Hula Valley Wetlands

Integrated Management Overview

Until the 1950s the original Lake Hula (13.0 km^2 and 1.5 m mean depth) and surrounding wetland (swampy) area covering more than 85 square kilometres existed within the upper Jordan River Valley of northern Israel. Following state formation in 1948, a major agricultural development scheme was implemented in the Hula Valley, causing the complete drainage of this wetland system and creating an extensive region of highly productive agricultural land. Beginning in 1990 efforts were undertaken to restore a small (500 ha) portion of this region (encompassing an area of relatively unproductive peat soils), to create Lake Agmon—1.1 square kilometres of wetland and 400 square kilometres of ecotouristic/safari land providing watershed management and ecotourism benefits.

Lake Agmon location: 33.7°N, 35.4°W – Galilee, Israel

Area 1.1 km^2 **Mean depth**: 0.6 m **Watershed area**: 200 km^2

Current condition: More than 90 per cent of the original wetland was drained for agricultural use. Today, a small part of the original system remains as the result of a restoration effort. Lake Agmon is in a mezo-eutrophic state.

Management focus: Another reason for the construction of Lake Agmon was concern over nutrient loads released from the drained Hula Valley into Lake Kinneret. Since project finalization, ongoing research has occurred to determine the role of the lake in reducing nutrient loads. Extensive efforts have been undertaken to understand the role of Lake Agmon's underlying peat soils as a nutrient source. To date, it appears the lake represents a relatively low source of total nitrogen (TN) and a moderate source of total phosphorous (TP). Future management challenges will need to focus on the increasing presence of migrating cranes, which stage around the lake for much of the winter, posing a growing wildlife-agriculture conflict for area landowners.

Agricultural Wetland Research Network
iisd International Institute for Sustainable Development / Institut international du développement durable
Instituto de Biología
Ducks Unlimited Canada
MIGAL Galilee Technology Center
University of Manitoba | Biological Sciences | Biosystems Engineering | Environment and Geography
Manitoba
Water Innovation Centre

Network Discussion Themes

Based on the integrated management framework utilized for this project (Oborne, 2009), the following have been identified as key **discussion themes**. Network discussions should focus on the following highlighted items.

Hula Valley integrated management discussion themes

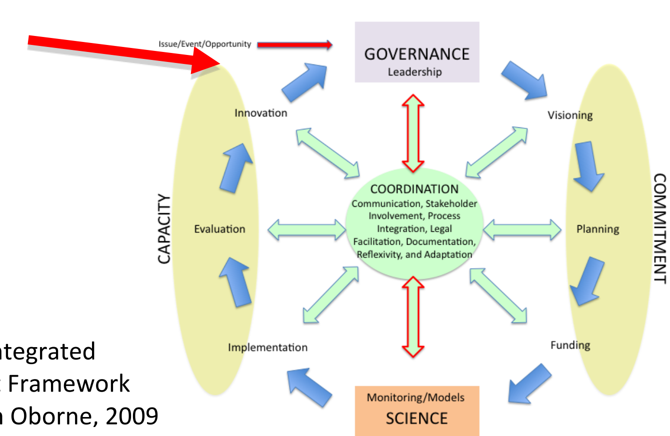
Governance	Commitment	Science	Capacity	Coordination
The Hula Project Board of Directors includes representatives from several key stakeholder orgs., particularly those with direct mgmt. authority today.	Funding of US$20M was provided by Israel and the Jewish National Fund to restore Lake Agmon. US$2M was also provided for research.	Monitoring has sought to explain the hydrologic, sediment and nutrient discharges from Hula Valley to Lake Kinneret. These may need to be clarified.	The Board of Directors appears to be effective. Since the project was established, there has been significant funding available for research and management.	The role of Lake Agmon and the entire Hula Valley are key elements of the hydrologic regime of the Lake Kinneret Watershed
There may be issues related to possible future discussions between Israel and Syria over control of the Golan Heights. Part its drainage area could influence Hula Valley water flows and quality.	The importance of Lake Kinneret for domestic and industrial water supply has ensured that the Hula Valley upstream is also a high priority.	There are growing concerns related to the increasing presence of migrating cranes that stage around Lake Agmon during the winter.	There may be future concerns as Israel increases its desalinization capacity and potentially decreases reliance on Lake Kinneret as a water supply.	There are multiple agents playing important mgmt. roles within the Lake Kinneret Watershed. It will be important to clarify these for improved future operation.

