Friendship Dam has been praised by Turkey as the beginning of "a major cooperation step" (Maden 2011), and has been announced as providing benefits to both countries: "Turkey and Syria will make use of the dam in a 50-50 model," said Veysel Eroglu, the Turkish Minister of Environment, in a statement to the *Hurriyet Daily News* (July 1, 2010).

This article's objective is to assess the arrangements and agreements made with respect to the allocation of benefits from and costs of the Friendship Dam prior to the political crisis in Syria. The paper briefly introduces the benefit-sharing approach including findings from dam case studies on border and transboundary rivers and the benefit-sharing mechanisms applied. It then analyzes the technical issues debated between Turkey and Syria and their implications for the allocation of benefits. It finally discusses if all parties are better off now ever since negotiations have come to a halt, as predicted by the benefit-sharing approach.

Information and data have been gathered from academic and official documents. Discussions with Turkish and Syrian members of the joint technical working group were held during the international workshop "Water Resources Management in the

Asi-Orontes River Basin: Issues and Opportunities" which was jointly convened by the Graduate Institute of International and Development Studies, Geneva, and the MEF University, Istanbul, in November 2014 in Istanbul. Interviews with Turkish officials were conducted in 2014 and 2015. The closing date for information on and the status of negotiations was March 2011 when the social unrest in Syria commenced.

## 2. Benefit sharing on dam projects on shared rivers

Benefit sharing is an approach, that changes the mere volumetric allocation of water to the allocation of the benefits gained from the use of the river (Sadoff and Grey 2002; Sadoff and Grey 2005; Phillips et al. 2006; Dombrowsky 2009). The prospect of potentially gaining higher benefits by cooperating rather than by maintaining the status quo or by taking unilateral action may encourage states to cooperate with each other in their use of shared rivers.

The concept suggests that riparian countries can turn the perceived zero-sum game of water allocation, i.e. allocating more water to country A results in less water for country B, into a positive-sum game, i.e. a win-win situation in which all riparian countries are better off with cooperation than without (Giordano and Wolf 2003). Rather than conceptualizing water use in quantitative terms, riparian countries should consider the river as a productive resource, and focus on the benefits they receive from its use. They should attempt to increase and ideally maximize the economic benefits from its use and share them in a manner that all parties are better off than they were, in the status quo ante, and/or in case of unilateral activities; or to minimize negative impacts from implementation of projects they cannot prevent (Egypt vis-à-vis the construction of the Ethiopian Grand Renaissance Dam).

Dam projects – both single and multi-purpose – have various kinds of benefits and external effects. Benefits could include energy production to meet energy needs, the expansion of irrigated agriculture to meet food demands, the mitigation of hazardous floods and droughts, and the improved navigability of rivers to enable trade. However, the generation of benefits through the construction of a dam may have external effects both on local populations and on other countries. Such "external effects" or "externalities" occur when the use of water by one agent directly affects the use of water by another, and when these effects are not "mediated by prices" (Mas-Colell et al. 1995), i.e. when they are not reflected in the cost-benefit calculation of the actor causing them.

In the case of *transboundary externalities,* upstream dams may, for instance, produce negative externalities in the downstream country by reducing water flow downstream for irrigation, navigation or drinking water supply, or by increasing peak floods. Conversely, upstream dams may also produce positive externalities downstream when the upstream dam improves flood protection downstream.

Thus, gaining benefits from a dam on the territory of one riparian country may have negative or positive external effects on other riparian countries. On a transboundary river (i.e. a river crossing an international border) these effects may occur downstream or upstream; on border rivers (the river is the international territorial border) external effects may occur in both countries, the extent of which depends on topography, settlement and land use.

Based on the distinction between transboundary and border rivers, (Hensengerth et al. 2012) have suggested typical hydro-political constellations and, for each constellation, potential incentives for states to cooperate (Table 2).

**Table 2 – International examples of benefit-sharing mechanisms applied**

| Project / river (countries) | Characteristics | Incentives for benefit sharing | Benefit-sharing mechanism |
|---|---|---|---|
| Manantali and Diama dams on River Senegal (Senegal, Mali, Mauritania, Guinea), 1985 | Upstream and downstream dams on transboundary river: hydropower, flood control, navigation, irrigation | Financial constraints on all riparians: attraction of funding sources.<br>Senegal and Mauritania lack appropriate dam sites for hydropower | Cost-sharing of jointly owned infrastructure in proportion to benefits (irrigation, navigation, hydropower) |
| Canadian dams on Columbia River (Canada, USA), 1964 | Upstream dams on transboundary river: hydropower, flood control | Flood control benefits to USA only; electricity gain for Canada | Increase in aggregate net benefits through altered dam design upstream: Canada builds dams for downstream flood control and upstream hydropower; USA compensates Canada for investment costs by paying half of the value of downstream flood protection and electricity generation |
| Lesotho Highlands Water Project on River Senqu-Orange (Lesotho, South Africa), 2002 | Upstream dams on transboundary river: hydropower, water supply | Increased water supply for South Africa; electricity gain for Lesotho | South Africa pays investment and operation costs and external costs of storage and transfer water from Lesotho; Lesotho receives hydropower benefits; net benefits are shared (royalties) |
| Kariba Dam on Zambezi (Zambia, Zimbabwe), 1963<br><br>Itaipu Dam, on Rio Parana (Brazil, Paraguay), 1973 | Dams on border rivers: hydropower | Electricity gains for all riparians | Joint investment, benefits allocated according to investment shares |

Source: Hensengerth et al. (2012)

The cases reviewed have shown that adverse environmental and social effects caused by dams either on a border or a transboundary river are not fully taken into account when net benefits are calculated. This refers to losses of land and other properties, and to the loss and degradation of natural resources. In this respect, the Friendship Dam on the Orontes River is a case worth studying. While high-level Turkish and Syrian politicians agreed to build the Friendship Dam on the stretch of a transboundary river where the river forms the current international border[3] (Map 1 and Map 2)[4], the expected and projected economic, social and environmental impacts on Syria deriving from specific technical issues have impeded the conclusion of a common approach by the Turkish and Syrian technical experts.

## 3. The multi-purpose friendship dam

The Orontes is a transboundary river that originates in Lebanon in the springs of Labweh, near the city of Baalbek in the northern part of the Bekaa Valley and in the Al-Zarqa spring near the city of Hermel. I It discharges onto the Syrian territory near the town of Al-Umeiry, passing through the cities of Homs and Hamah, and crossing the fertile Syrian Al-Ghab region. It forms the current Turkish-Syrian border for 27 km, flowing through Turkey where it unites with the Karasu and Afrin rivers before discharging into the Mediterranean Sea in Turkey. The total length of

3 The authors are using the term "current international border" to indicate that from the Syrian official perspective border issues between Turkey and Syria have yet to be politically settled.

4 The maps have been prepared by Ahmed Haj Asaad supervised by Omar Al-Shmaly using Geographic Information Systems (GIS).

the river is 404 km, of which 38 km are in Lebanon, 280 km in Syria, 27 km run along the Syrian-Turkish border and 59 km are in Turkey.[5] It is along these 27 km on the international border where the Friendship Dam is supposed to be built.

Due to the transboundary nature of the river, upstream-downstream effects occur because the river and its tributaries are intensively used in all riparian countries, mainly for irrigation purposes,[6] domestic water supply and to a lesser extent to service agro-industry (among others olive oil producers). These utilizations have an effect on water quantity and water quality, as a result of the expansion of irrigated areas specifically in Syria and Turkey, and from the inflows of untreated industrial, domestic waste water and from agricultural return flows (Yılmaz 2014). However, the primary motivation for the Friendship Dam was not to deal with these impacts.

