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Water and globalization: environmental risks and hydro-political conflicts

Riassunto. - Acqua e globalizzazione: rischi ambientali e conflitti idro-politici

Con l'avanzare della globalizzazione, la popolazione mondiale è aumentata, particolarmente nei paesi sottosviluppati, grazie anche al progresso della medicina moderna, dando luogo ad una crescente pressione sulle risorse idriche. Ciò ha reso inevitabile l'intervento umano, così che il corso naturale dei fiumi è stato deviato (Volga) e imponenti dighe sono state costruite (The Three Gorges Dam), per sfruttare al meglio le risorse disponibili. Spesso si tratta di opere colossali, risultanti da progetti di ingegneria civile di elevatissimo standard tecnologico. Tuttavia, talvolta questi progetti non sono stati realizzati col necessario approccio multidisciplinare (diga del Vajont), base essenziale per una valida pianificazione territoriale in cui il rischio ambientale è una variabile essenziale. In India e Israele, solo per menzionare pochi esempi, l'acqua è una fonte di conflitti che sorgono non solo dalla scarsità idrica, ma, soprattutto, dal fatto che il medesimo bacino idrografico (Gange, Giordano) appartiene a paesi diversi. In tali casi, il conflitto diviene inevitabile, soprattutto perché i paesi localizzati a monte fanno "abilmente" leva sull'acqua. Ciò è particolarmente vero se tali paesi controllano anche le sorgenti. Il processo di globalizzazione, che ha contribuito a creare questa situazione, non appare capace di risolvere i conflitti idro-politici. Ne deriva che, il conseguimento di soluzioni pacifiche e definitive appare ancora lontano.

Globalization, demographic growth and water resources

About 71% of the world surface is covered by water: 97% of this huge amount is salt water contained in the oceans, 2% is stored in the polar caps and glaciers, and about 1% is underground; lakes, soil humidity, rivers and the biological systems account for only a minimal proportion. Consequently, the amount of water, available for human consumption, is small and unevenly distributed on the surface of the Earth. In fact, about 80% of it is concentrated in few lake basins (the Great Lakes of North America, Tanganyka Lake, etc.) and in very few major river systems (the Amazon River, the Gange, the Yangtze, etc). Moreover, the rising globalization, thanks also to the progress in modern medicine and to a better quality of life (at least in the more developed countries), has produced a significant demographic growth. In the last twenty years, world population has increased by 60%, with an attendant rising demand for water (for drinking, agriculture, industry, etc.). The most developed countries (English-speaking world, Western Europe, Japan), which represent the global centre with prevailing active globalization, have approximately one billion inhabitants and a very low demographic growth rate, hardly 1% per year. Other countries (China, India, Mexico, Brazil, just to mention the most important amongst them) make up the global inner periphery, characterized by predominant passive globalization, gaining growing benefits from the most developed ones, and accounting together for approximately three billion people. The remaining areas coincide with the least developed world (Africa, part of Latin America, Asian countries such as Cambodia) because of lack of a sufficiently dynamic society, and they represent the external non-globalized periphery (Biagini, 2004). The population of these countries, which sums up to approximately two billion, grows annually by 3%. In 25 years time there will be two billion people more on the Earth. The greater part of it will go to increase the population in Asia, Latin America, Africa and the Middle East. Such growth will involve several consequences: one of these, surely not a negligible one, is represented by the growing pressure on water resources. Water is a primary and collective good, which prevides a basic element for human survival, for the birth and maintenance of every form of life. In order for this good not to become an extremely rare, precious and of exclusive property of a few people, careful planning is mandatory.

Already in the past, great civil engineering plans have been realized, such as those for integrated management of river basins. The first example of it was achieved in the USA, with the institution of the Tennessee Valley Authority in 1933. Dams, and therefore water and energy, occupy pride of place on the world stage. Today, as in the past, dams are built in order to channel river water into reservoirs, to render rivers navigable, to exploit waterfalls to generate electric power. In the world there are more than 800 thousand dams, 45,000 of which exceed 15 m in height, creating river basins with storage volume of more than 3 million m^3. The course of nearly half of the greatest rivers on Earth has been modified by building barrages. These works are not always realized taking in the just consideration possible environmental risks present in the area.

This is the case of the Vajont: it is a magnificent dam from a technical standpoint, but the geologic information about the area in which the reservoir was going to be located, which should have been an important alarm-bell, was not correctly evaluated. Construction works were therefore carried out disgregarding the writing on the wall of an "announced catastrophe".

Other works, of important technical value but linked to high environmental risk, are represented by the Three Gorges Dam, on the Yangtze River in China and by the management of the Russian water system. In the first case, risk is due to the strong regional diastrophism: if an earthquake was to strike, the dam could collapse causing a catastrophic flood. In Russia, the numerous interventions realized on the course of the Volga River have produced undesired and unexpected effects.

Water control, use and management have to take into account not only environmental hazards: water is often the direct cause of real conflicts or it creates conflict conditions. In fact, in some regions of the world (e.g. Israel), water constitutes an important source of economic and political instability. Nearly 40% of the world population depend on fluvial systems shared amongst two or more countries.

India and Bangladesh dispute over the waters of the Gange River but it is in the Middle East that disagreements about water are modelling the political scenario and the economic future. The increasing value of water, worries concerning its quality and amount of supply, and access granted at first and then denied, are making water a strategic resource of the same importance as oil or some minerals. And it is exactly because of its strategic quality that water is going to become a more and more contentious resource.

The Tennessee Valley Authority

On the 18 May 1933, President Franklin Delano Roosevelt proposed to the Congress of the United States the creation of the Tennessee Valley Authority: an independent agency with government powers but endowed with characteristics of flexibility and adaptation, typical of the privately owned companies. This represented one of the first government actions that was part of a wide-ranging complex of economic and social reforms. It became known as the New Deal and had in the TVA one of its more complete expressions. With the institution of this body, Roosevelt meant to react to the 1929 crisis (the Wall Street Crash, October) that had hard-hit the economic, political and social structure of the United States. To the TVA were not only entrusted competence on planning and economic programming, but also the task of managing the water resource as well: navigability improvement, flood prevention and exploitation of the hydroelectric resources. The main objective of the TVA, in order to guarantee a general economic and social well being to the nation, was the use, conservation and development of the natural resources of the Tennessee river basin and the nearby territories.

