RURALIZATION FOR WATER RESOURCES MANAGEMENT IN URBAN AREA REVISITED

RURALIZAÇÃO REVISITADA PARA GESTÃO DE RECURSOS HÍDRICOS EM ÁREAS URBANAS

RURALIZACIÓN REVISITADA PARA LA GESTIÓN DE RECURSOS HÍDRICOS EN ZONAS URBANAS

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ABSTRACT
The present study briefly evaluated the history of institutional and scientific aspects involving hydrology. In this evaluation, it is observed that hydrology is increasingly closer to society, discussing the interactions between society and hydrological processes. Therefore, hydrology has focused on analyzing the urban area, because this area has higher demographic concentration and larger socioeconomic and environmental problems. From a hydrological point of view, and considered as a set of removals from the natural conditions of vegetation, soil and rainwater, urbanization generates negative effects. On the other hand, in 2000 the ruralization of urban areas was proposed, which is the opposite process to urbanization. Therefore, this study revisited these concepts with approaches related to hydrology, philosophy and applied practices. Using the philosophical aspects "Small, Slow, Simple, Soil and Science are beautiful" as well as socio-hydrological knowledge, some ruralization actions such as urban storage, the rainwater utilization and urban agriculture were presented in detail. These actions should be supported with school catchments.

Keywords: Socio-hydrology; Urban storage; Urban agriculture; Rainwater utilization; School catchment.

RESUMO
O presente estudo avaliou brevemente a história dos aspectos institucionais e científicos que envolvem a hidrologia. Nessa avaliação, observa-se que a hidrologia está cada vez mais próxima da sociedade, discutindo as interações entre a sociedade e os processos hidrológicos. Portanto, a hidrologia tem focado em analisar a área urbana, pois esta apresenta maior concentração demográfica e diversos problemas socioeconômicos e ambientais. Do ponto de vista hidrológico, e considerada como um conjunto de remoções das condições naturais de vegetação, solo e água da chuva, a urbanização gera efeitos negativos. Por outro lado, no ano 2000 foi proposta a ruralização das áreas urbanas, que é o processo contrário à urbanização. Portanto, o presente estudo revisitou estes conceitos com enfoques relacionados à hidrologia, filosofia e práticas aplicadas. Utilizando os aspectos filosóficos "Pequeno, Lento, Simples, o Solo e a Ciência são lindos" e também os conhecimentos socio-hidrológicos, algumas ações de ruralização como o armazenamento urbano, o aproveitamento da água da chuva e a agricultura urbana foram apresentadas detalhadamente. Todas as práticas devem ser realizadas com os dados obtidos nas bacias-escola.

Palavras-chave: Socio-hidrologia; Armazenamento urbano; Agricultura urbana; Aproveitamento da água da chuva; Bacia-escola.

RESUMEN
El presente estudio evaluó la historia de los aspectos institucionales y científicos relacionados con hidrología. En esta evaluación, se observa que la hidrología, como ciencia, está cada vez más próxima de la sociedad, discutiendo las interacciones entre la comunidad y los procesos hidrológicos. De esta forma, la hidrología se ha centrado en analizar el área urbana, ya que tiene una mayor concentración demográfica y varios problemas socioeconómicos y ambientales. Desde el punto de vista hidrológico, es considerada como un conjunto de extracciones de las condiciones naturales de vegetación, suelo y agua de lluvia, la urbanización genera efectos negativos. Por otro lado, en el año 2000 fue propuesta la ruralización de áreas urbanas, que es el proceso opuesto a la urbanización. Así, este estudio revisó estos conceptos con enfoques relacionados con hidrología, filosofía y prácticas aplicadas. Utilizando los aspectos filosóficos "Pequeño, Lento, Simple, el suelo y la ciencia son hermosos" y también los conocimientos socio-hidrológicos, se detallaron algunas acciones de ruralización como el uso de agua de lluvia y la agricultura urbana, siempre en el contexto de una aplicación dirigida a cuencas-escuela.

Palabras clave: Socio-hidrología; Almacenamiento urbano; Agricultura urbana; Uso de agua de lluvia; Cuenco-escuela.

1. INTRODUCTION

Why does each individual or a group of individuals, i.e., the society, look for the health? Its answer may be encountered when the sustainable development of the society (UN, 2015) is treated. Health can be defined as a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity (WHO, 1946). Considering this definition, without health, each individual or society in general cannot achieve happiness, a good quality of life and, consequently, its sustainability. Therefore, as long as a society has problems, it can be considered unhealthy.