### 3.1. Motivations for promoting the Friendship Dam

Turkey had and still has an economic incentive for building this dam, above all, to control floods, and has offered the sharing of hydro-electricity generation to make the dam attractive for Syria.

As the downstream country, Turkey's motivation to build a dam on the Orontes where it forms the current Turkish-Syrian border has been nurtured by frequent disastrous floods which have inundated farm land, settlements and strategic infrastructure (i.e. the airport of Hatay) in the Amik Plain. This plain was once the bed of Lake Amik and a large flood retention area that completely disappeared when major drainage projects were undertaken by Turkey in the mid-1960s (the plain was fully drained in 1972). Due to the draining of the Amik Plain and the subsequent disappearance of this flood retention area, large floods occurred in 2002, 2003, and in 2012 (Selek 2014):

- When the Syrian Zeyzoun Dam collapsed on June 4, 2002, 1,600 hectares of farmland were flooded causing costs of around US$ 6 million.
- In 2003, floods inundated 110 houses and 10,000 hectares of farmland.
- From January to March 2012, floods inundated 17,500 hectares of farmland, villages, bridges, and the Hatay airport (which was completed on December 9, 2007). These floods caused losses of around US$ 10 million.

In June 2008, Turkey and Syria had already signed *The Protocol on Flood Early Warning System*, and had constructed flow measurement stations at Jisr al-Shaghur (35°48'38.18″N / 36°19'26.57″E) and Darkoush town (35°59′33″N, 36°23′35″E). According to Selek (2014), these stations, when operational, were able to send signals 60 hours before the arrival of floods.

Driven by the dire need to control floods, the stretch of the river where the Orontes forms the current border has been the most promising location for the dam.[7] Turkey does not have the choice to unilaterally build a dam further downstream to the North on its own territory due to the flat, unsuitable topography of the Amik Plain. This stretch of the border is the ideal choice for building a dam (table 3) with a storage capacity that is sufficient for controlling torrential floods (40 to 50 million cubic meters (MCM) were suggested by DSI (Selek 2014)).

The Friendship Dam also has an irrigation component that will benefit only Turkey: 8,000 hectares (net) are intended to be irrigated in Turkey. Rough calculations

5 The figures provided by UN-ESCWA / BGR (2103) are only understood as an approximation; other sources such as FAO (2009) and particularly Al-Shmaly (2013)) differ significantly.

6 The FAO (2009) estimates annual water withdrawals for agriculture in the basin as a whole of about 2,800 MCM (quoted in UN-ESCWA / BGR 2013, 233).

7 The Planning and Investigation Department, DSI Regional Directorate Adana, is aware that flood control means need to be, and are in fact, implemented also on the Karasu River (i.e. the Tahtakopru Dam) and the Afrin River (i.e. the Reyhanli Dam where construction is ongoing) (Kilicaslan 2015).

show that irrigation requirements amount to about 47.23 MCM (Selek 2014). However, the irrigation component is less important for Turkey than the implementation of flood control means.

The third component of the Friendship Dam proposed by Turkey – hydropower – will provide benefits for both the countries. According to Selek (2014), the generation capacity planned is 8.9 megawatts (MW) with an annual generation of about 13.34 gigawatt hours (GWh). However, how hydro-electricity generation will be shared between Turkey and Syria was yet not part of the bilateral negotiations.

**Table 3 – The Friendship Dam: incentives for benefit sharing**

| River / project | Characteristics | Incentives for benefit sharing | Benefit-sharing mechanism |
|---|---|---|---|
| Friendship Dam on Orontes (Syria, Turkey) | Dam on border stretch of the transboundary river: flood control, irrigation, hydropower | Lack of appropriate dam sites for flood control in Turkey<br><br>Flood control and irrigation benefit Turkey only<br><br>Electricity gains for Turkey and Syria | Sharing of investment and operation costs has not yet been specified and negotiated |

Source: Compiled by authors

According to official Turkish sources (Guler 2014; Selek 2014), Turkey is willing to bear a greater share, which is reasonable because the benefits that are intended to be generated are greater for Turkey (flood control, irrigation, and hydropower) than for Syria (hydropower only) (Table 4).

**Table 4 – The multi-purpose Friendship Dam: cost-benefit sharing**

| | Turkey | Syria | Comment |
|---|---|---|---|
| **Benefits** | | | |
| Hydropower<br>8.9 MW; 13.34 GWh/year | Yes | Yes | Shares yet to be defined |
| Irrigation<br>8,000 (net) | only for Turkey | | |
| Flood control<br>40-50 MCM reservoir capacity | only for Turkey | | |
| **Costs** | | | |
| Investment costs:<br>* Dam exploration-1st phase | 50% | 50% | Cost shares have not been officially confirmed |
| * Construction, electro-mechanical equipment etc. | – | – | Not yet negotiated |
| Operation costs | – | – | Not yet negotiated, but Turkish official sources assume that these costs will be paid by Turkey |

Source: Compiled by authors

Total investment costs are estimated to be 550 million Turkish Lira (TL) (official unit prices, 2015) which include costs for construction, expropriation and interest of the dam and the hydropower plant (345 million TL), and irrigation facilities (205 million TL) (Selek 2015; Dagdeviren and Aksu 2015).

Since flood control and irrigation benefits Turkey only, Turkish officials state that Turkey would bear all investment costs except the costs of expropriating land in

Syria which is to be borne by Syria – as Syria's contribution to overall costs. Due to the allocation of benefits, sources assume that Turkey would bear operation costs (Dagdeviren and Aksu 2015). These issues have not yet been negotiated.

Regarding expropriation, the Special Specification (2008-10, 2-1-5) mentions that both countries shall complete expropriation in accordance with their legislation but remains silent on compensation costs beyond expropriation costs such as new income-generating opportunities, the restoration of livelihoods of the populace affected, and for covering the costs of environmental mitigation means.[8] To date (spring 2015), 278.29 hectares of land have been expropriated in the reservoir area in Turkey, and about 17.9 million TL have been paid to farmers for compensation accordingly (Dagdeviren and Aksu 2015).

### 3.2. Technical issues and their implications for benefit sharing

When negotiations came to a halt due to the Syrian crisis, major technical issues were yet to be specified and agreed upon. The *Memorandum of Understanding* (October 19, 2007) signaled the political will of both sides to jointly build the Friendship Dam, and high-level Turkish and Syrian politicians have pushed the planning and laying of the foundation stone for the construction of the Friendship Dam within a very short time. The subsequently signed *Memorandum of Understanding* (December 23, 2009) did not entail technical specifications such as the location of the dam axis, the maximum storage volume in the reservoir, or the maximum water level – during flood periods.

Both sides agreed to form a joint technical delegation to study the technical issues pertaining to the construction of the joint dam. The delegation comprised experts from the Turkish DSI and the Syrian General Commissions of Water Resources / GCHS. These experts visited the Orontes river basin in Syria several times to examine the topographical and geological characteristics of the region and the places likely to be affected by dam construction. The controversial issues of that period are documented in the *Special Specification for the Preparation of the Feasibility Study and the Final Design of the Friendship Dam on the Orontes River.* This was negotiated from 2008 to 2010 between the Turkish and Syrian members of the technical working group (Special Specification 2008-10). While the overall purposes of the dam are not contested, the details are. The technical issues described below would determine the benefits that can actually be achieved and the actual impacts (the area that will be inundated, effects on farm land, settlements and on bio-physical resources), hence benefit and cost streams.

