Historical perspective on structural methods for flood protection in Lower Danube

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ABSTRACT: The purpose of this paper is to describe from a critical and historical perspective the employment of structural works at global, regional and local levels without separation from their context given by environmental, economical, political, social and cultural factors. The authors provoke the reader to reflect about the role of humans in the process of adaption to flooding. The first part of the paper addresses the definition and classification of structural works from different perspectives, the second part describes the context in which they are implemented and concepts such as 'hydro-politics', the third part shows structural works' evolution along Danube and at Gostinu study area level.

KEY WORDS: structural methods, flooding, hydro-politics, Lower Danube

1. Introduction

Mauch & Zeller (2008) in their book entitled '*Rivers in History*. *Perspectives on Waterways* in Europe and North America' discus about river control in Western Europe societies and in the arid West of United States, control which transformed not only the water courses, but also societies over time, it also introduces the concept of 'hydraulic West', ' a concept not without its critics'.

The first part of the paper addresses the definition and classification of structural works from different perspectives, the second part describes the context in which they are implemented and concepts such as 'hydro-politics', the third part shows structural works' evolution along Danube and at Gostinu study area level and the last part is devoted to conclusions.

The purpose of this paper is to describe from a critical and historical perspective the employment of structural works at global, regional (Lower Danube) and at the local level discuss the 'hydraulic' system put in place by the communists in Gostinu study area. The presentation takes into account the specific context given by a multitude of factors - environmental, economical, political, social and cultural.

The authors used a diachronic analysis of maps and research on hydrology, hydrological risks management, environmental anthropology revealing historical worldwide data and information from the Danube Basin, but also monographs, local archives, legislation, plans of local authorities, national strategies and publications released during European projects such as Floodrisk and Floodnet.

The use of structural methods for water management, land reclamation and flood protection has often proved inadequate (Toth & Nagy, 2006), inequitable (Sing, 1997; Mauch & Zeller, 2008), unsustainable (Sing, 1997) having associated environmental and social problems in countries such as USA (Steinberg, 2000; Bijker, 2006), England (Watkins & Whyte, 2009), Germany (Blackbourn, 2008), Romania (Lucaciu, 2006; Dobrescu & Popovici, 2010), and (Toth & Nagy, 2006) and India (Sing, 1997; Bijker, 2006).

2. Definition and classification of structural methods

A Romanian dictionary of geographic terms (Ielenicz, Erdeli and Marin 2007) does not use exclude the structural method term, but uses 'hydraulic works' defined as 'works that emphasize the hydraulic resources of a water course' and distinguishes between hydro-electric works, hydro-ameliorative (improvement) works, works to improve navigation, water-supply works, fishery works.

Current legislation or strategies (e.g. Government Decision, nr 846, 11 Aug 2010 and the Strategy of the Inspectorate for Emergency Situation for medium to long-term management of flood-risk) use the 'infrastructure works' term (Dobrescu & Popovici, 2010) or 'structural measure' term, which encompasses works such as: dams, dykes, levees, waterway conduits, river bank and wetland consolidation works, etc.

Lucaciu (2006) defines structural works against flooding as methods which affect the hydrologic and hydraulic system of water courses causing major changes in river biodiversity having repercussions on river ecology and determining a discontinuity between different components parts of the river (floodplain, river bed, meanders, etc) and classifies structural methods in:

a) Measures for flood reduction: permanent or temporary lakes, terracing and soil conservation works, river bed reconstruction and river slope consolidation; b) Measures based on soil conservation acting where excess water is generated: embankments, forestation, rainwater management; c) Techniques of water level reduction through a system of canals and irrigation or drainage pumping stations. These methods are usually employed by states and national authorities; d) Techniques of maximum water level reduction - control of river beds and removal of debris from the river bed after major flooding; e) Measures to protect human settlements, population and property: dykes, levees, embankments, gabions, spur dykes, groynes, revetments etc. The closer these structures are to the river, the greater is the destructive force of water in case of a breach occurrence.