One of society's greatest concerns throughout history has been the guarantee of access to water resources. In order to ensure the happiness, health and sustainable development of society, an adequate management of water resources is required in any basins where human occupation is encountered. The typical place with intensive activities of the society may be an urban area. From a hydrological point of view, conditions in urban areas are deteriorating considerably. In this context, Kobiyama (2000) presented the concept of ruralization for water resources management in urban area. Afterwards, more than two decades have passed. Some parts of science and technology associated to water recourses management have been improved while socioeconomic and environmental problems in urban areas have been more complex and serious.

Therefore, the objectives of the present work were: (i) to revisit the concept of ruralization for water resources management in urban areas from a new hydrological point of view; (ii) to present ruralization practices based on some philosophical aspects; and (iii) to emphasize the importance to construct school catchments with citizen science.

2. HYDROLOGY

2.1. Institutional aspects

The League of Nations (LN) was an intergovernmental organization founded on January 10th 1920, as a result of the Paris Peace Conference which ended World War I. Passing 26 years, on April 20th 1946, LN was replaced by the United Nations (UN) after the end of World War II. Then the UN inherited a number of agencies and organizations founded by the LN.

The name UN had been already in use when the United Nations Declaration was made on January 1st, 1942. However, shortly after the end of World War II, the UN started to officially exist on October 24th 1945 when the UN Charter was ratified by the governments of UK, France, Soviet Union, China and USA, and by other 46 signatory countries. Due to this signature, the October 24th is celebrated as "UN Day". To achieve its goals, the UN currently has several programs and specialized agencies such as FAO, IPCC, UNDP, UNEP, UN-HABITAT, UNICEF, UNV, UN Water, UN Women, WHO and WMO. The United Nations Educational, Scientific and Cultural Organization (UNESCO) was founded in Paris on November 4th, 1946, with the aim of contributing to peace-building, poverty eradication, sustainable development and intercultural dialogue through education, sciences, culture, communication and information.

In the 1950s, the water crisis was exacerbated due to global water shortages, which forced UNESCO to establish the Committee on Arid Zone Research. In 1965, UNESCO launched the International Hydrological Decade (IHD) with the principal objective to accelerate the scientific study of water systems for improving the water conservation, management and use (NACE, 1969). One year before the beginning of the IHD, UNESCO (1964) defined hydrology as the science which deals with the waters of the earth, their occurrence, circulation and distribution on the planet, their physical and chemical properties and their interactions with the physical and biological environment, including their responses to human activity. Furthermore, in this definition, hydrology is considered a field which covers the entire history of the cycle of water on the earth.

Due to the persistence of the water crisis in several countries and the importance of the issue for society, UNESCO initiated the International Hydrological Programme (IHP) in 1975. Up to now, 8 phases have been carried out: IHP-I (1975−1980), IHP-II "Hydrology and the Scientific Bases for Rational Water Resources Management" (1981−1983), IHP-III (1984-1989), IHP-IV "Hydrology and Water Resources Sustainable Development in a Changing Environment" (1990−1995); IHP-V "Hydrology and Water Resources Development in a under Vulnerable Environment" (1996−2002), IHP-VI "Water Interactions: Systems at Risk and Social Challenges" (2002−2007), IHP-VII "Water Dependencies: Systems under Stress and Societal Response" (2008−2013); and IHP-VIII "Water Security: Responses to Local, Regional and Global Challenges" (2014−2021). Jimenez-Cisneros (2015) mentioned that the main objectives of the IHP are to mobilize scientific and innovation networks; to strengthen the interface between scientists and decision makers; and to develop institutional and human capacities.

Currently, the IHP is on the eighth phase, dedicating to water security which is defined, according to Bigas (2013) and Jimenez-Cisneros (2015), as the capability of a population to safeguard access to adequate amounts of water with acceptable quality for maintaining human and ecosystem health at basin levels, and to ensure effective protection of life and property against water-borne pollution and the water-related hazards (floods, landslides, land subsidence and droughts) and also socio-economic development for these actions. The Phase VIII consists of six main themes: (i) water-related disasters and hydrological change; (ii) groundwater in a changing environment; (iii) addressing water scarcity and quality; (iv) water and human settlements of the future; (v) ecohydrology and engineering harmony for a sustainable world; and (vi) water education, key for water security.

In addition to the IHP, the United Nations General Assembly also promotes annually World Water Day which has been commemorated on March 22nd since 1993, and this Day intends to promote public awareness of the conservation and development of water resources. One of the main focuses of World Water Day is to support the achievement of the sixth Sustainable Development Goal (SDG) established by UN (2015), which seeks to bring water and sanitation to the entire population by 2030. In this sense, these observances serve to emphasize that activities promoting access to water and basic sanitation for the population are essential for poverty reduction, economic growth, and environmental sustainability (UN, 2021).