The Tennessee, a tributary of the Ohio River, and therefore pertaining to the Mississippi river basin, has its source on the Appalachian with two spring basin catchments (Holston from south-western Virginia to French Broad from north-western Carolina); nearly all its course lays between the outermost western spurs of the Appalachian system. The Tennessee River is 1050 km long from the Holston-French Broad confluence to the inflow into the Ohio River. Its river basin occupies a surface of 105,900 km^2. The area concerned with TVA services was at first limited to 105,900 km^2 of the river basin only, included, for the greatest part, in the state of Tennessee (55%), the rest being divided between Alabama (17%), North Carolina (13%), Virginia (8%), Georgia (4%), Kentucky (2%) and Mississippi (1%). Such territory included 125 counties. Subsequently, when the electric power stations were built, the area supplied with energy gradually widened to nearby counties, until it included a total of 201. No provision for further enlargements was then forthcoming, as the area became delimited by law (Biagini, 1974).

Notwithstanding numerous but sectorial attempts to control the course of the river, the Tennessee Valley, before the institution of the TVA, was regarded as an extremely depressed zone, because of frequent floods preventing the development of agriculture, of industries and of all connected activities. In particular, as it was a valley where the economic activity was mainly related to woodworking, the intense deforestation had started a devastating mechanism of continuous flooding and landslides. At the beginning of the 20th century, in order to find a way out of the recurrent floods a dam had been built at Muscle Shoals, as well as an industrial plant that, taking advantage of the electric power, produced synthetic nitrate (a primary component of explosives and fertilizers).

At the end of the First World War the strong demand of explosive materials waned and the costs to operate the dam resulted too high for the fertilizer production only, consequently it was shut down and the plant closed. Then, it was thought to privatize the dam, but negotiations with the government went on for the entire course of the 1920s. During such period, the dam with the annexed factory did not resume production and that just worsened the pre-existing underdevelopment and depression of the area. The region began to change face when the TVA started to build the dams: for 20 years one every year was completed. Every structure had been localized, planned and constructed in order to carry out a precise task. On the whole they formed a unique system for the control and the productivity of a great part of the river. Amongst the various dams on other rivers, the Hoover Dam, on the Colorado River at the border between Arizona and Nevada, must be singled out for its impressiveness (Tab. 1). When it was constructed, in 1935, it was the highest dam in the world, made up of a vast reservoir used by a large hydroelectric power station.

Tab. 1. Characters of the Hoover Dam.

materials	concrete
maximum height	222 m
storage	35 Kmc

The TVA considered the possibility to implant electronuclear generators. In 1967, in fact, began the construction of the largest nuclear power station in the world: the Browns Ferry Nuclear Plant (power 3,5 million kw), in northern Alabama. The activity of the TVA impressed deep changes in the landscape due to the realization of dams and reservoirs, hydro- and thermo-electric power stations, large port infrastructure and industrial plants. The area was interested by an intense agriculture development, by a rational exploitation of forests, by the creation of natural parks equipped for tourist receptivity and the study of nature and, moreover, urban structure became denser and more articulated. Flood damages were avoided thanks to the control system made up of a number of dams (33 large and 9 smaller in 1971, plus other 8 dams more on the Cumberland River).

The Tennesseee river, unsuitable to navigation in its natural conditions, had been transformed in an important waterway open all the year round, with 9 dams with sluice, plus another 10 on the Clinch River. This river, therefore, became part of an immense integrated system of inland navigable waterways (16,000 km) that connects the Great Lakes and the ports of the north-eastern Atlantic coast to the Gulf of Mexico, via the Mississippi River (Biagini 1974). The TVA represented, therefore, the most important success of the New Deal in the field of land planning. Not even the most tenacious opponents of the enterprise can argue about some objective results such as the 200,000 jobs in direct employment, the pioneering initiatives in several fields, the increase of incomes and consumptions as compared to the other regions of the country and the positive financial budget. Such elements, indeed, highlight the importance of the action carried out by the TVA devoted to the utilization, the conservation and the development of an area that was previously deeply depressed. Today the federal TVA is a corporation and the largest public energy producer in the United States.

The Vajont case

The Vajont Valley, that lies on the border between Veneto and Friuli Venezia Giulia, rises between two mountains: Mount Salta, on the right-hand side of the Vajont Torrent, and Mount Toc (1821 m), located on the opposite side. The Vajont Torrent, a left-hand tributary of the Piave River, into which it flows after a distance of approximately 13 km, has its source in the northern side of Mount Col Nudo, in the western Carnic Prealps. The valley is of glacial origin: ice melting, in the Pleistocene, caused such an intense torrential erosive action to exhume Cretaceous soils first, and eventually the Lower Jurassic ones. When Würmian ice melted, a relaxation of the rocks with consequent inner stress imbalance and several landslides took place (the old landslide of Mount Borgà happened in the 18^{th} century). The Vajont waters have always been considered for exploitation: the first official application for this purpose was submitted in 1900.

Subsequently (1929), Doctor of Engineering Semenza drew up the first coherent plan to exploit the Vajont waters and to build a large arch dam, 190 m high, able to store 46 million m^3, located near the Colomber Bridge. Construction began only in 1957, asccording to a new plan called "The Great Vajont", in which, for geologic reasons, it was decided to move slightly the location of the dam and to improve its technical characteristics (Tab. 2).

The first building phase, entrusted to the SADE group (Società Adriatica di Elettricità di Venezia, *Adriatic Power Company of Venice*) was characterized by some technical problems, nearly exclusively due to the nature of the ground. The company, then, decided to intensify geologic surveying, to which, initially, it had devoted only a puny percentage of the budget.