Yervjevich (1994) defines structural methods as physical control methods or physical measures and divides them in: a) extensive methods (area, space), consisting in reshaping of land surface, soil conservation methods, flow delay and increase of infiltration and b) intensive methods (point, line) divided in four categories 1. levees and dykes, 2. water storage, 3. increase of channel flood capacity, 4. flood plain polders and platforms.

Bijker (2006) emphasises the political context behind dikes, dams, levees, barriers, which he describes as 'thick things' being big in size, thick with values, such as the Oosterschelde Barrier, an example of democratic achievement from Netherlands, thick with power such as the systems for irrigation reflecting power relations and thick with politics because they reflect the political ambitions and ideologies of people in power.

Schanze (2004) uses the structural measure term as 'interventions based on a direct physical action', while 'instruments' are defined as 'interventions based on mechanisms indirectly leading to measures or influencing human behaviour'. The author states that the structural measure term is predominantly used for interventionist methods against flooding, while non-structural measure term is used for the rest of interventions.

Schanze (2004) divides structural measures in a) permanent measures - physical interventions leading to long-term changes of 'the physical conditions of the flood risk system', which include engineering work for flood control, methods improving resistance to floods of building and infrastructure activities and to increase the retention capacity of the floodplain and b) temporary measures-physical intervention reducing risks during flooding - mobile protection measures such as mobile barriers or sacks of sand, securing objects and goods, relocation and evacuation of animals and people.

During the last century different definitions were used, hydro-technicians or engineers such as Saligni (Greceanu, 1933) emphasise the advantages, ignoring the disadvantages and impact on communities, while the naturalists such as Antipa (1910) are concerned with loss of biodiversity and space for rivers to move laterally during floods. Sing (1997) thinks the reason is that up to the '80 there were no studies at larger scales to show both, the real advantages and disadvantages of dams and other structural works. The first paper to show these aspects was the Report of the World Commission on Dams published in 2000 which presents cumulative impacts of a series of dams on a river system.

As Sing (1997) points out there is a change in attitude at international level due to the high number of conflicts created by large dams and the need to reconsider the disadvantages , which mainly affect the local communities.

3. The context in which structural methods are developed

Wittfogel (1957) was the first to state that most evolved ancient societies were based on hydro-politics and supported his controversial 'hydraulic hypothesis' with evidence from Egypt, Mesopotamia, India, China and pre-Columbian societies. The author maintains that a hydraulic power is based on water monopoly and is a governing structure or 'bureaucracy', maintaining its power and rule through exclusive control over resources (water, food and energy) and use of military. A hydraulic civilization was led through an absolutist system and there was a strong link between the officials in power and the dominant religion and annihilation of other power centres.

The same elements of resource control central to the hydraulic empire were also characteristic to centralised communist and socialist societies from Central and Eastern Europe or European colonisers, which used similar extensive centralised and heavily controlled irrigation systems. Mauch & Zeller (2008) maintain that the West, especially the arid West of USA starting in 1930 and Western Europe were transformed or had characteristics of a hydraulic civilization, which led to the concept of 'hydraulic West'.

Rivers were often identified with societies established along them (Mauch & Zeller, 2008). For example Strauss' Blue Danube Waltz has associated a Viennese specific cultural context, 'blue' suggest that Danube was a clean beautiful river, and the waltz is associated with the Austro-Hungarian empire and society's wellbeing at the end of 19th century, becoming in time the unofficial hymn of Austria.

The contexts are created by humanity's relation with nature and technology, technology which is represented by artefacts (Schatzki, 2003), which replace, control, work together with nature towards adaptation. As Schatzki (2003) alleges, different from the classic concept through which technology mediates humanity and nature, in reality there are multiple examples when nature mediates humans and technology through flood-pulses (Junk et al., 1989), or through its chaotic and dynamic functioning (Hastings et al., 1993) or through disasters. An example of humanity mediating nature and technology is that of a hydropower station, which is a facility producing electricity through physical processes or control of natural processes and humanity appropriates the products of both - nature and technology.