Thus, exists internationally an attempt to solve water-related problems and to guarantee the life quality of the world population with hydrological studies. This fact implies that the application of hydrology for various sectors has been increasingly important. In 1922, the International Association of Hydrological Sciences (IAHS), which is one of the major communities of hydrology at the international level, was founded. Initially it was called the International Association for Scientific Hydrology (IASH), but in 1971, the name was changed to IAHS. The IAHS is one of eight associations that constitute the International Union of Geodesy and Geophysics (IUGG).

The IAHS has been carrying out scientific decade programs. Its Scientific Decade 2003-2012 “Predictions in Ungauged Basins – PUB” was performed for two main objectives: (i) examination and improvement of existing hydrological models to predict in ungauged basins through appropriate measures of predictive uncertainty; and (ii) development of new, innovative models representing the spatio-temporal variability of hydrological processes for making predictions in such basins with a concomitant reduction of predictive uncertainty (SIVAPALAN et al., 2003). Although Hrachowitz et al. (2013) reported that this Decade was successful, the Decade recognized the importance of understanding hydrologic heterogeneity in the soil, and showed the increasing need for observation and monitoring in the field. Attempts to create models that do not need to measure the hydrologic variables (PUB) ironically demonstrated the need for hydrological monitoring in the field. Hydrology should be, like other sciences, developed with basis on observation of real phenomena, especially by conducting field monitoring activities.

Based on the recognition obtained during the Decade 2003-2012 as well as the world situation, the IAHS started another Decade, i.e., IAHS Scientific Decade 2013-2022 (MONTANARI et al., 2013). Its title is “*Panta Rhei* Everything Flows: Change in hydrology and society”. Reflecting on the results of the Decade PUB, the Decade *Panta Rhei* puts the needs to intensify the hydrological monitoring and to study the interactions between hydrological processes and society. This trend has been recently causing a more intense discussion on the relationship between hydrology and society, making the socio-hydrology more popular (FALKENMARK, 1979; SIVAPALAN; SAVENIJE; BLÖSCHL, 2012; SIVAKUMAR, 2012; DI BALDASSARRE et al., 2013, 2019; MADANI; SHAFICE-JOOD, 2020).

Here it is worth mentioning that McCurley and Jawitz (2017) showed some modern issues about water resources to force the adaptation of scientific viewpoints towards an interdisciplinary context and analyzed an international trend in the various areas of hydrology through the use of the term “Hyphenated hydrology”. Their analysis highlighted socio-hydrology. Hence, the socio-hydrology will be surely one of the main and important subdivisions of hydrology. By observing the activities of UNESCO and IAHS, it can be thought that, at the institutional and scientific levels, hydrology considers the society much more now than before. In other words, hydrology can no longer exist regardless of society.

2.2. Scientific aspects

In observing rainfalls, rivers, wells and so on, not only McDonnell (2003) but also any citizen sometimes has relatively-simple questions: "Where does the rainwater falling onto the ground go?"; "When will the rainwater entering into the soil reach the river?"; "Which way does the groundwater look for to reach the river?". These simple questions are all related to the streamflow generation mechanism which is the main topic of hydrology. The discussion on the streamflow generation mechanism in hydrology was well reviewed and described by Beven (2006).

According Kobiyama, Mota and Corseuil (2008), three principles of hydrology are: (i) hydrological cycle; (ii) spatial heterogeneity; and (iii) temporal heterogeneity. The hydrologic cycle naturally occurs and consists of the hydrological processes, causing the spatial and temporal heterogeneities of water over the whole planet during the whole time. As mentioned above, one of the most important recognitions obtained during the Decade PUB is the important role of such heterogeneities in the hydrological cycle.

In practice, water transfer between basins is the primary measure that the society has been carrying out to reduce the spatial heterogeneity of water resources. Although there are several controversies regarding the implementation of basins transposition in Brazil, for example, the water transfer of São Francisco river (CASTRO, 2011), the survival of society which suffers from the spatial heterogeneity of water resources often requires the execution of this type of measure.

Other practical action to reduce the temporal heterogeneity is the construction of the water storage systems. At the basin level, this system is the dam and reservoir combination, while at the houses and buildings level, water tanks and/or cisterns (GROUP RAINDROPS, 1994).

The modification of the spatial and temporal heterogeneities of water in order to obtain its best condition for society can be done with water resources (or hydrological) engineering. For getting the best performance of this engineering, it is necessary to study hydrological heterogeneities through monitoring and modeling. Figure 1 schematically shows the principles of water resources and the corresponding human actions.