#### *3.2.1. Location of the dam axis*

The first Turkish proposal made in 2008 suggested building the dam near the Turkish town of Hacipasa (Map 1) with a dam height of 122 m above sea level which was unacceptable to Syria because impacts on the Syrian side were perceived to be undesirable: the reservoir would extend 5 km southwards of the town of Hacipasa where large cultivated and populated areas in Syria would be affected, especially the town of Darkoush (an archeological city). Further, the Ain Al-Zarqa spring which supplies drinking water for the Idlib Province would be submerged – more than 20 m above the normal level. The impact on Syrian territory would extend more than 14 km south of the Ain Al-Zarqa also inundating the tourist resort Sheikh Issa Bath with its natural hot thermal waters. The Turkish delegation then proposed to locate the dam axis near Ziyaret village. After conducting topographical, geological investigations and laboratory tests, the Ziyaret axis was selected (Table 5, Map 2).

8 International standards, for instance the World Bank's Safeguard Policies, call for the full compensation of such losses, and promote the financing of new income-generating opportunities, the restoration of livelihoods of the populace affected, and for covering the costs of environmental mitigation measures (World Bank 1999; 2001).

### *3.2.2. Dam operation for flood control*

The construction of the dam at the Ziyaret axis will inundate areas on Syrian and Turkish territory but impacts are still expected to be higher in Syria which can be seen on Map 2. However, most critical in this respect (i.e. extent of area inundated) is the maximum water level in the reservoir and the maximum storage capacity of the reservoir – both during flood periods. The Turkish side suggested a reservoir volume of 64.3 MCM (normal) and a volume at flood periods of 114.3 MCM; it further suggested a maximum water level of 100.8 m (normal) and a water level during flood periods of about 102.5 m.

These proposals were not welcomed by the Syrian delegation because the operation of the dam at this water level and with this storage capacity would flood large areas in Syria and the Ain Al-Zarqa spring. However, further decreasing the maximum water level during flood periods to not more than 100 m above sea level would lead to a reduced storage capacity of the dam of less than 40 MCM and affect flood control benefits for Turkey.

**Table 5 – Alternative sites of the dam axis**

| | **Hacipasa axis (Map 1)** (cancelled) | **Ziyaret axis (Map 2)** (technical specification as proposed by Turkey) |
|---|---|---|
| Thalweg level (m) | 94 | 86.2 |
| Dam top level (m) | 122 | 103 |
| Height from Thalweg (m) | 28 | 16.8 |
| Reservoir volume (MCM) | 274.6 | 64.3 (volume at flood periods expected to be 114.3) |
| Maximum water level in reservoir (m) | 120 | 100.80 (water level at flood periods expected to be 102.5m) |

Source: DSI 2008; DSI 2011

### *3.2.3. Dam operation for irrigation*

The irrigation component, benefitting only Turkey requires a bilateral agreement on the water amounts to be released. The debate on this issue is mirrored in the Special Specification (2008-10, 2-1-2, 3) where Turkey's proposal reads as follows: "(T) The water potential of the dam site will be calculated according to the present and previous measured flow values obtained from the existing gauging stations and *these calculated amounts shall be permanently ensured by Syria during the future projects to be realized by Syria*." Syria on the other hand proposed: "(S) Carrying a detailed statistical analysis and estimating annual yield of the river at dam site with different probabilities; water requirements on the river and its tributaries *for existing, studied, under construction and projection above dam site* shall be taken into consideration" (Special Specification 2008-10, 2-1-2, 3).

Behind these phrases lies the controversy over river flow data, on existing and future water use-rights. Particularly disputed is the actual mean annual discharge measured at Esrefiye gauging station which is located in Turkey shortly after the Orontes River enters Turkey. Since this gauging station is located downstream of the Yarseli pumping station (Map 1) and pumps water from the Orontes River to the Turkish Yarseli Dam, the Syrian side assumes that the actual annual discharge must be more than that measured at the Esrefiye gauging station which is reported to be 496.38 MCM/year between 1998 and 2009 (Selek 2014).

All these issues were not settled when the Syrian crisis began in spring 2011.

## 4. Conclusions

High-level politicians of both countries have initiated the Friendship Dam on the Orontes River to politically signal that an era of rapprochement started between the two countries. The Friendship Dam would provide benefits to both countries but more for Turkey than for Syria for which Turkey is willing to pay according to the benefits it will receive. An official Turkish source (Güler 2014) even mentioned that Turkey is willing to bear the lion's share of investment and operation costs, indicating Turkey's interest in building the Friendship Dam for flood control reasons. Syria, on the other hand, would contribute to investment costs by bearing expropriation costs occurring in Syria.

Besides political issues, Turkey's motivation as the downstream country for promoting the Friendship Dam has been driven by its desire to control disastrous floods originating from the Orontes River, for which the optimal location is where the river forms the current international border. In the absence of appropriate dam sites in Turkey for controlling floods, Turkey had no the choice of acting unilaterally. In order to attract Syria's interest, Turkey made an initial offer by adding a hydropower generation component that could be shared.

The Friendship Dam which is supposed to be built on the stretch where the river forms the current international border also shows that the impacts on the riparian states can be, and is highly asymmetric, and will depend on the location of the dam axis, the maximum water level and the maximum storage capacity – both during flood periods.

Despite potential gains from hydro-electricity generation for both countries, which have yet to be specified, the technical issues debated indicate that it has not been an easy task to strike the balance between Turkey's interest (effective flood control means) and Syria's interest (reducing impacts). While the motivation of the Syrian delegation has been to reduce negative social (resettlement) and economic (agriculture, drinking water supply) impacts and related costs, the Turkish delegation has favored technical options to mitigate negative social and economic impacts deriving from floods. While addressing Turkey's major interest (flood control) would cause negative effects on Syria; satisfying Syria's interest would specifically reduce flood control benefits for Turkey.

When negotiations came to a halt in March 2011, it was not clear under which arrangements both countries would be better off when compared to unilateral activities and/or no action, as the benefit-sharing approach suggests. When the political situation allows it, the issues that have not yet been settled will have to be re-opened and re-negotiated.