The study of artefacts, in the case of structural methods - dykes, dams, levees, barriers, sluices, sluice-gates, locks, and other physical control methods, or non-human (Latour, 1992), is important because artefacts are socially constructed as well as shaping society and provide 'crucial insights into the history and development of science and into the history and development of societies' (Bijker, 2006). Analysing the artefacts used for water management can help comprehend characteristics and socio-technical development issues of societies.

3.1. Worldwide contexts

Bijker (2006) brings numerous arguments through comparative case studies from the Netherlands, Unite States and India supporting the theory that artefacts cannot be separated from environmental factors (natural disasters, natural conditions, biodiversity), politics (decisional systems, politicians), power (conditioned by access to resources such as water and energy), corruption, economic interests and social problems (social un-equity, generational un-equity) loosing values and disadvantages for indigenous groups/societies, inhabitants of natural environments and advantages for inhabitants of built or urban environments. All 'thick things' are also important for the connections and networks associated with them.

Mauch & Zeller (2008) explain the social, economic and political context, in which structural works evolved in Europe. Rivers serve multiple purposes: boundaries between natural geographic units, important transport, industry and trade networks, national symbols and source of conflicts and natural disasters. Societies evolved along them while their natural course was straighten to reduce flooding and improve navigation. The hydrologists and engineers of 19th century wanted to remove any variation, reduce any pulse and transform rivers into quiet and predictable water courses seeing themselves as being at war with rivers, which needed to be 'tamed' (Scott, 1998).

Blackbourn (2008) shows the relation between river dynamics and humanity emphasising the material transformation of German rivers and presents the construction of engineering works on Oder and Rhine as projects aiming to 'maximise resources' for trade and transport.

The rivers were presented by ideologies as engines of modernisation and development in a similar way in USA (Steinberg, 2000) and in USSR (Zeilser-Vralsted, 2009), the differences being a decentralised system in case of Mississippi River and a centralised system in case of Volga River.

1930 Soviet literature abounds in works about 'taming' (Scott, 1998) nature to serve the socialist society (Zeilser-Vralsted, 2009), rivers were seen as a resource used by nations in the process of search and creation of their identity.

Steinberg (2000) in his book entitled 'Acts of God' starts with the explanation of the dichotomy between nature and culture - 'Nature is the What and Culture is the Who' affirmation which allows for the distinction between us (humanity) and it (nature) and permits us to accuse nature of being guilty of producing disasters in our society. This accusation has become a tool used to advance different political interests in society. The majority of people see disasters as strange events not connected with their everyday life or environment positioned outside of their morality and therefore no one is responsible for their occurrence. In reality disasters are produced as a chain of human decisions and interconnected natural happenings.

3.2. Danube's Hydro-politics

Danube is the most important river in Europe mainly due to its strategic position linking Eastern, Central and Western Europe. The modern history of Danube was marked by the Napoleonic wars (Hohensinner & Drescher, 2008) at the end of which the political situation in Europe has changes and a period of economical and political stability followed - the ideal time for ambitious river channelization program. All Danube riparian countries (except the Ottoman Empire), which participated at Vienne's Congress (1814-1815) promised to channelize and improve navigation on Danube through structural works. A leading role was taken by the UK and Russia.

Simion Mehedinti (1938) states that the UK facilitated Danube's opening for navigation, a role being played by the 'English liberals', who 'wanted free import from any country in the world' and in 1850 instituted a 'royal construction authority for the administration and implementation of technological methods along Danube'. This led to the creation of Danube's Commission in 1867, which determined the development of structural methods to improve navigation and protection against flooding.

From approx. 42 000 km² of former floodplains in the 19th century before the establishment of Danube's Commission, only 19 % (cca. 8 000 km²) have remained in the entire Danube basin until today (UNDP/GEF 1999) and 93 % of the Danube is “at risk” or “possibly at risk” due to hydromorphological alterations (Danube River Transboudary Diagnostic Analysis, 2006). Furthermore, currently from 2780 Km of Danube, 2588 are used for navigation and Rhine-Main-Danube and Danube-Black Sea channels link Black Sea with the North Sea through an important transport route - the Pan-European VII Corridor.