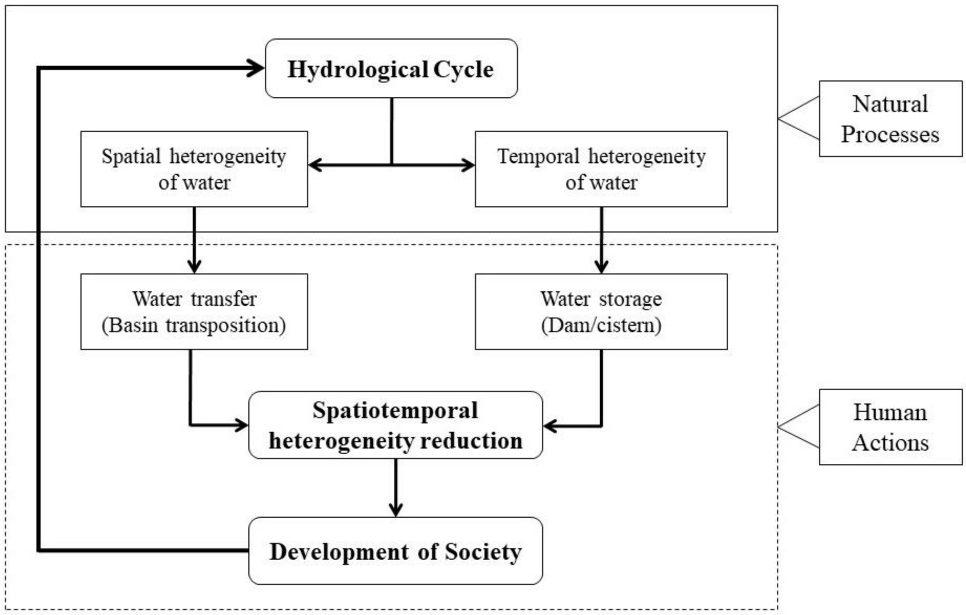

Figure 1 - Relations of water-human system.

3. TYPICAL PLACES WITH SOCIOECONOMIC AND ENVIRONMENTAL PROBLEMS

The disaster is defined as a serious disruption of the functioning of a community (or a society) at any scale due to hazardous events interacting with conditions of exposure, vulnerability, and capacity, leading to one or more of the following: human, material, economic and environmental losses and impacts (UN, 2016). Flood, landslide, drought, tornado, hail, typhoon, earthquake, volcano eruption, tsunami, among others, are just natural phenomena. When these intense phenomena occur in places, where the society is active, and result in damages, they generate natural disasters (KOBIYAMA et al., 2006).

In other words, the socioeconomic and environmental problems, or natural disasters depend strongly on the presence of the population as well as the population quantity and density. As Moreira, Brito and Kobiyama (2021) demonstrated in flood vulnerability studies' review, places where people live with larger concentration have more problems. This fact is also confirmed by Kotkit (2020) which studied the pandemic with the COVID-19. Hence, an urban area having higher density of population usually suffers from more socioeconomic and environmental problems. This fact naturally supports an argument for governments to engage more in the management of urban areas.

Using data from the demographic research in Brazil which the Brazilian Institute of Geography and Statistics – IBGE has been carrying out since 1940, the present work graphically shows the change of urban and rural populations in Brazil during the period from 1940 to 2010 (Figure 2). In the 1960s, the urban population exceeded the rural one in Brazil. A slight reduction of the rural population can be observed after 1970 while the urban population growth rate is always high during the analyzed period.

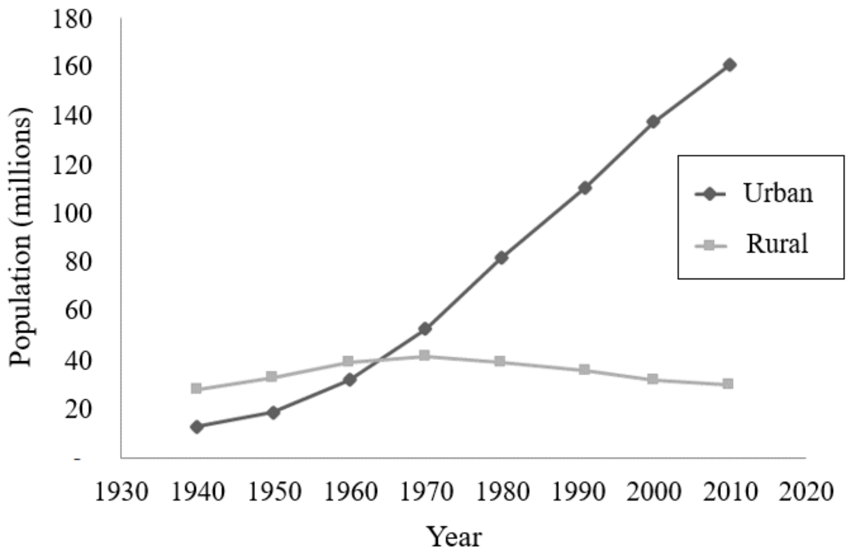

Figure 2 - Urban and rural population in Brazil during the 1940-2010 period.