From such surveys emerged that the land as subject to landslides. Doubts were cast by the experts about the safety of the plan. Notwithstanding this, construction went ahead and the dam was completed in the first months of 1959. It was the highest arch dam in the world, described as extremely beautiful for its double curvature. The danger of landslides, however, was always present, in fact some alarming events happened. In March 1959 by the dam of Pontesei, located just 10 km away from the Vajont, a landslide came off the foot of Mount Castellin and the Saint Peter Spiz, having a front approximately 500 m long and a volume of 3 million m^3: it produced a 20 m high wave, causing the death of a man and the collapse of a 70 tons bridge.

Tab. 2. Characters of the Vajont Dam.

typology	double curvature arch
material	concrete
level of foundation	463,90 m
level of crown	725,50 m
level of maximum storage	722,50 m
maximum height	261,60 m
lengthof crown	190,50 m
usable storage	150,000 million mc

To this event no particular prominence was given, in order not to stir alarm that could compromise the Vajont Dam, that had still to be tested. The SADE, in relation to that event, decided of appoint some experts (prof. Leopoldo Müller, a Doctor of Engineering expert in geo-mechanics, Semenza, son of the planner, and Giudici, geologists) so as to investigate the problem of the stability of the slopes around the future lake. From these studies emerged the existence of a palaeolandslide that could move further. In fact, later on, after the beginning of the first of the three storage tests, at the height of 590 m, a landslide (4 November 1960) took place: a rocky mass of approximately 800.000 m^3 fell down into the Vajont basin, generating a wave that, at the impact with the surface of the reservoir, rose up to 10 m. Damages were not recorded but the fact was an all too evident warning. Moreover, at the same time as the landslide, a long crack appeared, on the northern slopes of Mount Toc, like a huge 'M', more than 2500 m long.

After this event, measures were taken to empty the reservoir, as it was acknowledged the inelastic behaviour of the rock that, instead of repelling the water of the basin, "drank" it like a sponge. In order to avoid flooding the towns of Erto and Casso (main centres that faced the valley), in case other landslides blocked the valley itself, the SADE decided to drill a bypass gallery (4.5 m in diameter). Such gallery should have had to connect the two basins, in case of a fall of the landslide. This work was completed in January 1961 with the water surface level at 600 m of altitude. In addition to these measures, in March of the same year, the SADE, prompted by Prof. Ghetti from the University of Padua, made its technicians build a model of the Vajont reservoir in order to carry out tests so as to forecast the consequences of the fall of a landslide from the Toc.

This experiment was made with unrealistic data supplied from the same SADE. Therefore the model turned out to be somewhat approximate in design. That was denounced by the same Prof.

Ghetti in his final report. However, that report was never forwarded to the Testing Commission and the supervisory bodies. In spite of that, Prof. Ghetti established that, up to a water level of 700 m, no substantial danger existed. On the basis of such results, the SADE continued, throughout the 1962, to fill up to the 700 m level, without finding any failure. In March 1963, the dam passed from the SADE to the ENEL, that was entrusted with the Vajont system. The ENEL (*Ente Nazionale per l'Energia Elettrica*, National Authority for Electric Energy) demanded immediately (April 1963) the elevation of the water level to 710 m, few metres under the maximum capacity of the basin. In the following months (August, September), after the third infilling was carried out, increasing failures started to show up and moreover the landslide mass started to move again. Doctor of Engineering Biadene, succeeded to the late Semenza, established to proceed to a partial emptying of the basin taking the water level down to 695 m (a level that everybody thought to be well within the safety mark against any unexpected event). That was the last discharge, an extreme attempt that did not succeed to avoid the worst. At 10.39 p.m. of 29 October 1963, a landslide of remarkable size came off the northern slopes of Mount Toc (Tab. 3), and plunged into the lake below.

The violent impact brought about two waves. The first was approximately of 50 million m^3, rich of solid material in suspension, with a front 150 m long at the dam and 70 m long at the outlet into the Piave, reached an height of 930 m; the second one, of smaller size, reached a height of 70 m at the outlet into the valley. The first one was particularly destructive: after having licked the population of Erto, Casso and S. Martino, places that were upriver, struck the dam removing the upper part; then it flowed in the deep gorge of the Vajont reaching the underlying valley of the Piave and wiping away in a few minutes the large town of Longarone and other smaller settlements. It was a dramatic event that caused the death of approximately 2000 people.

The morphological effects of the two waves were impressive. The water removed the vegetation and part of the morainic and detrital deposits, laying bare the rock underneath. All man-made works went completely destroyed except for the dam that lost its top dam road, while no sign was left of the building site. The basin of the Vajont remained divided in three parts: a reservoir of considerable dimensions upriver from the landslide, known today as the Lake; a smaller one downstream, besides the dam, and a third one on

Tab. 3. Characters of the Vajont landslide mass.

surface	2 Kmq
volume front length	260 milioni di mc 2000 m
average height	150 m
speed	72-90 Km/h
upward front reach	160 m

the same body of the landslide, which disappeared in short time. In the years following the catastrophe, many scholars tried to find an explanation to the phenomenon. The most interesting study, and the one that has gone nearest the solution, is that carried out by Hendron and Patton (1985). First of all, they confirmed: the existence of a palaeo-landslide; the discovery, in several places along the surface of detachment, and also outside the landslide zone, of montmorillonitic clay, up to 5 cm thick; the existence, on the slope, of two aquifers separated by the aforesaid clayey level. These confirmations led the two authors to re-examine the hydro-geological structure of the whole area. They found out then, by using piezometers, different values between the upper aquifer and the lower one. This is because the level of the upper water bearing layer, that matches the mass of the strongly fractured and permeable palaeo-landslide, was influenced by the level of the lake. The lower water bearing layer, instead, was contained within the insufficiently fractured limestone of the Vajont, but was made permeable by karst phenomena, and was fed both by the lake and by rainfall. Its level, therefore, depended on rains but also from the rather long time needed for the water-bearing layer to be re-charged. Moreover, the permeability values, the shape of the two water-bearing layers, and their recharging times were very different. Extremely different were also the piezometric levels, thereby bringing about neutral pressures that favoured instability of the mass. Hendron and Patton assumed, thanks to these results, a correlation law between level of the lake, rainfall accumulated in the lower water bearing layer and displacement. According to these considerations, it became obvious that the hydro-geological structure of the area was the main cause of the catastrophe.