The first 1000 km of Danube were transformed into an artificial body of water, controlled by a network of 59 electricity producing dams. Along the Danube's Bavarian bank, Danube flows free only between Straubing and Vilshofen (70 km). In Austria, Danube flows free in Wachau area (35 km) and between Vienne and Bratislava (47 km). Downstream from Gabcikovo dam there are 1800 de km of free flowing, interrupted only by two major dams: Iron Gate I and Iron Gate II.

A WWF study (2002) shows that there are 11 conflict zones along Danube Some parts in conflict want more structural works, the destruction of islands between Romania and Bulgaria to improve navigation, Gabcikovo Dam, a conflict between Hungary and Slovenia. Austria and Hungary plead for river restoration and there are plans to connect Danube with the Adriatic Sea.

4. Structural methods implementation in Lower Danube area

According to Greceanu (1933) and Visinescu & Bularda (2014), in Romania before the First World War, Anghel Saligni, a famous engineer of the time was the representative of the 'engineering conceptual approach' who wanted to transform Danube's floodplain into agricultural precincts surrounded by un-submergible levees. The 1910's Law for the Reclaimation of Land from Danube's Floodplains' supported Saligni's plans and the establishment of the Special Authority for Land Improvement (SSIFs), which initially functioned under Saligny's leadership being part of the Ministry for Land Improvement and Development.

In opposition to the 'engineering conceptual approach' was the 'naturalist conceptual approach' of the famous biologist Antipa, the Director of the State's Fishery Directorate, who was seconded by Engineer Vidrascu. Antipa (1910) was in favour of submergible levees, which will allow for both agriculture and fishery use of the floodplains. Antipa (1910) was against the use of un-submergible levees, which in his view were going to determine, on a long term basis: loss of unique biodiversity specific for Danube's floodplains, a reduction of fishery production and a decrease of soil fertility. Floodplain soils are alluvial, non-mature soils, expensive to maintain for agricultural use.

Antipa (1910, 2010) who was fascinated by the ecological potential, biodiversity and fish production of the Romanian floodplain area and its interconnected lake system protested against Saligni's plans and called for the establishment of a commission to examine his concerns on the construction of un-submergible dykes and levees. Due to the First World War, Saligny's plans were postponed up to 1921 when The Agrarian Reform Law from 17 July 1921 (applicable to the two old Romanian kingdoms of Moldova and Tara Romaneasca and Dobrogea) forced the owners of floodable land to hydro-ameliorate their properties by 1932 (Greceanu, 1933) through dykes, levees and systems of drainage under the sanction of expropriation. Another law from 1925 - The Law for the improvement of Danube's flooded zone - contributes to the increase of bureaucracy and state power in land improvement works through the SSIF (Greceanu, 1933).

Engineer Greceanu was one of the owners of floodable land being conditioned to transform it in arable land until the end of 1932. The landowners were organised in syndicates for hydro-amelioration, legal entities led by SSIF and each precinct proposed to be surrounded by dykes and levees had a syndicate.

Greceanu (1928, 1933) who recognised the importance of the natural floodplain for the fishery industry and was a supporter of Antipa (1910, 2010) believed that it was not cost effective to build un-submergible dykes and levees in the area. Also Greceanu thought that construction of un-submergible levees would mean a high cost to be borne by all owners, including peasants 'who would not have any benefits' being 'abusive and un-equitable' and called for the state and SSIF to consider the high cost of maintaining the system of dykes and levees and the size of disasters due to potential breaches during flooding.

The problems raised by Vidrascu or Greceanu (Greceanu, 1933), who pointed to the issue of levees breaches only a few years after being built and the inefficient functioning of the state SSIF bureaucratic institution are still current. According to Greceanu (1933) Engineer Vidrascu published a paper in 1921 pointing out the problems of building un-submergible levees in Mississippi's floodplain (Greceanu, 1933), making analogies with future problems in Danube's floodplain and showing that they are not cost-effective. All these demonstrate that the discourse form the interwar period of Romania is not very different from the existing discourse on flooding and mitigation methods.