Although it is very common to use the terms of urbanization, urban planning, and urban areas, there is no international consensus on criteria to determine the boundaries of urban areas or to identify an urban area. Chaolin (2020) explained the urbanization as social process associated to the increasing industrial structure. In many countries, settlements designated as urban are expected to serve certain administrative functions (McGRANAHAN; SATTERTHWAITE, 2014). For example, in Brazil, the Article 32 of the Law No. 5172 defined the urban area by observing the minimum requirement of the existence of improvements constructed or maintained by the government with at least two of the following items: (i) the pavement with rainwater drainage; (ii) water supply; (iii) sewage system; (iv) public lighting network, with or without lamp posts for home delivery; and (v) primary school or health service center at a distance of 3 km from the considered site (BRASIL, 1966).

Urbanization has positive and negative effects on various aspects (society, economy, culture, health, environment, etc.) Several discussions about hydrological effects of urbanization have been done by urban drainage managers and researchers, for example, Niemczynowicz (1999), Delleur (2003), Tucci and Bertoni (2003), Akan and Houghtalen (2003), Ress, Hung and James (2020). In hydrology, the rate of impermeable areas is commonly used to quantify the urbanization degree. In this case, the more impermeable area, the more advanced urbanization. With this criterion and various researches' results, there are common recognitions in terms of the hydrological effects. Exaggerated urbanization without adequate planning generates negative hydrological effects such as: (i) increasing the hydrograph peak; (ii) increasing erosional processes and producing more sediment; (iii) generating flood areas; and (iv) intensifying water pollution. Even though every society expects to improve its comfort and happiness with all the actions of urbanization, these actions usually exercise negative effects by changing hydrological processes in basins.

Figure 3 schematically demonstrates how urbanization adversely affects society. In urban areas, due to the demand of water supply, the society constructs many wells to explore groundwater, which may cause the land subsidence. The soil sealing increases the hydrograph peak and makes shorter the occurrence time of this peak due to the increase in the surface flow velocity, which consequently generates floods and surface erosion more frequently. These natural hazards (flood, erosion and land subsidence) certainly destroy the infrastructure. Moreover, soil sealing reduces the amount of water infiltrating into the soil, and reduces the low flow, which may cause the water shortage in rivers. Urbanization increases the released amount of sewage and waste to the environment. It certainly causes deterioration of the quality of surface and groundwater, which also creates water scarcity situation in society.

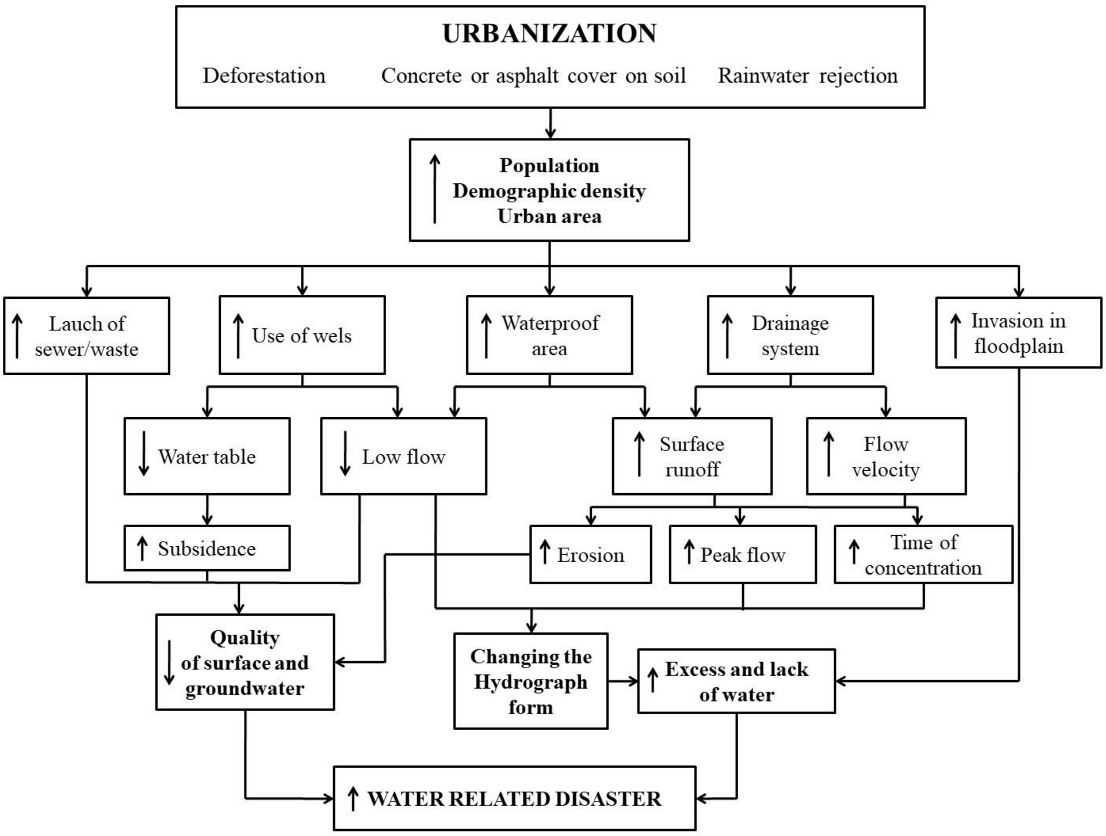

Figure 3 - Hydrological effects of urbanization.