Some other causes, defined preparatory or predisposing and determining, or triggering, of natural and anthropic origin, must be added to this one. Among the preparatory causes, particularly significant have been the geological structure of Mount Toc, deforestation, the cuttings and excavation resulting from the construction of roads and drains in the area in which the dam rises. One of the determining causes was the exceptional intensity of the rainfall recorded in the two months before the landslide occurred. This rainfall made the weight of the rocky stratum increase, produced the imbibition of its bed and consequently a lubricating action of the gliding surface of the future landslide. In the highest part of Mount Toc, subject to karst erosion, water penetrated underground, undermining the solidity of the rocky mass; the sudden filling and draining, carried out during the months during which the dam was tested, produced cracks in the rocks and this, because of the infiltrating water, had washing and removal effect (in solution and suspension) of the cementing components.

Moreover, water exercised a tension between interstitial grains within the rocks up to the point of causing their "floatation". This would explain why the collapsing mass fell in a single block and in a very short time. Rushing towards the realization of gain, the SADE's technicians and the same Test Commission, forgot the necessary precautions. In fact, limiting the capacity of the basin of a few metres would have meant to recoup construction costs in a longer time. Such costs, moreover, had increased because of the unexpected works (reinforcement of the dam's shoulders and, above all, the bypass canal) deemed necessary to enhance the safety of the project. The pride of being able to boast the higher dam in the world, created by specialized Italian technicians, together with an unfortunate rush towards profit, caused them to fail to estimate correctly the geological data and the significant signals warning of what was to happen. All these concomitant causes were sufficient to cause the uprooting of the landslide stratums and the sliding, extremely fast, of the immense mass that stroke into the valley of the Vajont basin, all in a single block without any break up.

The Three Gorges Dam on the Yangtze

The project for the Three Gorges Dam of the Yangze River is the most impressive engineering achievement of all times. It will give the opportunity to take advantage of its hydroelectric potential, it will facilitate navigation and control the turbulent nature of its waters. The Yangtze, the longest river of China (6300 Km, the third longest in the world), whose source is a tributary of the Tuotuo River on the Qinghai-Tibet plateau, flows through the Qinghai province, the Autonomous Region of Tibet, the Sichuang, the Yunnan, the Hubei, the Hunan, the Jiagxi, the Anhui and the Jiagsu and eventually flows into the East China Sea, at Shanghai.

Along its course, from the town of Fengjie to that of Yichang, in the Hubei, for approximately 200 Km, the magnificent gorges of Qutang, Wuxia and Xiling, known with the name of "The Three Gorges", extend. In the medium section of the ravine of Xiling, that extends for 76 Km, the Three Gorges dam is being built; it will be located in the city of Sandouping (in the Hubei province). The real father of this plan was Sun Yatsen, the nationalist leader, first president of post-imperial China. In 1919, he wrote "a plan for industrial development", in which he introduced an impressive scheme for a system of irrigation and flood control aimed at generating electric power through the construction of a series of large dams. Sun supported this idea for the remaining six years of his life and in his last documents he expressed a stronger and stronger belief in the fact that a dam of such grandeur would have generated 30 million horsepower, producing, therefore, an unimaginable wealth for the people living in central China.

The idea was subsequently resumed in 1930-1932, years in which an attempt was made to work out a plan, in order to begin construction, but the turbulent political situation did not allow to carry such programs out. The USA, in 1944, promised the Chinese government aid in order to realize their plan but the civil war stultified all efforts. In 1949, the People's Republic of China was born and Mao Zedong together with Zhou Enlai entertained again the idea of the dam. It was not before 1980 that studies of preparation of the work started. Just in 1991 the plan was ready to be presented for approval, the following year, by the Congress of the People. Such approval, like the following works, were accompanied by a mounting wave of controversies and boycotting campaigns by international environmentalist organizations.

The Chinese government, under the pressure of such criticism, found itself alone to meet the expenses for this work, since all the great international agencies, including the World Bank, withdrew any support. No foreign enterprise is, therefore, directly involved in the works even if Europe (Great Britain, Switzerland, Germany and France) supplies generators and turbines. This plan of multifunctional development schedules the construction of a dam 185 m high and 2309 m long, that it will create a basin of 1045 km^2, with a storage capacity of 39,3 billions of m^3 enough to produce 18,2 million kW/year. This work will be finished in 17 years (1993-2009) and the generating station will enter in full activity once works will be completed. The cost of this work, interests and devaluations included, varies from 24 to 35 billion dollars.

The plan is divided in three phases: during the first (1993-1997) the main course of the Yangtze river has been blocked; in the second (1998-2003) filling of the basin has officially begun (July 2003) and during the third phase (2004-2009) four turbines every year will be installed. By the end of the construction works the largest and most impressive hydroelectric generating station in the world will have been created with its 26 turbines that will produce 700,000 kW each, for a total capacity of 84,7 billion kilowatt-hour of electricity per year. Moreover, such a system (with a distance that varies from 500 to 1000 km from the load control centres in eastern Sichuan and in northern, southern, eastern and central China) will convey alternating current, on 500-kilovolt cables, towards eastern China and eastern Sichuan, and direct current, still on 500-kilovolt cables, to eastern China, and will be connected to electrical networks in the north and the south of China.

The Three Gorges Dam will not only play a fundamental role in electric power generation but also in the control of the turbulent waters of the Yangtze, which have caused in the course of the centuries, disastrous repeated flooding and have been a source of traumas for the local populations. Some historical documents report that in a span of 2000 years, between the Han Dynasty (206 B.C. - 220 A.D.) and the Tsing Dynasty (1644-1912), the river caused 214 severe floods. In the course of the 20th century three relevant floods took place, causing the death of 317,000 people. Moreover, it has to be borne in mind that, the last the flood so far, in 1998, hit 100 million people, destroyed approximately 5 million houses and submerged more than 200 million hectares of land. The national economy was also heavily hit, in fact, a tenth of the harvest of grain was lost. Improvement of navigation represents the third fundamental objective of the plan: it is expected that barge tonnage, from Chongqing to Yichang (in the Hubei province) will increase up to 10,000 tons and the annual cargo volume will reach 50 million tons in each direction.