After this, during the communism period the system of levees and dykes continue to develop even more intensively. The un-submergible levee built by Greceanu and other levees built before 1933, partially resisted the 1940's floods (Mihnea et al., 2008), but some were breached by the 1963's flood (Oinacu Village Archives). The event of 1963 was used as an excuse by the communist regime of the time to redevelop the entire Danube floodplain.

The Romanian Communist Party (Sarbu, 1972) had very ambitious plans to transform Danube's dynamic floodplain environment into agricultural land and 'develop a modern, intensive and multilateral agriculture'. The system put in place by Ceausescu's regime in mid '60s contains characteristics of a hydraulic system, being highly centralised and resources (land, water, food, energy) were highly controlled by an army of state bureaucrats. The plans were established through the Party's 10th's Congress (August 1969), which established 'an imposing programme for the 'continuous enlargement and perfectionism of the technical-material base of the socialist agriculture' and included more investments in the major Danube irrigation and drainage system.

As result of this extensive development, the Lower Danube's floodplain was transformed into 50 agricultural precincts (Dobrescu & Popovici, 2010) (Figure 1) with a total surface of 430 000 ha through a system of 1 200 km of dykes and levees, a process which irremediably affected Danube's hydro-geomorphologic system and local and regional climates. This phenomenon was accentuated by recent climate change with more extreme and frequent hydro-meteorological events obstructing Danube's course flow during 'high waters' periods (April-May) (Visinescu & Bularda, 2014).

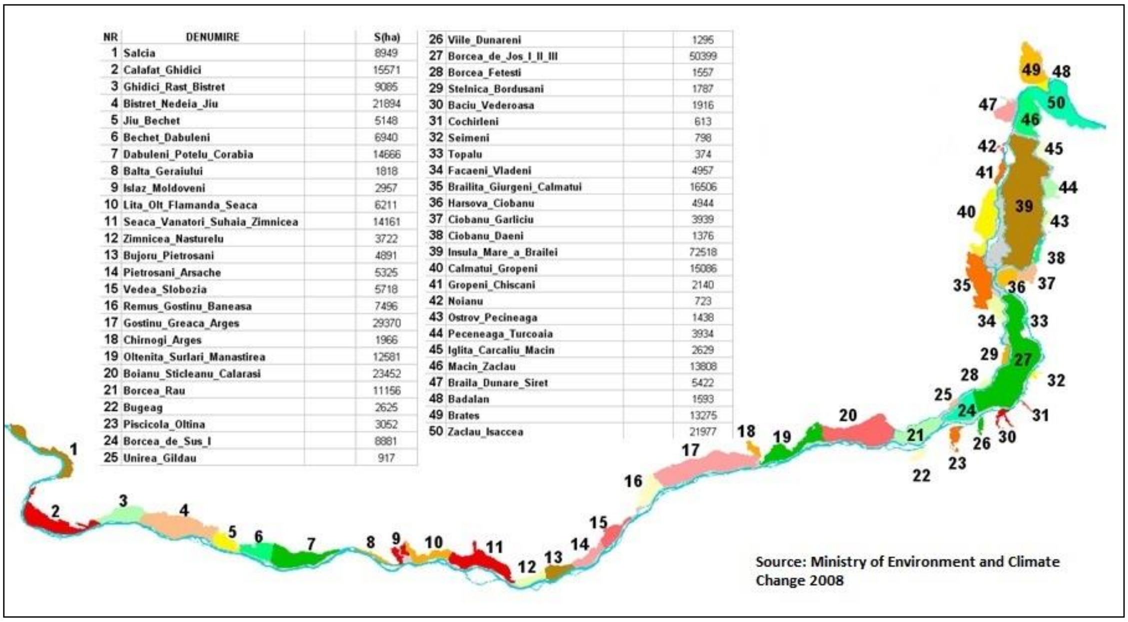

Figure 1 Lower Danube's floodplain- agricultural precincts delimited by structural works.