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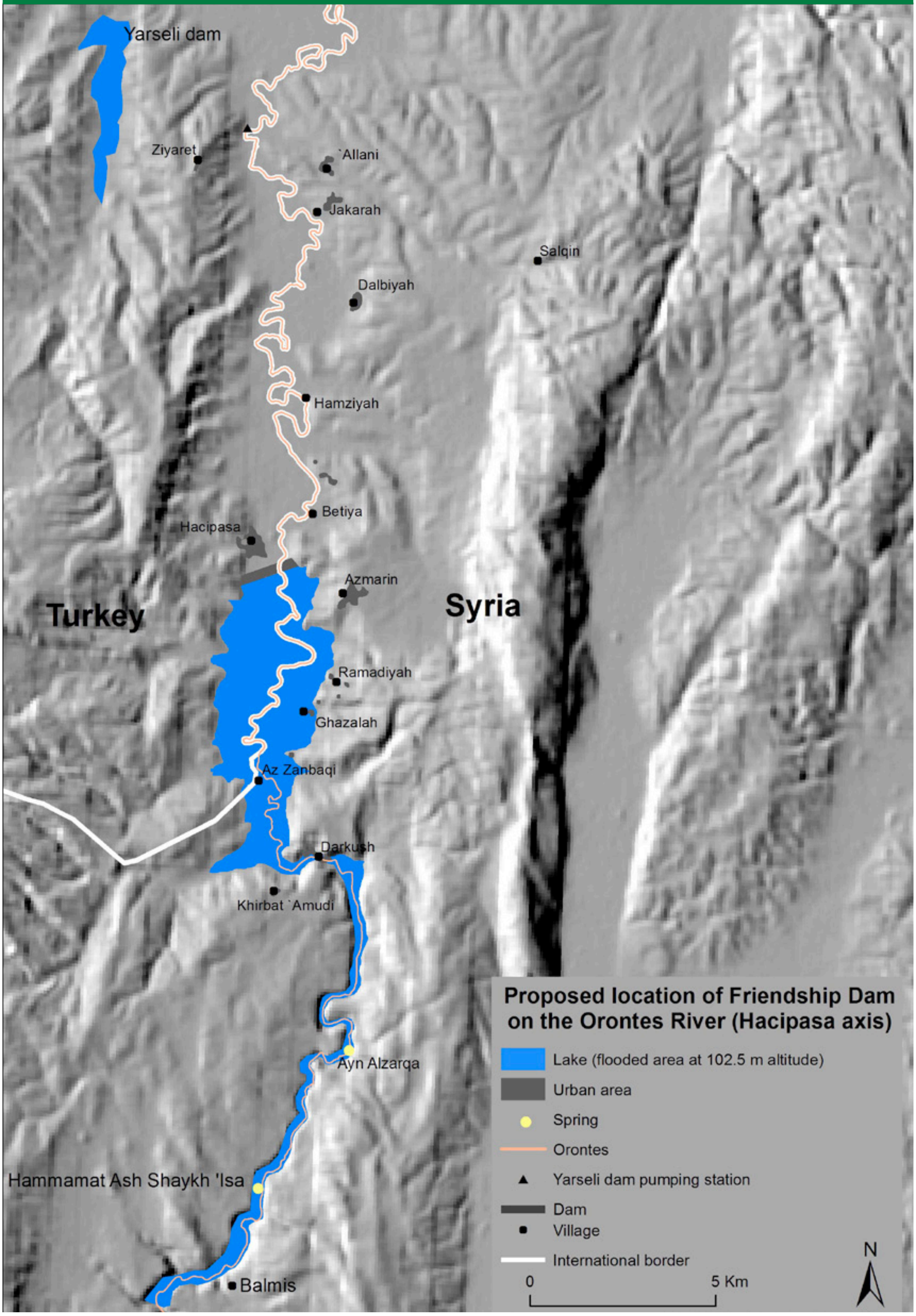
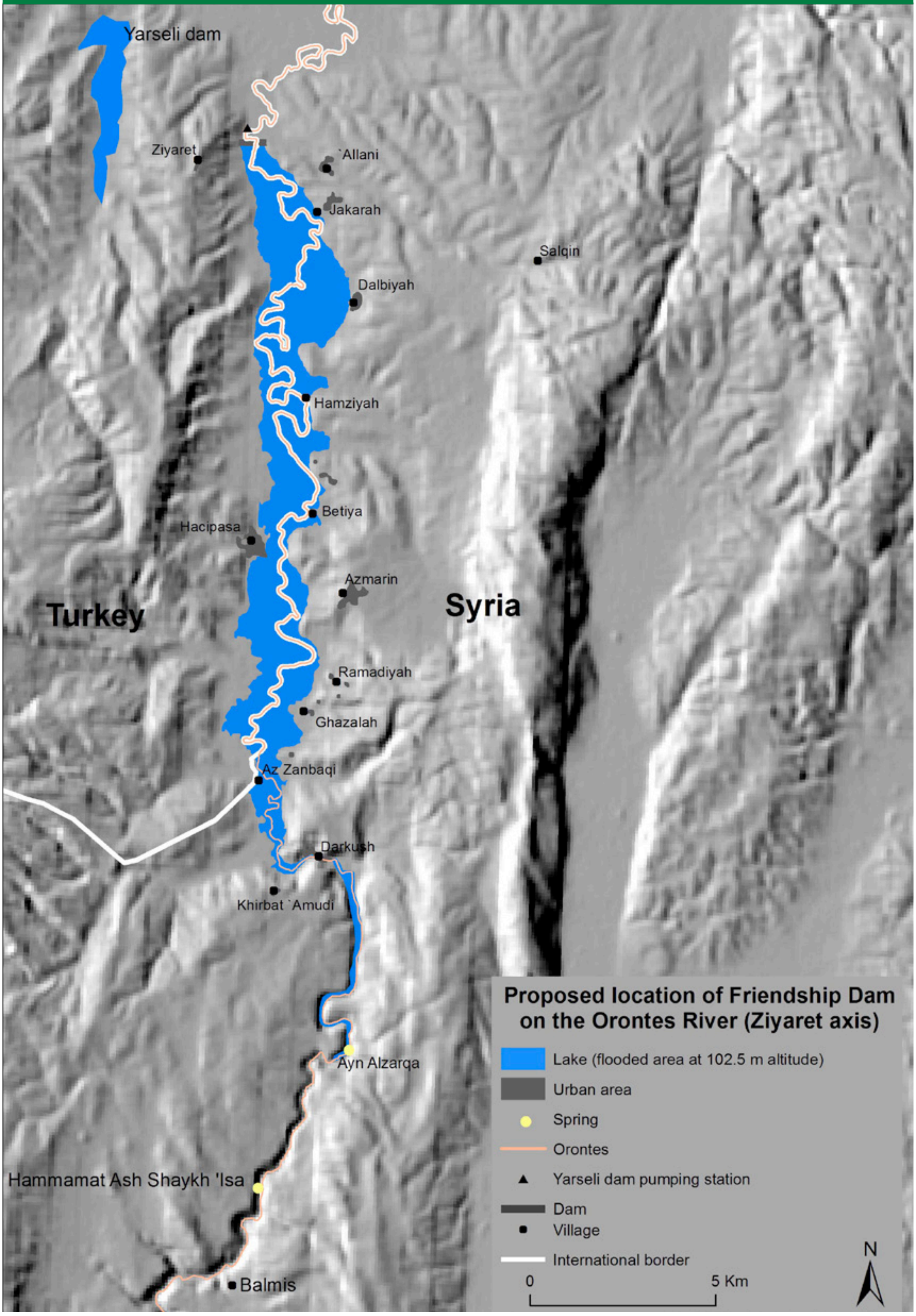
## *Abbreviations*

| | |
|---|---|
| BCM | Billion cubic meters |
| BGR | German Federal Institute for Geosciences and Natural Resources |
| DSI | Turkish State Hydraulic Works |
| FAO | Food and Agriculture Organization of the United Nations |
| GCHS | Syrian General Company for Hydraulic Studies |
| GWh | Gigawatt/hour |
| GIS | Geographic Information System |
| HLSCC | High-Level Strategic Cooperation Council |
| MCM | Million cubic meters |
| MW | Megawatt |
| TL | Turkish Lira |
| UN-ESCWA | United Nations Economic and Social Commission for West Asia |

**Map 1 – The Hacipasa axis (cancelled)**



Map 2 – The Ziyaret axis (proposed)



# Transboundary Water Relations in the Asi Basin: The Case of Syrian-Turkish Relations

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## 1. Introduction

This paper aims to analyze transboundary water relations in the Asi River Basin by utilizing some relevant assumptions of contending approaches to transboundary water politics. It starts with a theoretical discussion on how contending approaches differ in their main units of analysis, and issues they tend to prioritize. Then it follows with an assessment of transboundary water relations between Syria and Turkey in the Asi basin particularly by scrutinizing the dynamic set of relations in political-economy domain.

Diplomatic negotiations and legal treaties on water sharing provide sources of the formal status of transboundary water relations between riparians. However, such analyses need to be complemented with studies focusing on the political-economy aspects of the constantly changing set of relations among riparians.