Integrated Management Assessment

This project appears to be in a second management phase. It seems improved **governance** will be required in the future to respond to emerging challenges related to: political control of the region's resources, continued scientific exploration and agriculture-wildlife conflicts.

Contact

Dr. Moshe Gophen, Research Lead
Limnology/Ecology of Wetlands/Lakes
MIGAL – Galilee Technology Center
Box 831 Kiryat-Shmona 11016 ISRAEL
Tel. 972-4-6953556 Fax: 972-4-6944980
Email: gophen@migal.org.il



Hula Valley Integrated Management Framework adapted from Oborne, 2009

Historical Background

Until the late 1950s the Hula Valley (altitude: 62.00–70.00 m above mean sea level) was covered by the shallow Lake Hula (1.5 m mean depth; 13 km^2 water surface), and 35 square kilometres of swamps. The swampy area was completely water-covered in winter and partly covered in summer. The bottom sediments underneath the swamps' vegetation were comprised of organic peat, and were nitrogen rich under reductive conditions: they were covered by water with low levels of oxygen content, and probably anoxic during the night (Dimentman, Bromley & Por, 1992). North of the swamps, there was a 32 square kilometre area where water-table levels were high during the winter, making agricultural development impossible. During summer periods, when underground water levels declined, these 32 square kilometres were successfully cultivated.

Regional Hydrology

Three major rivers (Hatzbani, Banyas and Dan) flow from the Hermon mountain region, located in the north part of the Kinneret drainage basin. These rivers flow into the Jordan River, which crosses the swampy area in two branches, and flows into old Lake Hula. From Lake Hula, at an altitude of about 61 m above sea level, the Jordan River flows downstream into Lake Kinneret at an altitude of 209 m below sea level for about 15 km. The Jordan River contributes about 63 per cent of the Kinneret water budget and more than 70 per cent of total nutrient inputs. We have very little information about nutrient fluxes through the Jordan River into Lake Kinneret before the 1950s (Dimentman, Bromley


Dan River upstream of the Hula Valley (source: Bryan Oborne)

& Por, 1992). Nevertheless, it is suggested that inputs of available nitrogen were originally high prior to 1950 since the dominant nitrogen species was ammonia and it is known to be more available than nitrate for phytoplankton. Long-term records (1970–2000) have documented that nitrate and organic nitrogen (N) are the dominant N-species in the Jordan loads. The water level in old Lake Hula fluctuated annually with an amplitude of 1.0–2.0 m, flooding the swamps in winter when the water level was at its maximum (Gophen, 1998).

The Hula Project

During the 1950s the newly established State of Israel (1948) drained the Hula wetland. More than 65 square kilometres of natural wetland area, with a unique natural composition of fauna and flora of exceptional diversity, was turned over to agricultural use to serve as an income source for residents of the northern part of Israel. For 40 years, the dried area was successfully cultivated and agricultural products (mostly cotton, corn and alfalfa) were economically produced; nutrient fluxes into Lake Kinneret did not threaten its water quality. Nevertheless, as a result of inappropriate management, drainage canals were blocked, irrigation methods not suitable for optimal soil structure protection were applied and the water table declined. Consequently, the soil structure of the upper layers (0–0.5 m) deteriorated, and heavy dust storms occurred quite often in fall and spring due to regional east winds (*Sharkiya*). These storms resulted in subsidence of soil surface (an average of 7–10 cm/year) and blockage in drainage canals increased. Outbreaks of underground peat fires occurred frequently in the summer due to the decline of the water table level, leading to lower soil moisture, longer periods of time in which soil was left uncovered by vegetation (agricultural crops or weeds) and inappropriate agricultural management. Vast

Intensive agriculture in the Hula Valley (source: Bryan Oborne) amounts of water were needed to extinguish the fires, which enhanced the nutrient flux into Lake Kinneret. Rodent population outbreaks caused severe damage to agricultural crops and the stability of drainage canal banks. Ten per cent of the total drained area in the middle part of the valley (at its lowest altitude) experienced extreme soil deterioration and subsidence, making it impossible to maintain beneficial cropping; these 0.5 square kilometres were therefore neglected and not cultivated. The threat to declining Kinneret water quality rose.