4.1. Gostinu Study Area

The study area (Figure 2) includes Gostinu comune from Giurgiu county (18 km Eastwards from Giurgiu Town), which is located in Danube Floodplain and is delimitated towards North by the Burnas High Plain (Fig. 2). Gostinu's communal land belowngs to two precint areas: Precint 16: Malu Rosu-Baneasa-Gostinu and Precint 17: Gostinu-Greaca-Arges, divided by Baneasa-Gostinu transversal dyke.

In the study area (Fig. 2), Greceanu (1928, 1933) and Antipa (1910, 2010) suggested to use submergible compacted earth levees, without interrupting the connection of the floodplain with its main lakes or ponds, which had a high productivity for fish - 600kg of fish/ha of natural floodplain (Antipa, 1913) and were the only natural spawning areas. The use of un-submergible levees determined a decline of fisheries in the area as well as in the entire lower Danube (Danube Transboundary Analysis, 2006).

Danube's floodplain area in 1910, before the construction of any structural works, was once known for its lake and fishery industry (Antipa, 1910). As presented in Figure 3, the morphologic floodplain reduced its size dramatically. The current floodplain was reduced to the area between the levees, which embedded the Danube River, restricting its lateral movement.

Greceanu (1933) stated that the use of un-submergible levees will destroy the local fishing industry and 'will deprive the Romanian nation of its wealth' and his statement was not far from the truth. According to Mihov & Hristov (2011), until the mid-20th century the wild carp made up to 60% of the fish capture in the Danube, 50 years later the wild carp became an endangered species. Nowadays there are some varieties of the cultured carp, which make up to 6% of the fish capture and the total fish capture is about ten-fold lower (Mihov & Hristov, 2011).

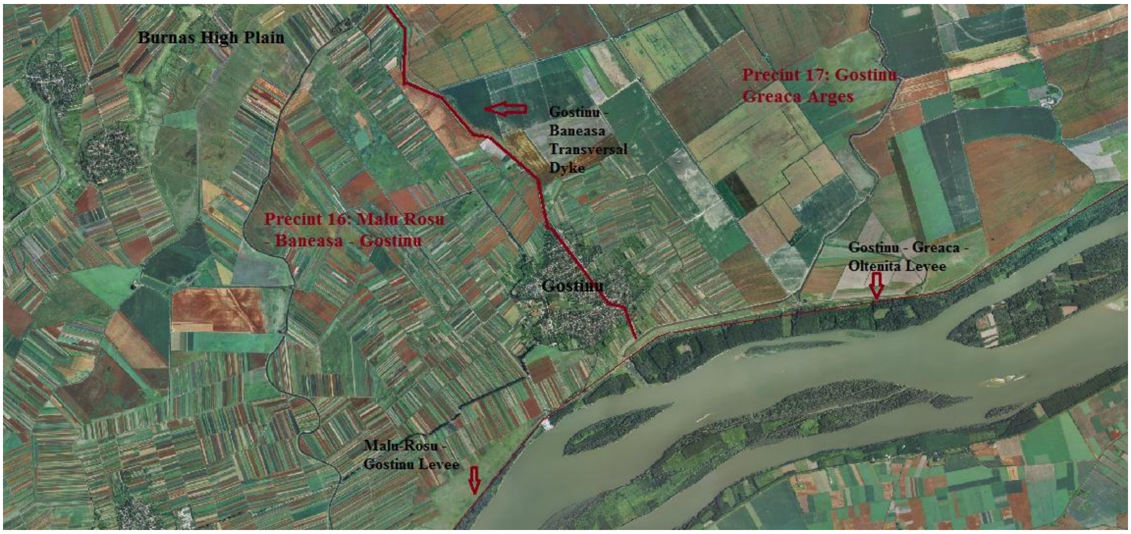

Figure 2 Gostinu Study Area - current situation (ortophotomap 2009).

During 1963-1966 the submergible levees built in 1929 were replaced by un-submergible levees with 1% guarantee assurance level (made to withstand floods with return period of once in 100 years) (ANIF Report, 2010-2013). Malu Rosu-Gostinu Precinct and Gostinu-Greaca-Arges Precinct were drained by a system of natural (Comasca, Moarta etc) or artificial channels (Dumescu, Cioranu) and drainage pumping stations.