Thus, despite the many efforts of urban drainage managers, the general public, on the contrary, begins to feel that urbanization negatively affects urban development from the hydrological point of view. Although the demonstration of Figure 3 is geared to the urban area, the context might be also valid in rural areas.

4. RURALIZATION

4.1. General concept

Kobiyama, Mota and Corseuil (2008) described some sanitation techniques, for example septic tank, wetland system, rainwater harvesting and utilization, and composting. Although all of them are performed in both urban and rural areas, these techniques can be found more commonly in rural areas than in urban areas. Some of sanitation techniques in urban and rural areas are briefly presented in Figure 4. An analysis of the cost-benefit and energy efficiency for each technique shows that rural sanitation techniques can be usually better than urban ones.

URBAN	RURAL
Water supply system Water treatment plant	Water harvesting and utilization system Cistern
Sewage collection Sewage treatment plant	Septic tank Wetland system
Landfill Dumping ground	Compositing Vermicomposting
Urban drainage	Reservoir/Dam Irrigation and agricultural drainage

High technology Modern High energy consumption Larger scale	Simple technology Antique High efficiency Smaller scale

Figure 4 – Comparison of sanitation techniques between urban and rural areas.

The observation of the recent tendency where many people in cities frequently seek ecotourism, rural tourism, farm hotel, among other rural contents, supports to say that rural condition is often better than the urban one. According to information from the Chico Mendes Institute for Biodiversity Conservation (ICMBio), Brazilian conservation units received approximately 15 million visitors in 2019 (ICMBio, 2020). This reinforces the fact that society is increasingly looking for exercising more activities in natural environments. Looking for proximity to the so-called "rural life" is strongly related to the new life-values, especially in urban area. It is as if the individual or society seeks simple life, slow life-pace, fresh air and human-life quality, as opposed to urban.

Thus, questioning the modern urbanization which negatively affects the society, and based on the hydrological point of view, Kobiyama (2000) defined urbanization as the set of three actions: (i) removal of vegetation and soil, (ii) the land cover with concrete and asphalt, and (iii) rainwater rejection by making it go away as fast as possible through the urban drainage system. Because of the current situation where the advance of urbanization intensifies water and environmental problems bringing disasters to society, the author proposed still the ruralization concept to live together with vegetation, soil and rainwater.

The ruralization was defined as a set of actions to retrieve vegetation, soil and rainwater with their uses and harmonious coexistence (Figure 5). Being process contrary to modern urbanization above mentioned, ruralization in urban areas can be considered as a new stage in sustainable urban development. The environment mainly consists of vegetation, soil and water, being that the action to reject those environmental components is normally called urbanization, meanwhile the action to live together with them is called ruralization. The culture leading to ruralization can be called “ruralism” which is naturally born in the rural environment.

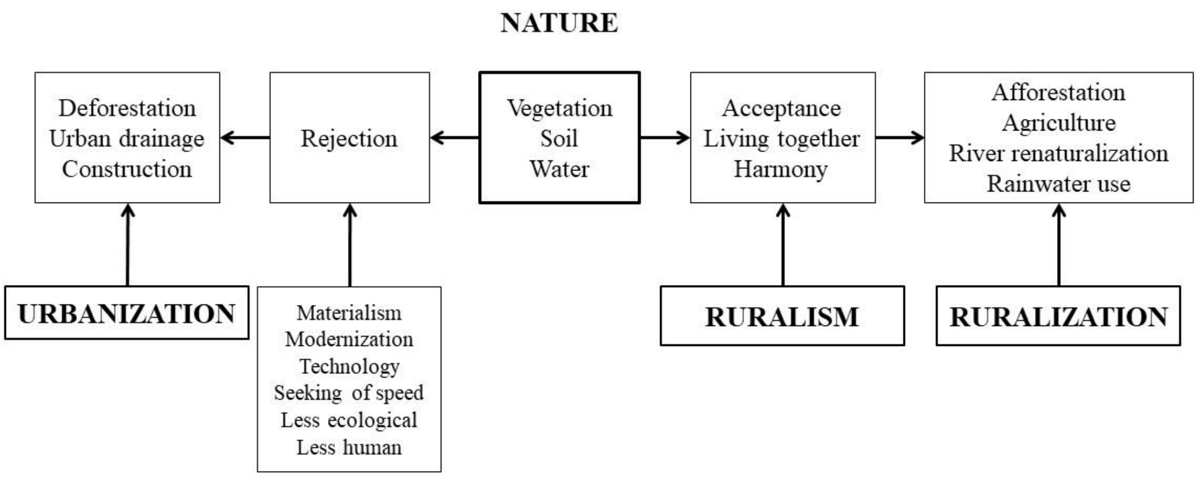

Figure 5 - Concepts of ruralization and ruralism.