As a result, a reclamation project was proposed and implemented (1990–1997), which was aimed at reducing nutrient fluxes from Hula soil by partially modifying economical use of the land from agriculture to ecotourism. Significant structural changes occurred within the system, including hydrological modification and restoration using natural fauna and flora. The reclamation project, entitled the Hula Project, included increasing the level of soil moisture by elevating the water table, changing the irrigation system and renewing the hydrological system of the valley.

The Hula Project area included 90 km of drainage canals that were used both for water supply for establishing a higher water table and draining excess waters. The effect created the shallow Lake Agmon (0.6 m average depth; 1.1 km^2), which was to be operated as a drainage basin for the valley and ecotouristic wetland. Water flows from Lake Agmon are removed by a pumping system, with free flow occurring downstream via open canals returning to the Jordan River. The function of the lake is not only to be part of the drainage system but also to serve ecotourism objectives. As such, its water quality and landscape, and the composition and density of its flora and fauna affect its quality.


Lake Agmon (source: Bryan Oborne)

The ecology of Lake Agmon was studied from 1994–2002. Comprehensive information about Lake Agmon and adjacent areas is presented here with an attempt to emphasize the need to combine economical, limnological and ecological aspects in one constructed wetlands project (Gophen, et al., 1998; Degani, et al., 1998). The Agmon wetlands ecosystem is an example of management design and constructed infrastructure involving three sectors of our society: 1) the land owners (farmers), as the Hula Valley area is an income resources for them; 2) water managers, who are responsible for the limnological protection of Lake Kinneret for drinking water supply; and 3) the "greens"—nature ecologists. Protection of Kinneret water quality is essential because more than 50 per cent of its external load mass (nitrogen and phosphorous forms, sulfate, etc.) originate from the Hula Valley zone (Geifman & Rom, 1998).

The Hula Project plan was formulated by a committee comprised of all relevant organizations, including: the Lake Kinneret Authority, Kinneret Limnological Laboratory, Kinneret Drainage Authority, Nature Protection Society, Nature Conservation and National Parks Authority, Regional Municipalities of all Hula Valley, Water Planning for Israel Co., Water Commission and Jewish National Fund (JNF). Three major alternatives were considered: 1) doing nothing; 2) agricultural soil improvements; and 3) a combination of drainage-agricultural improvements and ecotourism. Socioeconomical, limnological and ecological aspects were considered. All the meetings were open to the public; the third option was chosen and entitled the "Hula Project." The money allocation and responsibilities for implementing the Hula project were carried out by state authorities and the JNF. A Hula Project Board of Directors was established to follow up activities and budgeting. Responsibilities for the operation of the research program was given to MIGAL, Center for Research in the Upper Galilee region, with a follow-up steering committee comprised of representatives from all relevant sectors. The total investment in the construction of the Hula Project infrastructure was C$20 million, including C$2 million for research.

Research

The Hula Project construction and the accompanying research are some of the biggest ecological operations carried out in Israel since the 1950s. Landowners are looking forward to allocated money for commercialized development under the framework of the program. Data and long-term analysis of nutrient inputs from the catchment into Lake Kinneret are given in Geifman, et al. (1970–1998) and Rom (1999). Since 1994, MIGAL and research teams from the Tel Hai Academic College and the Kinneret Limnological Laboratory have monitored: nutrient concentration and calculated inventories; inputs and outputs; temperature; conductivity; pH; dissolved oxygen; phytoplankton and zooplankton; macrophyte biomass and their nitrogen and phosphorous contents; water inflows and outflows into Lake Agmon and the vicinity; and phosphorous content in the sediments. The information on spatial and temporal distribution of macrophyte vegetation has been incorporated with the limnological data in an attempt to formulate an overview of the present ecological, limnological and agricultural status of the Hula wetlands ecosystem. This overview summarizes the updated knowledge of the ecosystem with an insight into its proposed functions: ecotourism and conservation of natural elements; protection of Lake Kinneret water quality by nutrient removal; and income generation for the landowners.