Moreover a system of sluices and lifts for boats will make navigation easier. The completion of this plan will involve the creation of a reservoir that will submerge 27,280 hectares of tillable land, inundating 116 towns, 1711 villages, 1599 factories and at least one million and three hundred thousand people will be forced to leave their homes and to move elsewhere. This "forced" relocation is a particularly bad experience, especially for old people, for whom changing house means to see a system of relations of solidarity so ancient as their existence come to an end. On the other hand, the attitude of the young people is completely different: they regard the fact of moving to the new cities (these have been built, with their 20-30 storey towers, upstream of those that will be soon submerged) like an opportunity making it possible for them to enjoy a better quality of life. Moreover, with the creation of such basin, more than one thousand archaeological sites will be completely submerged: an immense historical and cultural heritage that has formed thanks to the influence that the Yangtze River along its course, above all in the area of the Three Gorges, has exercised on culture and development of the ancient civilizations.

Action in order to safeguard and protect this heritage has begun together with the plan for the dam. For this purpose, the Chinese government has invested a considerable amount of money: to the tune of figures equalling the annual funds that the same government allocates for the protection of all the archaeological assets in the rest of the Chinese territory. Among the protected monuments, the White Crane's Crest deserves special mention: it is known as the most ancient hydrometrical station in the world. From 1993, many specialists have made great efforts in order to find a solution to safeguard it. After several failures, they have worked out a method called "the container without pressure". With this method the crest will be covered with a transparent non-pressurized container, so that it will be possible to admire it even when it will be submerged.

The local fauna (the dolphin "baiji", the sturgeon of the old river, the river porpoise and the Siberian crane) also resent the construction of this reservoir. In fact these are animals whose survival is closely related to the life and the good water quality of the Yangtze River. Such work will drive these species, already severely threatened by navigation that has drastically reduced their populations, towards extinction. The Three Gorges Dam, the greatest creation of hydraulic engineering of our times, already renamed "the Chinese Wall of the XXI century", is rising in a region in which there is a remarkably dangerous environmental risk: diastrophism. In fact, not far away from the dam there are six active faults, one of which is ten kilometres only upstream of the reservoir and other two have been classified as potentially dangerous for the area of the dam. In the past, China has already experienced the effects of an earthquake on a dam: in 1962 the barrage of Xinfengjiang was seriously damaged by an earthquake of magnitude 6.1 on the Richter scale, after that a series of seismic swarms hit the area since filling of the basin begun.

On 1 July 2003, the enormous reservoir on the Yangtze has begun to be filled and approximately one thousand micro-earthquakes have taken place in less than one week. The director of the Centre of Seismologic Prevention and Monitoring of the Hubei, professor Xu Guangbin, has made clear that this seismic activity was expected, since it is related to the beginning of the filling of the basin, as well as possible earthquake tremors (up to 4 degrees on the Richter scale) that might occur with the elevation of the water level (135 m) in the basin. When the dam will be finished in 2009, the expected telluric movements could reach even 6,5 degrees on the Richter scale. According to the experts, the structure has been planned to stand a magnitude 7 earthquake. Moreover, in the area where the dam will rise, there is also a risk of landslides. The area is made of limestone with scattered cavities containing clay. In 1992, the group of geologists and seismologists involved in the feasibility study of the dam, identified 260 potential landslides, 140 of which were beyond one million m^3 of earth and rock; some were classified as unstable, others in motion and 14 at activation risk as a result of filling the reservoir up. The basin of the Three Gorges presents, therefore, similarities with the sadly famous dam of the Vajont.

The Russian hydrographic system

The Russian region is characterized by vast hydrologic catchment basins: the Ob River and its affluent, the Irkush, that run for 5410 Km from north-western China through the Siberian lowland to flow into the Glacial Arctic Sea; the Amur River that marks, for great part of its course, the border between China and Siberia; the Volga River that flows through European Russia. Such hydrographical system discharges 4,400 km^3 of fresh water every year into the sea. Notwithstanding that, vast territories suffer from recurrent droughts that limit land productivity: in fact, approximately 85% of the capacity of the Russian rivers flow through cold lands in which agriculture cannot be practiced, and then reach the Arctic Ocean or the Pacific. In the western Siberian lowland, a humid area (2 million Km^2) that, in some periods, becomes a real marsh because of water from the Ob and the Jenisei. From such hydrographical situation derive the two historical objectives of Russia: irrigation, of fundamental importance for agriculture, and the strategic improvement of water resources, through technical intervention (Biancotti, 1995).

To such purpose, Russian rivers have undergone modifications of such magnitude that they form today the least natural hydrographical system in the world, because of the almost integral artificial regulation imposed on them in the last fifty years (Biancotti, 1995). The Volga River (3531 Km), together with its tributaries (Kama and Oka) is the most important fluvial system in European Russia: it has its source in the Valdaj Mountains and then flows into the Caspian Sea, near Astrahan, with a vast delta. With a river basin of 1360 thousand Km^2, it is a waterway of fundamental importance because it connects the inner zones to the ports of the Caspian Sea and from there, through a system of canals, to those of the Black Sea.

The first great works on the Volga go back to the Thirties, when Stalin tried to launch the country in the industrial era by means of the "Unified Hydraulic Economy System" plan. The final aim of such plan was the modification of the course of the great rivers in order to convey southwards (Kazakhstan, Uzbekistan and Turkmenistan) the water from the north, so as to make agriculture possible exploiting the modest gradient of the vast Russian-Siberian plateaus, the immense lowlands with a minimal slope. Electric power generation was another important objective of these first interventions: the realization of artificial barrages (the first one in 1937 and the last one in 1983) was aimed at the creation of hydroelectric reservoirs. Today, the energy annually generated is 39,5 milliard kilowatt-hours, hardly 3% of Russia's energy production, a somewhat disappointing result.

Another important plan, called " The Five Seas System", aimed, through intervention on the Volga River, at reorganizing the waterway system of European Russia: a system of canals, dug in the steppe, and sluices built along the watercourse interrupted by the dams, would have connected the Caspian Sea, the Black Sea, the Azov Sea, the Baltic Sea and the Arctic ocean.