4.2. Philosophical aspects

Through the comparison between two opposite actions: urbanization and ruralization, it is understood that human action entirely relies on the philosophy that an individual or society has. Thus, any activities should be carried out with an adequate philosophy so that they can be successful. Based on the philosophical principle of the book "Small is Beautiful" written in 1973 by the German economist E. F. Schumacher (1911-1977), the present study proposes five major philosophical aspects for developing any activities in the ruralization.

According to Schumacher (1973), the current world, built on the modern philosophy, science and technology, had begun to face three crises: (i) the human nature is suffocated by inhuman technology and organizations; (ii) the environment that sustains human life is damaged and has already shown the first symptoms of collapse; and (iii) important non-renewable natural resources, such as oil, are depleted in current economic growth models. These crises resulted from materialism and belief in giant technology that arose in the context of ambition, individualism, and wealth concentration. Therefore, the author emphasized that the methods and tools used in education, technology, urbanization, industry, agriculture, economy, and so forth should be small and low-cost enough for almost everyone to acquire, and encouraged each person’s creativity. Thus, the concept “Small is Beautiful” was proposed and is still now an international slogan.

In a similar philosophical line of sustainable development, but another aspect, Tsuji (2001) proposed a concept "Slow is Beautiful" in his book, and emphasized the importance of slowness in the social development process, for example, slow business, slow food, and slow knowledge. Extending the concept "Slow is Beautiful" to hydrological engineering, Kobiyama, Mota and Corseuil (2008) mentioned that urban drainage also needs to reduce the speed of the hydrological cycle to minimize water-related disasters.

Furthermore, in order to implement structural and non-structural measures at a smaller scale that can reduce the water flow speed and water-related risk, Kobiyama, Mota and Corseuil (2008) manifested the necessity of more simple measures, and proposed the concept "Simple is Beautiful". Simplicity can lead to various benefits such as lower costs, elevated accessibility and lower energy consumption. For advancing hydrology, Dooge (1997) emphasized the importance of systematically looking for simple models which involve the fewest possible assumptions and a low number of parameters. In a telecommunication sector, Demers (2019) also explained why the future of technology lies in simplicity. Hence simple ways are very important in science and technology.

To obtain simple measures in small-scale which allow the slower water dynamics, society needs a more adequate science that theoretically supports. Then, Kobiyama, Mota and Corseuil (2008) quoted famous words of the Polish and French physicist/chemist Marie Curie (1867-1934), i.e., "*We must not forget that when radium was discovered no one knew that it would prove useful in hospitals. The work was one of pure science. And this is a proof that scientific work must not be considered from the point of view of the direct usefulness of it. It must be done for itself, for the beauty of science, and then there is always the chance that a scientific discovery may become like the radium a benefit for mankind*." As an adequate management of water resources requires correct understandings of hydrological processes, the authors used her words and emphasized that the science or more specifically hydrological sciences must be beautiful, saying "Science is Beautiful".

To these four aspects "Small, Slow, Simple and Science", Kobiyama, Chaffe and Aguiar Netto (2014) furthermore added the importance of valorization and consideration of soil. The soil hydraulic properties influence on hydrograph forms (TANI et al., 2020), increasing or reducing the hydrograph peaks and making steeper or gentler recession curves. The microbiological activities of soil degrade chemical compositions of sewage and waste onside and inside the soils. The more study of soil characteristics, the more recognition of the importance of socioeconomic and environmental pedo-functions, which are well-known as ecosystem services (e.g., MILLENNIUM ECOSYSTEM ASSESSMENT, 2005; BIRKHOFER et al., 2015; BAVEYE; BAVEYE; GOWDY, 2016; BAER; BIRGÉ, 2018). However, society does not have much practice to utilize the soil ecosystem services. This fact, i.e., insufficient use of soil ecosystem services, is not new. Short before World War II, when the XXXII President of the United States, Franklin D. Roosevelt (1888-1945) observed the soil loss in various regions within his country, he sent all the state governors the letter on soil conservation law. Roosevelt (1937) wrote "*The Nation that destroys its soil destroys itself*". It is exactly true and has been seen a lot during the human history (e.g., HILLEL, 1991; MONTGOMERY, 2007). Not only for understanding soils, but also for protecting them and using their ecosystem services better, soil sciences should be more advanced.