Lake Agmon Wetlands

Classification of the trophic status of freshwater lakes in the world (Wetzel, 1983) indicates that Lake Agmon can be classified as closer to eutrophic than to hypertrophic status. Lake Agmon has three major runoff water sources: 1) Jordan River waters via its reconstructed route; 2) drainage water from peat soils in the Hula Valley, north of the lake via Drainage Canal Z; and 3) drainage waters from the eastern peat block through the eastern Hula Canal. The Jordan waters carry nutrients eroded by runoff, loaded with nitrogen (mostly nitrates), phosphorus and suspended matter (Gophen 2000a, 2000b). The drainage waters are loaded with peat-originated nutrients—mostly ammonia produced in anoxic conditions, sulfate (from gypsum dissolution) and nitrate from oxic conditions. Because the bottom of Lake Agmon is topographically lower than the northern water table, there are artesian hydraulic pressures throughout the lake bottom forming advection flows of about 0.5–1.0 mm/day during the winter (i.e., 500–1000 m^3/lake/ day) (Kolodny, et al., 2000). There are water losses from Agmon through bottom infiltration to the southwest and probably the southeast of the valley.

The water budget for Lake Agmon and the cultivated area that surrounds it was calculated and two examples are presented here: for the years of 2000 and 2002 (2001 budgets are given in Gophen, et al, 2003). The total area of Agmon is 1.1 million square metres and the volume is 6 million square metres. Evaporation in Lake Agmon was calculated at 6 mm/day. Water diversion at Kfar Blum Dam (north of Lake Agmon) comes from Jordan River main discharge and from the “connection canal” flowing through both the reconstructed Jordan route and through drainage canals. The diversion is used for irrigation and for increasing the water table, and considered as total water income to the wetlands region.

The diversion supplies Lake Agmon and irrigates the agricultural area to the north (0.4 Km^2). Lake Agmon water-level changes in both 2000 and 2002 were combined and annual change was calculated (increase was considered as outflow).

Irrigated Production in Hula Valley (source: Bryan Oborne)

Water loss in Lake Agmon through bottom infiltration was calculated as such: changes of total inflows minus total outflows (m^3/1,000 m^2/day). During 10 months in 2000, total inflows minus total outflows in Lake Agmon indicated 1.4 million m^3 (4.2 m^3/10,000 m^2/day), which was considered underground infiltration loss. In 1999 the loss through infiltration was almost two times higher. Due to three years of drought (1999–2002), and taking into account that the Hula Valley and Jordan River represent a substantial portion of Israel’s water supply (Jordan-Hula-Kinneret system), the total diversion from the Jordan to the Hula Project via Kfar Blum Dam passing through the “connection canal” was reduced in 2000. Consequently, bottom infiltration in 2000 was lower than in 1999. In 2000 the mean Residence Time (RT) of water in Lake Agmon was 36 days; in 1999, it was 29 days; and in the first 5 months of 2001, it was 63 days. A longer RT in 2000 could be one of the reasons for the increase in phosphorous and chlorophyll (phytoplankton) content in the water. The considered area includes agricultural irrigated land, Lake Agmon and the grass-covered open meadow (savanna) around it. Results of a total water balance model for March through December 2000 indicated total inflow of 14.3 million m^3 and outflow of 12.2 million m^3. The difference between inflow and outflow (2.1 million m^3) is too low to cover total approximated evapotranspiration over the whole area (3–5 mm /day) (Gophen, et al., 2003). The total inflows into the wetlands area are higher than those that were measured (other underground, unmeasured sources are probably involved). Similar water budgets were calculated for the first five months of 2001 and results indicated total water inflows lower than measured outflows to the whole area, and particularly to Lake Agmon. Consequently, in 2000–2001 additional unmeasured underground waters were involved. In 2002 discharges in additional stations (canals) were measured. The hydrological balances of the Hula Valley in 2002 took into account the following parameters: total area (0.8 km^2); the area of Agmon (0.11 km^2); the areas north and south of the 2.8 km plastic barrier along south Agmon (0.4 km^2 each); rainfall (700 mm); and evaporation (2,054 mm/year).