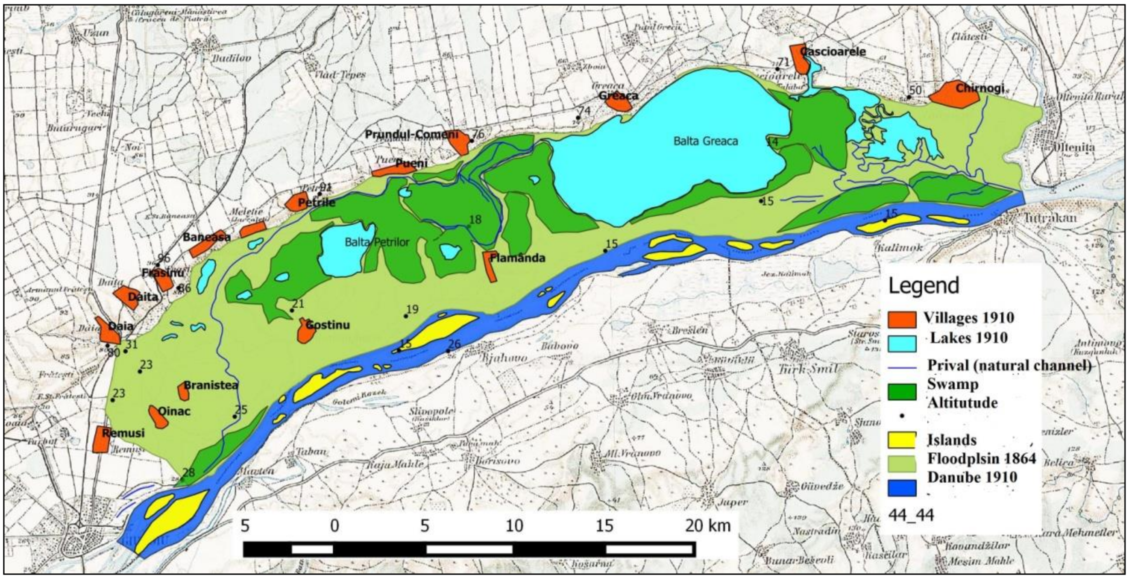

Figure 3 Danube Flood Plain before the construction of dykes and levees.

Until 1978, the relatively natural Danube floodplain became totally embanked and transformed into agricultural land (Mihnea et al., 2008), Greaca and Pietrele Lakes were drained completely, the only remains being some marsh areas. According to Mihnea et al. (2008) the dams built between 1910-1966, though resisted many floods with minimal damages were breached during the singular flood of 2006, when 17% of the embanked precints, were flooded, main causes being the lack of the maintainance of the levees after the collapse of communism in 1989.

After the 2006 flooding event the Romanian Water Authority (ANAR) has reconsidered its position regarding the use of structural methods (Fig. 5), taking into account the reintroduction of some lakes or ponds in the floodplain area and aiming to protect (through levees) only economic assets and settlements.