## 2. A theoretical discussion on transboundary water relations

There are a number of scholarly approaches dealing with the nature and scope of transboundary water cooperation among states, including studies on the Asi River Basin. These might be grouped into two broad categories of analyses. The first category of analyses tends to focus more on the politico-legal dimension of transboundary cooperation with an interest on how the competitive use of water resources by the riparians may have an impact upon the treaties regulating water sharing among countries. They tend to see the nation-states as unitary as well as the main actors of policy. Another common theme within this category of studies is describing transboundary water issues as high-politics and sometimes security-related issue. These studies treat transboundary water problems as a reflection of the power distribution in the basin. In order to overcome the power-based asymmetries in water sharing, legal norms are of great significance.

One of the early examples in the category of studies focusing on the legal regimes in transboundary waters is Caponera's (1993) analysis of transboundary legal aspects of, inter alia, the Asi River Basin. Caponera, following a discussion on the basic features of legal agreements in the basin, calls for establishment of a "regional water authority" where all riparians would join and an adherence to Helsinki rules (1966) which envisage "the equitable apportionment and eventual joint monitoring, inspection, and control of the water resources". Thus, according to Caponera, solutions must rely on agreements based on sound legal principles.

Except from basin-specific studies as exemplified by Caponera's, there are also works on the generic capacity of international water law at theoretical and practical levels. For instance, through in-depth analyses of the basic premises of international law on transboundary waters as well as a number of selected cases (the Zambezi, Niger, Mekong, Danube, and Drin), Wouters (2013) provided a general survey of the challenges of the international water law, which, according to her, mainly stem from the irreconcilable interests of sovereign nation-states, and highlighted the need for improvements in coherence and consistency of the international water law. In a similar vein, McCaffrey (2014), following a summary of selected recent developments in the field of the law of international watercourses concluded that despite a number of defects (such as the ILC's draft articles on transboundary aquifers which emphasize sovereignty and overlaps with the 1997 UN Water Convention), international water law has demonstrated a capacity to promote and facilitate cooperation in transboundary basins.

Studies focusing on the unsettled legal entitlements and subsequent confrontational relations in transboundary river basins generally resonate the premises of political realism. The realist paradigm in International Relations (IR) argues that states are the ultimate actors in international relations. Realism in IR sees the interstate relations as anarchic with no superior authority above nation states (Mearsheimer 1994). In such a setting, states are preoccupied with their national interests that center around the main goal of "survival" (Mearsheimer 1994). Besides survival, all other interests are secondary. This brings the analysis of politics in two distinct realms: "high politics" versus "low politics". While high politics relates to vital matters for state survival, such as the classical understanding of national security that sees military-related issues as the key dimension, low politics pertains to issues of allegedly lesser importance such as economic or welfare related topics. Since distribution of power among states is the main determinant of what states may realize in terms of their interests, states have a natural inclination for more power. Because the only thing states can depend on for their survival is their power. Power, as perceived by realists, is basically made up of material capabilities (Hensel 2005).

Antecedent of this argument, namely the "upstream unilateralism" traces back to several decades. Lowi (1993), for instance, argues that upstream states, due to geographical advantage (which, indeed, is an element of power), do not necessarily need to bother with downstream demands; they can do as they please (especially if they are the powerful riparian states and have the technological capabilities). However, while upstream riparians may use water to gain political control, downstream riparians tend to use military power to gain more control of the water, according to Warner (2004).

Maximization of power with all possible means appears to be one of the main side effects of "anarchic international arena" understanding of realists. This manifests itself in efforts towards increasing economic assets of the state, alliance formations, armament, and even war. Based on this rather pessimistic view of international relations of the realists, then, cooperation is less likely than conflict. However, conflict can be averted if the most powerful riparian in a river basin can provide guidance to transboundary water relations. Having inspired by realist and constructivist accounts, Zeitoun and Warner developed hydro-hegemony as a framework of analysis of transboundary water affairs. According to Zeitoun and Warner (2006), the so-called hydro-hegemons are able to exert varying degrees of influences over other riparians based on their riparian position (upstream vs. downstream), power, and exploitation potential. In this respect, through their capabilities in writing and rewriting the rules of the game, hegemony may bring peace to a transboundary water context.

A recent work by Comair and Scoullos (2015) also argued that hegemonic countries in the Asi Basin which had the superior political and military power, were able to "influence and dictate the negotiation process" preceding the bilateral agreements. They argued, for instance, the first bilateral agreements in the Basin were concluded under the French dominance, while 1994 Agreement was signed under Syrian influence (Comair and Scoullos 2015). They, thus, see power asymmetry as one of the "fundamental aspects" of hydro-political negotiations between riparians.

All in all, as it can be inferred from the analyses above, state-centrality is one of the indispensable elements in the realist framework. The analyses falling within the realist paradigm generally tend to adopt zero-sum logic, i.e. the water amount to be shared in a given river basin is constant and thus, one party's gain needs to be the other's loss. This type of approaches run the risk of ignoring the broader benefits that might be created around the river, which could even go beyond the direct benefit that apportionment of water might yield.

A different category of studies focuses on the political economy of relations between riparians; as well as on the actual network of relations and practices created by this broader setting. The political economy of water is defined by Jensen and Lange (2013) as "the interests vested in water resources by public and private stakeholders from multiple sectors; the institutions established by authoritative stakeholders to secure these interests; and the processes that create, sustain and transform institutions and stakeholder relationships over time." Economic dimensions of water management are intertwined with the political situation in a given basin, which in turn creates the foundations of transboundary relations. According to this view, water-related economic relations between countries of a shared basin may go beyond the framework drawn by the treaties and demonstrate more dynamic features. On the other hand, transboundary diplomatic relations, which could be traced in international agreements over water allocation generally reflect somewhat suboptimal solutions.

In other words, as Mirumachi and Allan (2007) observed that "the invisible and silent political economy processes" are quite significant. Analysis of politico-economic interactions may shed more light on capturing the "actual/practical" ways of cooperation in a given transboundary river basin. As Mirumachi and Allan noted, "cooperative transboundary waters behavior and the evolution of transboundary regulatory institutions and agreements are closely associated with the diversity and strength of the economies of the riparians." The authors argued that there is a correlation between wealth of riparians and their propensity for cooperation, i.e. richer riparians have the resources to use in cooperative initiatives over transboundary waters than leaders of economically and institutionally challenged poor economies. This means a diverse and strong political economy will be more able and inclined to cooperate.

Blatter and Ingram's work (2000) also fits in our analysis. While they accept that states still play significant roles in domestic politics and international arena, they are "neither the only powerful hierarchical actors in domestic politics nor the sole representatives of a monolithic national interest in international politics." They argued that the laws and treaties governing transboundary relations represent ineffectiveness of inter-state relations. Instead, to Blatter and Ingram, the main actors in transboundary water policies are "collective and corporate actors, including agencies from different sectors and levels of government, non-governmental organizations, corporations, and scientific communities". Therefore, there is not a central actor or arena for decision-making processes in the transboundary water realm.

The benefit sharing approach which could be regarded as part of the liberal political economy school, focuses on the sharing of benefits rather than physical water. (Sadoff and Grey 2002; Sadoff and Grey 2005; Phillips et al. 2006; Dombrowsky 2009). The concept of benefit sharing is defined as "the process where riparians cooperate in optimising and equitably dividing the goods, products and services connected directly or indirectly to the watercourse, or arising from the use of its waters." It is accepted that the prospect of potentially gaining higher benefits by cooperating rather than by maintaining the status quo or by taking unilateral action may encourage states to cooperate with each other in their use of shared rivers. According to benefit sharing framework, riparian countries can turn allegedly zero-sum game of water sharing, into a positive-sum setting, which would translate into situations where all riparians are better off (Biswas 1999, Giordano and Wolf 2003). Instead of focusing on the volumetric formulations of water sharing, riparians need to deal with increasing the benefits that they can harvest from river waters they use. Benefits may include anything provided that the society deems it as valuable: livelihood improvement, food security, gender equality, amelioration of ecosystems and biodiversity, aesthetics, ethics, etc. (Tafesse 2009). Therefore, although the approach of benefit sharing coincides largely with the liberal political economy framework, in the sense that economic relations can nurture peace and prosperity, the extent of available benefits (e.g. ecosystem, biodiversity, aesthetics, ethics) makes it broader than an understanding that takes economic activity as it center of attention.