The Ghawarna Culture in the Hula Valley

Prior to 1830, there were no permanent settlements of Ghawarna peoples in the Hula Valley. These settlements developed very slowly during the nineteenth century and significantly accelerated during the first half of the twentieth century. British sources reported that in 1877, 520 Ghawarna residents had settled in the Hula valley. By 1935 the number was up to 12,400; in 1941, it reached 13,350 residents; and in 1948, it peaked at 31,740. Most of the information we have about the Ghawarna population was documented by external cultures such as Europeans, Turks, British and Jewish historians. Ghawarna tribe settlements in the Hula Valley came to an abrupt end in 1948, with extensive re-settlement efforts following the creation of the State of Israel. In the 1830s residents from the surrounding mountains descended with their cattle herds for grazing and agricultural cropping and stayed most of the summer in those parts of the valley that were not inundated. This was the summer paradox of the Hula wetlands prior to the twentieth century: the dryer the winter, the more grass for cattle grazing and land for agriculture were available. The cultivated land was divided into a series of plots called *Mazraa* (also known as *Azeva*).


Ghawarna people utilizing Lake Hula papyrus reeds in 1946. Photos by Zoltan Kluger (source: Israel Government Press Office, 2011)

If we go further back in time, Karmon (1956) concluded that the Hula Valley had been turned into a wilderness by the Mongolians in 1240 ACE. Karmon (1956) also suggested that the malaria was introduced into the Hula Valley by Crusaders and the Hula Valley became further inundated as a result of the 1260 construction of the Benot Yaakov bridge downstream at Bivers. Later on, malaria became a major factor affecting human activity in the Hula.

The Hula Valley Agro-Ecosystem: Land Use and Land Cover in Relation to Global Climate Changes

The Hula Valley and its surroundings form an agro-ecosystem, encompassing habitats for three purposes: nature reserves, co-habitation with human activities and attractions for ecotourism. The agro-ecosystem includes: rain-fed pastures on the mountain slopes; field and horticultural crops covering the valley flatlands and some of the terraces on the slopes; and aquaculture in fishponds. The Hula Valley area is rural, and the economy is based on a mixture of agriculture, tourism and light industry. Local stakeholders face internal conflicts between ecological and economical interests (Gophen, 2008).

About 35 per cent of Israel's water resources are passing through the Hula Valley. Water utilization in the Hula Valley is restricted by government regulations. Most wastewater in the Hula Valley is collected in a reservoir (*Einan*) and pumped to the highlands for irrigation; however, small quantities of wastewater are also used within the valley for irrigation. Shifts in land use and land cover to less water-intensive crops have been initiated to accommodate political decision about water allocation (Gophen, 2006).

The outflows from the Hula Valley contribute about 63 per cent of the Kinneret water budget and over 70 per cent of total nutrient inputs. These conditions indicated a strain on the national water supply. As a result, a reclamation project (the Hula Project) for this area was implemented and aimed at reducing nutrient fluxes from the Hula soils, while allowing the economical use of the land to continue, though through partial modification from agriculture to ecotourism. The concept of the new land use at Hula is based on incorporation of planned tourist developments composed of natural components (fauna and flora), including the new Lake Agmon. Structural changes in the hydrologic system include: elevating the water table; introduction of mechanized irrigation systems; and reconstruction of the drainage/water supply canal system in the valley (90 km of construction) in order to maintain ample soil moisture and ensure year-long vegetation cover (Gophen, 1995–2006).