In this way the Volga was transformed into an important electric power source (50 million kwh/year), in an economical system of water transport (60% of the traffic), and a water resource able to provide irrigation for huge areas. Upsetting the hydraulic regime of the Volga River, during the Soviet period (1917-1991), has produced benefits but also real ecological disasters. In fact, the Volga's catchment is a vast plain, so that, in order to create an artificial lake able to store a significant water volume, it was necessary to submerge extensive areas: for every cube kilometre stored, an average 200 km^2 of territory had to be covered. That involved the submersion of previously cultivated areas and the forced resettlement of the population. Moreover, water, collected in those reservoirs, is subject to intense evaporation because of the continental climate that characterizes the semi-arid environment of the Russian steppe. Such physiological loss, together with the use of the water of the Volga River for irrigation, have determined a substantial modification of the water supply which has decreased of approximately 35 km^3 while previously it totalled up to 300 km^3.

As a consequence, the balance between inflows and outflows into the Caspian Sea has been severely altered, with an attendant lowering of its level of 25 m, as compared to the beginning of the past century. Extensive areas which once were submerged are today unhealthy swamps. In order to increase the flow into the Caspian, every summer, the bulkheads of the reservoirs are heaved up in order to raise the capacity of the Volga. To re-establish the hydrological balance of the Caspian is very difficult. However, action has been taken to reduce at least the strong evaporation to which the basin is subject. Therefore, it was decided to close the gulf of Kara Bougaz, a large bay surrounded by arid lands, by means of the construction of a dam. Draining this bay would have reduced the total surface of the sea, thereby reducing losses by evaporation. Moreover, because of the water evaporation, that was thought to provide an opencast mine of mineral salts at the bottom of the bay. However, it had not been considered that the salt deposits, undergoing the erosive action of the strong winds of the steppe, would have spread sodium chloride on vast agricultural surfaces making them sterile.

The transformation of the Volga fluvial system into a terrace of closed and isolated water systems, brought about a decrease in fishing stocks. Being no longer able to go upstream, fishes cannot complete their own biological and reproductive cycles. This resulted in a catastrophic fall of catches with attendant negative repercussions on the economy: between 1910 and 1935, 150,000 tons of Rutilus (*Rutilus rutilus caspia*) were caught every year, whereas today catches hardly total 10,000 tons (Biancotti, 1995). Such a situation is further aggravated by water pollution because of the high industrial concentration along the river. Other rivers like the Peciora (1809 Km) and the Irtys (4248 Km), which flow through the vast Russian northern lowlands, have endured deep modifications. In the thawing season such rivers flood thousands of square kilometres of land feeding a complex system of watertables that allow the life of the taiga and of the virgin conifer forest of this area.

The attempt to divert southwards the course of their waters from the Arctic Ocean, in the direction of the Aral Lake, that is today silting up, has caused a decline of the inflow with consequent running dry of a once flourishing and well vegetated territory (Biancotti, 1995). The effects of such intervention were not less negative in the south where the lakes, excessively supplied of water, doubled (and, in some cases, tripled) their surface. The rise of the groundwater level favoured therefore occlusion of ground's pores, essential for air circulation, indispensable to the radical apparatus of cultivated plants (cotton, etc). Once again, on the Russian ground, human and technical intervention has managed to alter irreversibly a previously productive and profitable environment.

Water as a source of conflict: the Farakka Dam in India

In some countries, water for human uses is becoming more and more rare, and the probability of tensions and conflicts is high, particularly where catchment basins belong to more than one State. This is the case of the Gange fluvial system that flows in India for 2125 km and, for the remaining 298 km, in Bangladesh. With a watershed of approximately one million km^2, the Gange has its source in the glaciers of the Himalayan region beyond 4500 m a. s. l., on the northern face of the Gangotri Mountain. After crossing the plain, where it receives numerous tributaries (Jumna, Gumti, Gogra, etc), it flows into the Bengal region with a delta covering 44 thousand km^2.

In 1974, India decided to build, at 18 km from the border with Bangladesh, the huge dam of Farakka that diverts a large part of water of the Gange towards Calcutta. With the realization of this diversion, the river capacity, during the dry season, has decreased by 70%. This has turned out to be devastating for Bangladesh and particularly for its south-western region completely dependent from this river. The lower water supply has brought about a rise of the salinization of soils, a consequent reduction of fertility and therefore a lower grain production per hectare.

The consequences on the population are disastrous: poverty and malnutrition for 40 million peasants particularly during the five months of winter drought; thousands of families have been forced to emigrate towards the shantytowns of the big cities (Calcutta and Dacca) in search of better living conditions. The traditional economy, hanging on a fragile balance, and lacking the necessary financial resources to invest in the purchase of hydraulic pumps and in the realization of more efficient wells, has been disrupted. Total annual economic damage endured by Bangladesh has been estimated at approximately 4 billion dollars. The construction of the Farakka dam has, therefore, produced a very complex situation of difficult solution.

After more than twenty years of growing tension and official protests, an international agreement has been drawn up whereby India engaged itself to leave Bangladesh half of the water stored in the reservoir. However, such agreement did not stop India from constructing several dams upstream of the first one, and from continuing to reduce the amount of water destined to the adjacent country. As far as future water supply is concerned, a heavy threat lie on India and Bangladesh: the Gange is, in fact, a highly polluted river. Survival and well-being of nearly 40% of the population depend on this great river, that, with its 2500 km long course, flows through more than one hundred large and small cities. Such urban settlements have grown in a such a massive way so as to determine, in a time span of approximately 50 years, a fourfold growth of the population.

The Ganges is, therefore, subject to an increasing anthropic pressure that brings about a constant worsening of its waters. Moreover, the river crosses the most fertile and productive territories of northern India, and therefore receives along its course an enormous amount of residues of fertilizers, pesticides, and of industrial and urban wastes. Therefore, in the immediate future the pollution rate is expected to increase; in fact, it is believed that, within the next twenty years, the river basin of the Gange will harbout more than a billion inhabitants on its territory. For Bangladesh, it will be more and more difficult to manage such explosive social and economic situation, and hydro-political conflicts are likely to intensify.