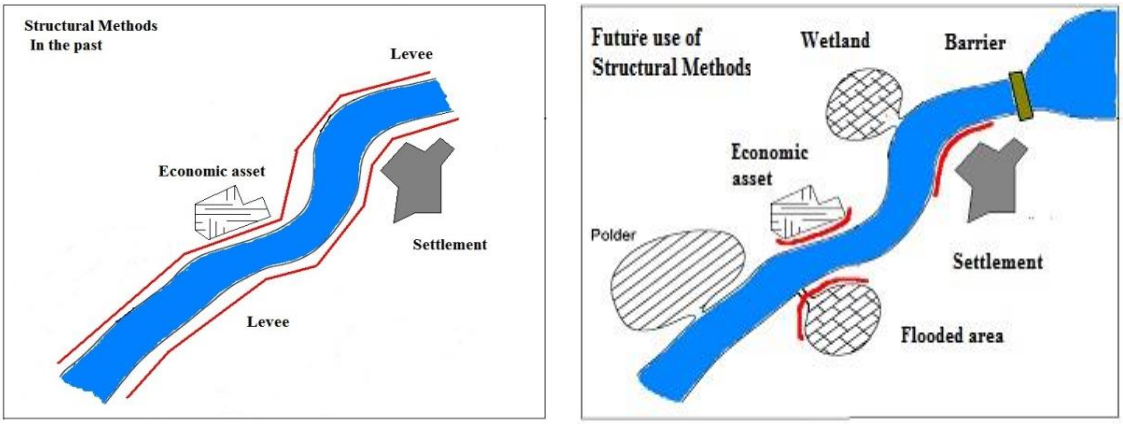

Figure 4 Future use of Structural Methods with introduction of wetland areas - Source: ANAR 2006.

5. Conclusions and Discussions

In conclusion the structural method term is used mainly by experts, being a complex and collective term (Schanze, 2004), which is less understood and preferred by local communities (Schanze, 2004; Luncaciu, 2006), some local authors use the 'hydraulic works' term (Ielenicz et al., 2007), others such as Yervjevich (1994) use physical control methods or physical interventions (Schanze, 2004). Recent definitions tend to present these methods linked with their negative impact on the environment and society, while traditional definitions stress the importance and advantages of structural methods.

There are similarities between developmental contexts of structural methods' implementation, the 'hydro-politics' of ancient societies were replicated by modern societies in the West and by communist societies in Central and eastern Europe (e.g. Romania) and rivers were used to promote ideologies and propaganda of states systems at the time, as qualities of a river were attributed to nations.

In Romania the interwar discourse was not different from the current discourse regarding flooding, inefficiency of bureaucracies implementing big structural methods for hydro-amelioration and that Mississippi's case study was presented by scientists of the time as a lesson to learn before irremediably transforming Danube's floodplain through a system of un-submergible levees and dykes.

The prediction of Greceanu (1933) regarding loss of fishery for Danube's floodplain communities such as Gostinu is now a reality. Areas that once had a production of 600 kg of fish per ha of natural floodplain are now part of agricultural precincts affected by infiltrations. According to Gostinu's Mayor, once in three years, 10-15% of the arable land of Gostinu village is affected by infiltrations from underground and the accumulation of water in certain areas known to be the old ponds and lakes represented above on Fig. 3. Therefore nature is trying to re-establish its presence, reinstating its floodplain environment in areas that once were natural ponds and lakes.

Gostinu's community has evolved from a community living in harmony with nature and having a mixed economy based on semi-wild livestock breeding and growing, fishing from floodplain ponds and lakes and Danube and agriculture practiced on raised areas to a community relying on agriculture. The only problem is that agriculture is dependent on the system of drainage and irrigation put in place by the communist system. After 1989 the drainage and irrigation system is barely functioning due to high cost of electricity (ANIF price per hours of functioning, 2014) and lack of maintenance (Mihnea et al., 2008).

The context in which structural methods function is very important. In Romania, during the communism, the system was completely centralised, electricity was produced by state companies for a high costs (environmental costs too), which was paid by high agricultural productivity, agriculture being practiced intensively and extensively on land, which had only one owner - the communist state. The system seems now redundant as the majority of land owners in Giurgiu county and Gostinu village are subsistence farmers having less than 5 ha of land (Tempo online data base of the National Institute for Statistics, 2014) and being unable to practice competitive agriculture and pay for a run-down high-maintenance cost drainage and irrigation system build in the '60s and '70s.

Studying the historical evolution of structural methods implementation and the contexts in which they are implemented gives insights into the types of problems created by them, most important being the transversal and longitudinal discontinuity inducing loss of biodiversity and loss of space for water to flow towards lakes and ponds, which are repository of waters, with great potential in flood prevention. However, implementation of structural methods in some places such as the Gostinu study area shows that the long term impact is a reduction of possibilities of adaptation for the local communities. This shows that structural methods planned, implemented and maintained based on ideologies of any kind and without public participation and contribution of local communities are not viable any longer. The principles of sustainable development should be at the foundation of any structural method implementation.

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