On the other hand, Jaubert et al. adopted a critical approach in examining political economic processes in the Syrian part of the Asi River Basin. They have recently published a report (2014) making assessments of the impact of the Syrian civil war on population displacements, drinking water availability, domestic and agricultural water infrastructures, and agricultural development in the Asi River basin in Syria. Jaubert et al. conclude that mainstream approaches in assessing water security in the Middle East have primarily focused on transboundary issues per se. Re-capitulating the fact that there is not a basin-wide agreement on the sharing of water resources in the Asi River basin, like other basins in the Middle East, Jaubert et al. examine the actual implementation of the bilateral agreement (1994) between Lebanon and Syria. While Jaubert accepts that the agreement between Lebanon and Syria is still valid on paper, he notes drilling illegal wells in Lebanon actually violates the Agreement. However, as Jaubert notes, this is to be read as part of a broader and tacit network of relations among various stakeholders in both parts of the border. Jaubert also emphasizes the holistic nature of groundwater resources in Lebanese and Syrian parts of the Asi basin (Northern Bekaa valley), which creates a zero-sum setting in which one party's extraction would mean the other's loss. Additionally, ignoring groundwater in water sharing formulations can partly be explained by corrupt intentions of bureaucratic elites in both Syria and Lebanon (Jaubert 2015).

As such, Jaubert et al.'s approach differs from conventional international relations perspectives; be it legal or realist, by stressing the growing concerns in recent years on "the increased pressure on water resources and water quality". They are also critical of the lack of scholarly interest on "the rampant social and political crisis in the Syrian section of the basin, which is one of the causes of the ongoing conflict" over water resources. Jaubert et al. also diverge from liberal political economy accounts on the grounds that transboundary water relations along Syrian-Lebanese borders are seen to be framed by exploitative and power-based class structures in both countries, rather than mere rational economic logic as liberals think.

As illustrated in the discussion above, the studies dealing with political economic relations in transboundary water contexts cover a lot of ground over a wide-range of issues. One of the most notable strengths of these approaches is related with its capacity to capture the actual interconnectedness of the economic and political spheres within the context of water management, and linkages among economies of riparian countries in a river basin, regardless of suboptimal bilateral agreements on water sharing. So, these analyses are more interested in how we can better understand the evolving set of transboundary relations in a given river basin through explanations concerning the alterations in politico-economic activity.

The degree of power of explanation in this line of studies basically stems from the fact that they go beyond the basic "ladder of cooperation" arguments that sticks to the diplomatic realm and legal agreements pertaining to water sharing. They also provide more nuanced analyses on how the river creates a number of (sometimes differing) venues for interaction between various stakeholders including non-state actors, and in examining the ways the river sets the limits for cooperation.

Another point is that these studies tend to take the "relational" dimension of politico-economic setting among the riparians, unlike "situation-oriented" studies. That is to say, rather than elaborating on the actual status-quo as a finished case, these analyses are more interested in the changes in relations among riparians. In so doing, these analyses may provide more robust scrutiny over the "flux" of transboundary water relations, instead of dealing solely with the "status". This provides the former with strength in perceiving the changes in the level of cooperation between riparians more swiftly. Because some of the material-level changes observed in the politico-economic framework can either be translated into water sharing agreements much later, or have never been reflected in the water sharing treaties. And finally, these studies generally do not put the state at the center of their analyses. In other words, in an implicit fashion, they go beyond the realist analyses confined to focus on inter-state relations, which are only able to produce written agreements.

Analyses of politico-economic aspects are rather interested in the practical and influential, but informal exchanges in the basin. The implementation of Syrian-Lebanese Treaty of 1994, and its amendment in 2002 is illustrative of this view. While the Agreement remains intact on legal level, the actual implementation provides a different story. Creation of a quasi-economic network across the border have resulted in concurrence of violations of the Agreement through triggering uncontrolled expansion of groundwater use in Lebanese part of the Asi River Basin.

## 3. Transboundary relations in the Asi basin: The case of Syrian-Turkish relations

This section of the paper deals with transboundary water relations between Syria and Turkey in the Asi River basin with an eye on the changing dynamics of the broader political-economic relations between two countries. It could be argued that changes in political and economic realms of relations might provide alternative departure points for analysis regarding the transboundary water relations in the Asi Basin.

### 3.1. Basic features of the Asi River basin

The Asi is a transboundary river which originates in Lebanon in the springs of Labweh near the city of Baalbek in the northern part of the Bekaa Valley and in the Al-Zarqa spring near the city of Hermel; it discharges onto Syrian territory near the town of Al-Omeiry, passes through the cities of Homs and Hamah, and crosses the fertile Syrian Al-Ghab region. It forms the current Turkish-Syrian border for 27 km, flows through Turkey where it unites with the Karasu and Afrin rivers before discharging into the Mediterranean Sea in Turkey. It has a total length of 404 km, of which 38 km are in Lebanon, 280 km in Syria, 27 km along the intentional border between Turkey and Syria, and 59 km in Turkey (UN-ECSWA and BGR 2013).

Asi is one of the most significant watercourses in Syria. It provides 25% or one fifth of the total water resources in Syria. Additionally, the Asi basin has provided a quarter of the agricultural output as well as a third of the industrial production of the whole country. It has been argued that the significance of the basin for the country's economy is related to the availability and access to water resources (SDC 2014). Besides, the Asi basin in Syria is said to have a "highly strategic nature" based on the diversity of its population, the existence of bordering areas with Lebanon and Turkey, and its location enabling access to the coastal areas and the Damascus–Aleppo highway (SDC 2014).

Asi is also significant for Turkey in terms of irrigation, flood control, water quality issues (Kibaroglu and Sumer 2015), hydropower generation (Kibaroglu et al. 2005), and environmental protection (Ozsahin 2010). Turkish section of Asi basin is highly dependent on waters from Asi and its tributaries (Afrin and Karasu) (UN-ECSWA and BGR 2013: 231). Amik Plain is a notable agricultural area which was reclaimed from a lake in 1940s. Frequent floods in the area destroy agricultural lands, cause harm to lives and property (e.g. Hatay Airport). There is growing thirst for electricity in the region due to increased industrialization, population growth and intensified agricultural activity. Both countries, Syria and Turkey, agreed to establish a joint dam on the border, in the late 2000s, in order to, inter alia, produce electricity for the region. Should established, the so-called Friendship Dam will produce a considerable amount of hydropower (16Gwh/yr) (UN ECSWA and BGR 2013: 236) which is needed in Hatay province and beyond. Water quality in Turkish part of Asi basin is problematic mainly due to pollution in the Syrian segment of the basin, and has serious ramifications for human health (Kibaroglu and Sümer 2015). The refugee influx in Turkey has exacerbated the situation, with risks of open defecation, exposure to animal excreta, lack of adequate hygiene supplies and lack of garbage collection. Last, but not the least, there are environmental concerns. The Asi Delta has been a vital natural habitat for migratory birds, among other species, that need to be protected. Thus, sustaining environmental flows is crucial in this regard.