The hard-fought water: the Jordan river

The Middle East is, with north Africa, one of the most arid regions of the planet: it represents 10% of the world surface, is inhabited by 5% of the world population but has only 0.4% of the water resources. Currently, Israel, Jordan, Cis-Jordan and Gaza are below the threshold of absolute poverty, since every inhabitant consumes an average of 500 m^3 of water per year; the remaining middle-eastern countries are placed below the threshold considered critical, 1000 m^3 of water per person per year. The constant water shortage is due, in the first place, to some natural factors such as the presence of an arid climate with consequent rainfall scarcity, as well as the geological make-up, mostly mountainous, and a hydrographical system constituted mainly by smaller water courses of torrential character and by a small number of large rivers. To these factors, some others of anthropic nature have to be added: demographic growth, evolution of life styles and an increase of demand by emerging economic activities that make still more problematic the exploitation of already insufficient water resources.

Moreover, the situation is further aggravated by the fact that the largest part of the river basins cross or are located on the borders of more countries or are in regions involved in long-standing conflicts. Therefore, a sort of multi-ownership of the water resource arises in a country where water, in the course of history, has always carried out an essential role in defining development conditions. To control this resource means to be able to deal with the neighbouring countries from a force position, to have in hand a strategic weapon of exceptional value. Currently, Israel masters this weapon. Its control on water resources is a consequence of the military power exercised during the Six Days War (1967). Through this war it not only occupied some territories (West Bank, Gaza Strip and the Golan Heights) but managed to extend its control on the sources and the course of the Jordan River.

Moreover, it transferred the authority on the water resources, that it confiscated declaring them a state property, to the military command and prohibited water infrastructure construction without licence. Israel, therefore, enjoys, through the military power, the right of exploitation of primary resources in the occupied territories even if that has never been recognized at an international level. The Jordan River, that in addition to Israel, in the northern part runs along Lebanon, Syria, in the central area of Cis-Jordan, laps Jordan and the

Palestinian Authority, is one of the most important water resources under Israeli control.

Its catchment basin includes the Beqaa Valley in Lebanon, the Galilee Sea (the Tiberias Lake), the Jordan Valley and the Dead Sea. On an area of 18.300 Km^2, from Mount Hermon in the north to the Dead Sea in the south, it covers a distance of approximately 360 Km, with one annual average capacity of 150 million m^3. Passed Lebanon, the river crosses the Golan Heights, where its waters are enriched, with a total capacity of 550-660 m^3 per year, by three tributaries: the Dan, the Hasbani and the Banyas. The course of the Jordan continues and forms the Tiberias Lake, the only natural reservoir of the river basin, situated entirely inside the Israeli borders. After the inflow of further tributaries, such as the Zarqua, for a capacity equal to 300 m^3 per year, and smaller streams, the river flows into the Dead Sea.

The Golan Heights, a region astride of Syria and Israel, are made of two different geographical areas, divided by the Sa'ar Stream: the Golan Heights in the strict sense, and, a little more northwards, the slopes of Mount Hermon. The heights are a plateau (1070 km^2 of basalt and other volcanic rocks) that, in the west, slopes down to the Syrian-African fault, where the Jordan River flows and the Tiberias Lake opens, and in the south it is interrupted by the gorge of the Yarmuk River. Nearly the whole Golan belongs to the catchment of the Kinneret: numerous seasonal streams (172) flow down from the Golan towards the lake, which in turn guarantees 30% (770 million m^3 per year) of the water supply of Israel. The control of the Golan Heights is fundamental for two reasons: for their strategic position, since they grant the Israeli forces a good control of the area and therefore warrant them greater security; and because the heights are located at the confluence of a third of the Jewish country's water resources. In order to consolidate their position on the territory, the Israelis have built numerous farming settlements.

Another important water resource is the Tiberias Lake, under Israeli control as well, that supplies water to all the country through the National Water Carrier: the 130 km long Israeli national water system, capable of delivering up to 4,5 million m^3 per day. It carries southwards the water from the north of the country, where it is more plentiful. It is the main artery to which the regional water schemes are connected and is used in order to take the winter water surplus to the sites of infiltration so as to recharge the water tables. Israel is also heavily dependent on groundwater: the mountainous aquifer and the coastal one. The water-bearing mountainous layer, situated in the chains of central Giudea and Samaria, is made of limestone and dolomite. Its total production is approximately 632 m^3 per year (452 m^3 of fresh water and 180 m^3 of brackish water). It is subdivided into three zones: the western one, (Yarkon-Taninim) the most profitable; the north-eastern one (Shem Gilboa) not very rich and the eastern one (125 m^3) that flows down towards the Jordan river.

The first two sections are shared between the Palestinians and the Israelis, while the last one is entirely under Palestinian control. The coastal aquifer extends from Mount Carmel in the north up to the Gaza Strip in the south. It is made of sand and sandstone formations along the Mediterranean coast and is resupplied by surface rainfall. Annual production is estimated around 280 million m^3, representing approximately 15% of the country's total resources. About 1700 wells are scattered along the coastal aquifer and pump water from depths between 50 to 150 m for a total amounts of approximately 450 million m^3 per year. However, the excessive pumping, particularly in the last 25 years, has brought about a lowering of the water table and a seeping of brackish water. It will be necessary, therefore, to close down many wells because of the increasing salinity. Israel, although it has secured control of the most important water resources of the region, nonetheless suffers from a serious water deficit. The recharge rate of the water table is 15% lower than consumption.

Therefore, Israel cannot absolutely afford to yield to the Palestinians either the aquifers or even less any access to the Jordan river, whose waters have already, with difficulty, to be divided with the Hashemit e Kingdom. Currently the Palestinian residing in Cis-Jordan endure constant rationings and unexpected water supply interruptions, but a more dramatic situation is experienced in the Gaza Strip. This is an area with a high influx of refugees, particularly after the 1948 and 1967 wars, and it is one of the most populous regions in the world (2000 inhabitants per km^2) whose water resources are extremely limited. The water table there, an extension of the coastal aquifer of Israel, should be exploited, in a sustainable way, for 60 million m^3 per year, but its utilization is equal to exactly double that figure. This intense withdrawal has determined the infiltration of brackish water in the phreatic layer altering negatively the already low water quality, and destined to get worse with time.