The Hula Valley is located in the transition area between the ample northern precipitation belt and the semi arid southern zone, as well as on the transition line between the increased and decreased rain fall regions expected to emerge with global climate changes. Consequently, fluctuations in water supply are expected in the near and far future. Quantified model scenarios capable of predicting the consequences of expected water supply on land use, general economic productivity, and the pressure on natural resources provide a basis to support the decisions made about water resource allocations (Payne, et al., 2009).

A comprehensive monitoring program has been carried out as part of the Hula Project. The geo-referenced data were incorporated in the Hula geographic information system (GIS) database, which consists of environmental conservation and planning data, hydrological monitoring data, migrating birds and nesting locations, natural plants cover, flora and fauna data, water-quality data, land use, ownership of lands, cropping information, municipalities, etc. The data are available to be manipulated, analyzed and presented to the users as comprehensive and detailed maps and reports to support model development, planning and maintenance of the valley. This GIS data set is now available for the proposed Globaler Wandel des Wasserkreislaufs Jordan River (GLOWA JR) Land Use-Land Cover sub-project to be implemented in a larger model. It will include the whole Hula Valley (including agricultural lands) and the surrounding mountain slopes beyond the Hula Project boundaries. This GIS information offers the best resource link for Hula Valley stakeholders, because the data is collected into a single database where it is organized, manipulated and analyzed, and the various model scenarios can easily be presented and evaluated.

Land Use-Land Cover Model

The use of existing models of yield/water response for agricultural crops and water availability for cropland-use planning at the beginning of a season is now available. Pasture yields can be evaluated as a function of precipitation and the carrying potentials of specific grazing plots can be estimated. Changes in the extent and quality of natural habitats can be modelled by the analysis of two aerial surveys per year since 2005, three of them in consecutive droughts. Water yields in the valley as a whole and outflows to the Kinneret can be simulated by soil-vegetation-atmosphere transfer SVAT modelling procedures. The partial models can be integrated into the GIS to simulate diverse climatic scenarios and draw conclusions on ecological, economical (i.e., agriculture and tourism) and socioeconomic influences resulting from global climate changes. The constructed model enables us to use different rainfall regime scenarios showing land-use and land-cover consequences. The Hula Project data set, organized in GIS format, can be incorporated into the model. The existing GIS-formatted data can be calibrated within the models for different agricultural crops and sorted by classes: summer, winter, pasture, orchards, aquaculture, etc. Vegetation surveys of cultured and non-cultured plants accompanied by present hydrology, rainfall and evaporation information complete the datasets. Climate conditions have been routinely monitored using our regional environmental meteorological network for model validation. It was found that the contribution of total nitrogen by Lake Agmon outflow with respect to the annual flux measured at Huri Bridge into Lake Kinneret is only 4.5 per cent and that the phosphorous total is 1.4 per cent. Conclusively, this represents low input from the Hula region (Gophen, 2006; 2008).

A mass balance of Lake Agmon nutrients fluxes indicates that 50 per cent of the TP input is included in the outflow, while the remainder is incorporated into lake sediments, incorporated by vegetation or infiltrated underground. Only 7.5 per cent of the TN influx is included in the outputs and the rest is fluxed into the atmosphere by denitrification, incorporated into sediments, incorporated by aquatic plants and/or infiltrated underground. Similarly, 3.5 per cent of the sulfate inputs are out-fluxed while the remainder is infiltrated underground, incorporated by plants or incorporated into sediment. Geochemical conversion of sulfate to sulfide is not strongly apparent within the water column (Gophen 2006; 1995–2006).