### 3.2. Understanding riparian relations between Syria and Turkey: How explanatory contending approaches are

There has been extensive literature (Aras and Polat, 2008; Altunisik 2008; Hale 2009, Hinnebusch and Tur 2013; Kibaroglu 2013) on different aspects of the Syrian-Turkish relations which are generally characterized by a cyclical pattern. In a synopsis, Mahfudh (2012) concluded that "the Syrian-Turkish phenomenon is an example of the working of two opposing dynamics, the first being the policies and factors of rapprochement, intersection, and mutual dependency, and the second representing the policies and factors of separation, disengagement, and antagonism."

Relations between Ankara and Damascus started in a context driven by problems of Ottoman legacy. First and foremost, for the Syrians, the Ottoman Turks were their repressive historical enemy. This long-lasting antagonism was exacerbated when France decided to withdraw from Hatay province (Alexandretta) in favor of Turkey in 1938. Although it was mainly aimed at maintaining Turkish neutrality in an approaching war (World War II), one of the side-affects has been the revival of Arab nationalism within Syria, which later culminated into the Baath Party, ruling the country starting 1963 onwards (Phillips 2011). Secondly, the resolution of the issue of Hatay at the expense of Syrian demands appeared to be a stumbling block for more than six decades between Syrian-Turkish relations.

Following the Second World War, in 1946, Syria became an independent country. Soon after the independence, Syria began to find itself within the Eastern Bloc, whereas Turkey has increasingly engaged with the Western Allies, eventually becoming a NATO member in 1952. Syria first needed Soviet backing in order to firmly establish their national army following the country's independence. Soviets, then, sought to support Syria when it, in 1955, refused to join the Baghdad Pact that United Kingdom and United States had facilitated. Continued Soviet military aid to Syria during the Cold War raised Turkish concerns and caused an impediment to the progress of relations. Hence, in addition to long-lasting antagonisms, two countries ended up in different camps during the Cold War, a context of interstate relations which was mainly defined by superpower rivalry. Within this atmosphere, the relations between two countries remained stagnant. To illustrate, in fifty years of independence no single Syrian head of state had ever visited the Turkish capital (Phillips 2011).

In brief, greater power struggles between two superpowers of the Cold War reflected on the relations between Syria and Turkey. Being in two opposing camps, and preoccupied with their survival and security interests (i.e. high politics), two countries were not able to circumnavigate the Cold-War conditions and find ways for cooperation in issues of low politics. This dominance of realism which, thus, went hand in hand with limited economic relations between two countries, continued for around five decades.

Relations between two countries deteriorated in the midst of ethnic separatist terrorism in Turkey, which had been allegedly substantially supported by the Syrian regime during most of the 1980s and 1990s, through hosting a number of terrorists within its territories, including its leader Abdullah Ocalan. It increasingly became unbearable for Turkey to endure with Syrian support for terrorism, which was perceived by Turkish authorities as a clear hostility. Finally, it was in October 1998, when Turkey deployed 10,000 soldiers in areas close to Syrian border and threatened Syria with the use of force, Hafez Assad agreed to expel Ocalan. Soon after this, signing of the Adana Security protocol on October 20, 1998 started a new positive era in not only political but also in economic relations between two riparians of the Asi.

Water has been one of the variables during the process culminating into Adana Protocol. One of the aims of the Syrian regime of Hafez Assad, allegedly, was to use its backing for terrorism as a bargaining chip for getting more water from Euphrates (Fawcett 2013). Turkey, in response, promised to release 500 m3/second of water from Euphrates in a bilateral Protocol in 1987, hoping that this would satisfy Syrian demands on water and thus it would not support terrorism in Turkey. However Syria did not fulfill its promise and continued to support separatist terrorism in Turkey until the Adana Protocol.

It is interesting to note that until the period of rapprochement started in 1998, negotiations between Turkey and Syria over the Asi River were tied the Euphrates-Tigris which was shared between Turkey, Syria and Iraq. Since the start of negotiations between Turkey, Syria and Iraq under the mandate of the Joint Technical Committee in the early 1980s, Turkey and Syria adopted conflicting strategies with regard to the subject of negotiation. While Turkey insisted that negotiations would encompass all regional transboundary waters including the Asi, the Euphrates and the Tigris, Syria refused to formally discuss the Asi with Turkey. Syria considered the Turkish province of Hatay, through which the Asi flows and where it discharges into the Mediterranean, as Syrian territory, and hence regarded the Asi River as a “national river” (Kibaroglu et al. 2005).

There are two trends that contributed to convergence of Syrian and Turkish interests in 2000s. One is related with Syrian external relations. This country faced with a strong wave of isolation when the EU, US and Arab countries started a diplomatic boycott in 2005 on the grounds that Damascus was behind the assassination of Rafiq Hariri, former Prime Minister of Lebanon. In this process, Turkey -although it joined the international coalition demanding Syrian withdrawal from Lebanon- appeared to be a friend that Syria can approach and escape from isolation (Phillips 2011). Secondly, Turkish economy had entered a booming period after the crisis of 2001 and began to search for new markets. Syria, with its relatively significant potential as a market for Turkish goods and services, has rapidly become a notable trade partner of Turkey (Phillips 2012).

In addition to improving diplomatic and political relations after the Adana Protocol of 1998, which was illustrated by reciprocal visits of Syrian and Turkish Presidents and Prime Ministers in early 2000s, there has been significant progress on the economic dimension of the relations: bilateral trade numbers have has risen to $724 million in 2001, from negligible amounts prior to 1998 (Oktav 2003). On December 22, 2004, two countries signed the Agreement on Avoidance of Double Taxation and Agreement on Reciprocal Promotion and Protection of Investment which further fostered economic connections between Syria and Turkey. This trade agreement also included an anticipation of the establishment of Syrian trade missions in Hatay which was considered by Turkish authorities as de facto recognition of the international borders of Turkey, particularly with regard to the Hatay province (Scheumann et al. 2011). It was after this agreement negotiations over Asi River gained momentum which finally evolved into the project of "Friendship Dam".

Within this context, in 2009, Republic of Turkey and the Syrian Arab Republic have agreed in principle to develop the "Friendship Dam", to be built on the Asi River on the border between Syria and Turkey. A Memorandum of Understanding (MoU) was signed on December 23, 2009, in Damascus, between two countries clarifying details of the project. According to the Memorandum, a technical working group was to be established under the co-chairmanships of the General Director of the State Hydraulic Works of the Ministry of Environment and Forestry of Turkey, and the General Director of the Water Resources General Commission of Syria (MoU, Article 2). It was decided that, following the studies of the technical working group, the construction work would commence through signing of "A Contract on Construction of the Friendship Dam" between Turkey and Syria on the one hand and the company/companies on the other (MoU, Article 5).

The memorandum adopted a rather flexible approach regarding the cost-sharing. According to MoU, the cost of the construction would be shared between two counties "in proportion to deriving benefits from the dam" (MoU, Article 8). According to feasibility studies, the Dam will produce electricity of 13,47 Gwh/year with an installed capacity of 8.94 MW. The Dam will irrigate some 8,000 hectares of land in Turkey and will protect 6,000 hectares of land from flooding (DSI 2012). The dam is expected to be approximately 15 m high with a capacity of 110 to 147 million cubic meters[1]. 40 million cubic meters of water will be used to prevent flooding and the rest for energy production and irrigation.

After lengthy negotiations between two countries on the exact site of the Dam, the foundation was laid down in February 2011 with a spectacular ceremony attended by high-level officials from both Syria and Turkey. The Friendship Dam has been regarded -at the time of commencement- as the "jewel in the crown" of Damascus-Ankara ties, symbolizing a peak in Syrian-Turkish cooperation.