The Palestinians, whose daily consumption per capita is 70 litres, against the 270 litres used by the Israelis, claim rights, historical by now, of exploitation on the water resources stored in the aquifer that have their source in Cis-Jordan, including those that, naturally, flow down in the territory of Israel and that mostly are taken advantage of by this country. Moreover the Palestinians think that the Israeli administration is responsible of an insufficient water resource allocation that heavily restricts their urban and industrial development. Serious problems derive from such ever-intensifying exploitation of the water resources: the water of the aquifer risks, as we have seen, a progressive impoverishment with consequent exhaustion of the water of the wells and an increase of salinity, particularly in the valley of the Jordan River and in Gaza.

The Jordan River is threatened by an increasing pollution rate because of chemical waste released in increasing amounts from agricultural, industrial and urban sectors. Existing sewage works are not many and not always efficient, and less than 40% of the families are connected to the disposal system. That is not all: the capacity of the Jordan is constantly decreasing due to excessive exploitation of its waters. The level of the Dead Sea has dropped from -395 m a.s.l. in the 1950s to -414 m a.s.l. nowadays, and continues to lower of approximately 8 cm per year, with a consequent contraction of its surface from 1000 km^2 to 770 km^2.

In order to check this drying up process, fostered by the strong evaporation to which the basin is subject because of the local climate, the hypothesis has been advanced of the construction of canals to take water, from the Mediterranean and the Red Sea to the Dead Sea (Med-Dead Canal). This measure was part of the Oasis Plan (first introduced by LaRouche in the 1970s) that involved mainly the construction of nuclear power plants to supply the desalinization systems located so as to create development corridors in the desert zones. To the 1940s date back the first attempts (Lowdermilk Plan, 1944; Hayes Plan, 1948, etc.) to reach an agreement so as to solve the problem of the chronic water shortage that affects mainly Israel and the Palestinian Authority but that, in reality, is of interest to the entire Middle East.

In 1953 it was drawn up, by Middle Eastern and American experts, the Johnston Plan, with the aim to carry out a development of the waters of the Jordan catchment. The construction of dams was considered, as well as of hydroelectric systems as, through this plan, it was hoped to set up a Jordan Valley Authority akin to the Tennessee Valley Authority. Jordan, Israel, Syria, Lebanon and the former Palestine would have taken advantage from this intervention. After two years of difficult negotiations the plan was dropped for political reasons: the Arabs absolutely did not intend to improve development perspectives for Israel. Negotiation stopped for good in 1955. Various attempts at mediation have been tried since (Oslo Agreement in 1993, temporary Second Oslo Agreement in 1995, etc.) but a final and peaceful solution of the disputes, between Israel and the Palestinian Authority, about the water supply was never reached. The future of water resource management appears, therefore, ever more complex and delicate, particularly so in an area where water, insufficient by nature and, what is more, shared out between various countries, is enduring increasing pressure because of continuous demographic growth and ongoing economic development.

Conclusions

Since the days of yore, water courses have attracted human settlements because of fresh water availability, favourable ground layout and land fertility. Even intervention on the rivers in order to regulate their course are carried out from time immemorial. Since the end of the 19th century rivers have started to be deeply modified. In a relatively short time (about a century) a huge work and a vast anthropic alteration of the river courses have been carried out, resulting in a superimposition of highly artificial regimes on natural hydrological and morphological systems.

At present, there are in the world 45,000 dams higher than 15 m (to which have to be included those between 5 and 15 m high) and with a reservoir larger than 3 million m^3. Most of them are in China, the USA, Japan and India. There are 20,000 dams higher than 30 m located in various parts of the world. There is then a fine dust of small reservoirs of little impact that single communities build to satisfy local needs. Without complex works on rivers, water accessibility would be enormously lower. Many barrages protect from potentially disastrous floods and supply drinking water. Moreover, dams provide 20% of the world electric power (without atmospheric pollution) and about a third of irrigation water. Some dams are works of great technical value, symbolize human ability to subdue nature through technology and progress, but nature and history have dramatically shown the frailty and limits of these "great works".

The case of the dam of the Vajont, where human imprudence together with ignorance have been fatal for more than two thousand people, has been emblematic. Instead of a multidisciplinary approach, that to the advanced engineering techniques joined geological and geographical knowledge, pride and conceit of being able to boast the highest (for those times) dam in the world, with the relative "benefits" that such construction involved, have prevailed. Today we are witnessing the construction of a colossal work, the Three Gorges dam, the largest in the world, on the Yangtze. The huge size of this work will be really justified? From an economic point of view, will the ratio between investment and return be positive? And what about the impacts on the natural (devastating repercussions on habitats) and social environments (uprooting of huge numbers of people)? Moreover, the earthquake risk, looming large on the Three Gorges dam, cannot be overlooked.

Water, an extremely precious good, is the focus not only of important works of elevated engineering value aimed at an optimal use of it, but it is also a cause, particularly where it is in short supply (Israel, etc), of real conflicts. Wars for water stem always from the clash of two opposing principles: territorial sovereignty, defended by those who think of being in the right to use at leisure water that has its source in the controlled territory, and territorial integrity, supported by those who believe that territories located downstream have the right to benefit of a constant and not diminished rate of the water courses that flow from other countries.

The clash, therefore, is always between different political actors, among which the one who is located upstream is obviously in an advantageous position, and even better if it controls the sources, and takes great care not to assume a conciliating attitude. In fact, water has always been used as a power and social inequality lever. To this purpose, it has to be reminded the-wolf-and-the-lamb philosophy: *Ad rivum eundem lupus et agnus venerat / siti compulsi: superior stabat lupus / longeque inferior agnus.* The etymology itself of the word "rival" is significant: the one who is on the other side of the river, that depends on the same source and from whom it is necessary to defend oneself. Globalization cannot eliminate water-related conflicts, cannot offer easy solutions in relation to a resource that, in the near future, could stir up more political conflicts than the black gold. In fact, in some regions of the world, water is, increasingly, an important source of economic and political instability.

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