It was found that, during high range of the Jordan River discharges (20–70 m^3/sec), the TP concentration is averaged as 0.273 ppm, while during low range of discharges (1–19 m^3/sec), the mean concentration is 0.172 ppm. This range indicates high inputs of nutrients by the Jordan River into Lake Kinneret during high discharges. Daily infiltration from Lake Agmon to the groundwater is approximately 12.4 L/m^2/day. Evaporation from Lake Agmon hits its peak in July (0.27 mcm per month) and is at its lowest in January (0.057 mcm per month). Data showed that during dry seasons (427 mm per year) the TP concentration in the peat-drained waters is higher (0.157 ppm) than in normal years (662 mm per year), by 0.078 ppm. Soil surface subsidence was higher during years when underground water levels were lower; after 1997, the water table was increased and soil surface subsidence slowed down. The information gathered in this project emphasizes the importance of a high moisture policy in the Hula Valley.

References

Degani, G. , Yehuda, Y., Jackson, K. & Gophen, M. (1998). Temporal variation in fish community structure in a newly created wetland lake (Lake Agmon) in Israel. *Wetland Ecology and Management 6:* 151–157.

Dimentman, Ch., Bromley, H.J. & Por, F.D. (1992). Lake Hula: Reconstruction of the fauna and hydrobiology of a lost lake. Jerusalem: Israeli Academy of Science and Humanities.

Geifman, Y. & Rom, M. (1995). *Loading from the Jordan River Basin to Lake Kinneret: Analysis of events and changes.* Mekorot Water Company Watershed Unit Report. Israel.

Gophen, M. (ed.) (1995–2006) Various Hula Project reports: Meteorology, Avifauna, Hydrology, Nutrients dynamics, Underground water table, agriculture, aquatic plants, Land-use-Land-Cover (GIS), Eco-tourism.

Gophen M. (1998). From natural to man-made Hula Wetland (Israel) (1950-1998): Utilization and nutrient removal. In S.M.T. Tornisielo (Ed.) *Proceedings of the 6th International Conference on Wetland Systems for Water Pollution Control.* pp. 195-205.

Gophen, M. (2000a). The Hula Project: N and P dynamics in Lake Agmon and pollutants removal from the Kinneret inputs. *Water Science and Technology, 42*(1–2), 117–122.

Gophen, M. (2000b). Nutrient and plant dynamics in Lake Agmon Wetlands (Hula Valley, Israel): A review with emphasis on Typha domingensis (1994-1999). *Hydrobiologia 441*, 25–36.

Gophen, M. (2006). The Lake Kinneret Drainage Basin: Headwater discharges, hydrology and nutrient dynamics in the Hula Valley Wetland. In J. Krecek and M. Haigh (Eds.), *Environmental Role of Wetlands in Headwaters.* NATO Science Series 4. *Earth and Environmental Sciences*, *63*, 233–236.

Gophen, M. (2008). Climatological and anthropogenic influence on biodiversity in Lake Kinneret (Israel). *Verh. Internat. Verein. Limnol. 30*(3), 1278–1802.

Gophen, M., Tsipris, Y., Meron, M. & Bar-Ilan, I. (2003). *The management of Lake Agmon Wetlands. Hydrobiologia, 546–549,* 803–809.

Gophen, M., Yehuda, Y., Malnikov, A. & Degani, G. (1998). Food composition of the fish community in Lake Agmon. *Hydrobiologia, 380*, 49–57.

Israel Government Press Office. (2011). Images of Arab life in the Hula Valley from 1946 (Image No. D814-008, 009), Photographer: Zoltan Kluger.

Karmon, Y. (1956). The Northern Hula Valley: Its natural and cultural landscape. Jerusalem: Magnes Press, Hebrew University.

Kolodny, Y., Shamir, U., Dubinsky, Z. & Markel, D. (2000). *The state of Lake Kinneret and its watershed (summer–fall 1999).* Israel: Water Commission Publications.

Oborne, B. (2009). Integrated Governance Framework, unpublished. Retrieved from: www.panterraman.com/2011/01/24/integrated-governance-framework/

Payne, R.J., Ryan, P.A., Nishri, A. & Gophen, M. (2009). *Testate Amoeba communities of the drained Hula Wetlands (Israel): Implications for ecosystem development and conservation management.* Wetlands Ecology and Management. Netherlands: Springer.

Wetzel, R.G. (1983). *Limnology*. 2nd ed. Toronto: Saunders College Publishing.