On the side of commercial relations, the pace of improvement continued unabated in the second half of 2000s. With the Free Trade Agreement (FTA) entering into force in 2007, volume of bilateral trade and investment grew exponentially (Butter 2015): Syria's exports to Turkey rose from $187m in 2006 to $662m in 2010 (Phillips 2012, 2011). Turkish companies have built much-needed infrastructure, such as cement plants and hotels, and boosted the oil and tourism industry in Syria. One side-affect, though, was that the FTA caused superior Turkish manufactured goods to threaten previously protected Syrian businesses. For instance, the Kouefati Group, one of Aleppo's oldest textile manufacturers, had gone bankrupt (Marshall 2009) within two years after the Agreement (Phillips 2011). On the other side of the border, Turkish exports saw a three-fold increase between 2006 and 2010, rising to a value of $1.85bn, making Syria Turkey's seventh largest market in the Middle East and North Africa (Phillips 2011). Reduced tariffs on overland trade also contributed Turkey to use Syria as a gateway to increase its exports to further south, to Jordan and the Gulf countries.

1 Second figure has started to be used very recently.

Deepening economic bonds and improving diplomatic dialogue encouraged two countries' authorities to take additional steps. Syria and Turkey agreed in September 2009 to abolish visa requirements between two countries (Bank 2011). Meanwhile, Syrian visitors to Turkey increased more than sevenfold between 2002 and 2011 to just under a million a year, significant enough to prompt a mini-tourist boom in the southern Turkish cities of Antakya and Gaziantep (Phillips 2012).

However, since the beginning of internal conflict in Syria in 2011, trade relations became a different story. Bilateral trade dropped away sharply after 2011, with Turkish sales reaching a low point of $500 million in 2012 and Syrian exports dropping to $67 million in the same year. However, Turkish exports to Syria have recently recovered to some extent. An important cause of this is related with outsourcing activities of Syrian companies. Butter (2015), who used data from Turkish official statistics, reported that about a quarter of the companies having foreign shareholders that were established in Turkey, in the first eleven months of 2014 included Syrian investors. According to Butter (2015) aid supplies through Syria-Turkey border have also partly contributed to recovering of Turkish exports to Syria. Although the biggest Turkish companies, or industrial cities (such as Istanbul, Bursa, Kocaeli) remain largely unaffected, Turkish border provinces that had benefited from the previous booming period have now been the ones most negatively affected. A notable example is Hatay province. President of HASIAD (Association of Businessmen and Industrialists in Hatay, Turkish acronym) has declared in as early as 2012 that Hatay was witnessing an unprecedented economic crisis (Radikal Newspaper 2012).

Even greater costs have been caused by huge influx of Syrian refugees into Turkey. It is estimated that 2 million Syrians are currently living in Turkey (ORSAM 2015). Turkish President Erdogan has declared that Turkey has spent some 5.5 billion USD for Syrian refugees by February 2015 (Hürriyet Newspaper 2015). Hatay is one of the cities most affected by the Syrian migration. A recent assessment on the economic impacts of Syrian migration into Hatay found out that without the influx of migration, imports would have been the same, whereas exports from the region would have increased by 24% (ORSAM, 2015). The same study also concluded that the prices of goods in the city went up after the arrival of Syrian migrants. Although demographic characteristics (age, gender, profession etc.) of the participants of this survey are not clearly defined, the authors of this study suggest that 78% of the respondents in Hatay perceived a downfall in wages and increase in rents with the arrival of Syrians (ibid: 18). Nonetheless an econometric assessment by Akgündüz et al. (2015) found that while housing and to a lesser degree food prices increased, employment rates of natives in various skill groups remained largely unaffected in migrant-receiving cities in Turkey. Given the current conditions, population related uncertainty might have long-term effects on the economy and natural resources of the region at large.

The Asi basin comprises some of the most conflict-affected areas in Syria. The city of Homs and the rural districts of Al Qusayr and Ar Rastan have been destroyed heavily. Two-thirds of the four million inhabitants of the basin have been displaced over the past three years (Jaubert 2014). FAO mission that took place in late January 2013 found out that Syrian agriculture -as a whole- is witnessing severe decline as the conflict continues, with wheat and barley production showing a 55% drop, vegetables 60%, and fruit trees and olive oil production 40% (FAO 2013). Moreover in a recent analysis, Jaafar et al. (2015: 9) found that irrigated agricultural production in Syrian section of Asi dropped between 15% and 30% in 2000–2013, with hotspots in Idleb, Homs, Hama, Daraa and Aleppo. Using GIS and remote sensing of vegetation, these authors suggest that northern Lathikiya (on the Syrian–Turkish border), the banks of the Asi River, parts of Idleb, and Aleppo were suffering from the highest EVI drops (Enhanced Vegetation Index, an indicator of agricultural production) (ibid: 9). Concomitantly, serious declines in agricultural activity in Syrian Asi basin suggest an increase in water flow to Turkey. This, along with the diminished industrial production in the region, may also contribute to an amelioration of the quality of water entering Turkey. However, these predictions need to be tested and validated by systematic scientific studies. Additionally, the internal conflict in Syria caused a suspension in the construction of the Friendship Dam since mid-2012. At the time of writing, it was out of sight whether the works would resume soon.

## 4. Conclusion

This article analyzed the two categories of approaches in analyzing transboundary water relations, with a specific reference to Asi River Basin and Syrian-Turkish relations. It aimed at critically evaluating these approaches vis a vis Syrian-Turkish relations in the context of politico-economic setting created by the Asi River. While the first category of analyses tends to focus more on the politico-legal dimension of transboundary cooperation with an interest on how competitive use of water resources by the riparians may have an impact upon the treaties regulating water sharing among countries, the second line of argument deals more with the political economic evolution of relations between not only riparian states, but also non-state actors in a given basin.

In this context the article showed that Syrian-Turkish relations in the context of Asi Basin demonstrated a cyclical pattern: while political and economic relationships between two riparians of the Asi River during the Cold War era until the end of 1990s could be analyzed within the framework of political realism; the first political, and then economic rapprochement of late 1990s and 2000s has provided explanatory power to liberal political economic analyses. The demise of collaborative relations between Damascus and Ankara in 2011 appeared as the most recent turn in cyclical relations between two countries, which gave rise to state-centric and security-based realist paradigm.

In specific, it could be argued that political-economic dynamics in Asi Basin represent a more colorful picture than the legal framework, namely treaties, protocols pertaining to water issues. More broadly, the rise and fall of cooperative atmosphere in political and economic relations between two countries had reflections over transboundary water management. Laying the foundation stone of the Friendship Dam was made possible after a relatively long period of rapprochement between Damascus and Ankara. Counter intuitively, as happened in the recent recovery of Turkish exports to Syria, both amount and quality of water flowing into Turkey may get better because of the war in Syria, given the decrease in agricultural and industrial water use in Asi Basin in Syria.

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## WATER MANAGEMENT IN THE LOWER ASI-ORONTES RIVER BASIN

### Issues and Opportunities

The book addresses water resources management challenges in the Turkish section of the Asi-Orontes River basin. It is a product of the International Workshop, *"Water Resources Management in the Asi-Orontes River Basin: Issues and Opportunities"* which was convened at MEF University in Istanbul in November 2014. The workshop was attended by academics, experts, policy-makers and practitioners. It was organized as part of a research program on the Orontes River basin led by the Graduate Institute of International and Development Studies with the support of the Global Program Water Initiatives of the Swiss Development and Cooperation Agency. The program aims to analyze water management challenges and perspectives in the Orontes River basin and to establish a multidisciplinary scientific and technical network on water management including Lebanese, Syrian and Turkish organizations. The first phase of the program initiated in 2012 focused on the upper and middle reaches of the Orontes River basin. The second phase includes the lower reach of the basin largely located in the Hatay province in Turkey.

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