Resuming the above mentioned considerations, the five important philosophical aspects for ruralization in urban areas are:

- Small is beautiful.
- Slow is beautiful.
- Simple is beautiful.
- Soil is beautiful.
- Science is beautiful.

Based on these aspects, various practices of ruralization should be exercised not only in urban areas but also in rural ones.

5. PRACTICES OF RURALIZATION

Since ruralization seeks to live together with the plants, understanding the functions of the forest ecosystem may be important. These functions are: (i) climate mitigation (especially temperature and humidity); (ii) hydrograph mitigation; (iii) erosion control; (iv) improvement of water quality in the soil and river; (v) reduction of air pollution; (vi) oxygen supply and carbon dioxide sequestration; (vii) prevention of wind and noise; (viii) amenity, recreation and education; (ix) production of biomass, medicine and food; (x) energy supply; (xi) history statement (witness), among others. The essential feature of the forest can result from the simultaneous execution of all its functions even though the effectiveness degree of each function varies. For example, one person can think that an air-conditioning system can reduce the high temperature in a room on a very hot day more than the forest does as its function of climate mitigation. Indeed, the effect of the forest for reducing the maximum temperature might be smaller than that of the air-conditioning system at the room level. However, the forest exerts other functions like hydrograph mitigation and erosion control while the air-conditioning system never does. Thus, the use of the forest in urban areas, i.e., urban forestry, is one of the main practices of ruralization. For increasing the total porosity of soil, fixing CO_2 into the soil and producing food and medicine, agriculture should be introduced to the urban environment, as urban agriculture (SMIT; RATTA; NASR, 1996).

Sanitation techniques in more rural way (Figure 4) can be implemented more extensively. However, since these rural techniques certainly demonstrate their high efficiency when implemented at a small scale, sanitation must be decentralized (RONDINELLI; NELLIS; CHEEMA, 1983; LENS; ZEEMAN; LETTINGA, 2001; BERNAL; RESTREPO; GRUESO-CASQUETE, 2021). In other words, decentralization of sanitation is a typical practice of ruralization in urban areas. Though there are many ruralization techniques in this way, the present study discuss just urban storage, rainwater utilization, urban agriculture and school catchment implementation, by considering the above-mentioned philosophical aspects.

5.1. Urban storage

The concept "Slow is beautiful" implies the necessity to increase the roughness on the watercourse and to store water in urban drainage in order to make flows slower. The increase of roughness can be achieved in two ways: (i) increase the coefficient of roughness by putting obstacles on the surface and by creating larger friction against the flow; and (ii) prevent the straightening of watercourse (e.g., do not make the artificial channel straightened in meandering rivers). Under natural conditions, a basin normally has the larger coefficient of roughness and more meandering channel. With its high storage capacity, the natural basin slows the water flow. According to de Boer and Bressers (2011), the work which artificially creates a river with a natural feature is called the river renaturalization. Its implementation processes are very complex and dynamic. Though the renaturalization processes were discussed for riparian zone recovery by Souza and Kobiyama (2003) and Kobiyama et al. (2020a), such processes should be more performed more in urban environment.

In order to solve problems caused by the rainwater excess in the urban area, the classical and usual urban drainage practices which are parts of urbanization have tended a reduction of both surface roughness and channels' meandering, and consequently have increased the water flow velocity. They are all to try to remove (drain) rainwater from the interested site as rapidly as possible to other places. Kobiyama, Mota and Corseuil (2008) suggested a reversal of this logic, coining the term "urban storage system", as opposite practice to urban drainage system. It is just to emphasize the establishment of slower speed in the hydrological cycle in urban areas by using storage system. The principal problem results from the concept "drainage basin", for example, Gregory and Walling (1973) which considered a basin as drainage system.

In hydrology and geomorphology, it is common to use the concept "drainage basin". Such common consideration has been erroneously brought to urban drainage practices. As seen in some hydrological models like Tank Model (SUGAWARA, 1961) and Bucket Model (MANABE, 1969), the essential function of a basin can be water storage not water drainage. It might be time to change this concept "drainage basin" to "storage basin" in both hydrology and geomorphology. Then urban drainage system would be technologically transformed to urban storage system.

Through hydrological monitoring in Mineirinho creek basin in São Carlos municipality, Brazil, and hydrological modeling of scenarios of 1972 and 2025, Benini and Mendiondo (2015) investigated the effect of the municipality's Master Plan (Figure 6). The result showed that the Master Plan would be able to reduce the negative impact of urbanization in this basin but that urbanization executed with the Master Plan still keeps the high potential flooding problem. According to the authors, the runoff over 9 m^3/s triggers the flood in this study area.

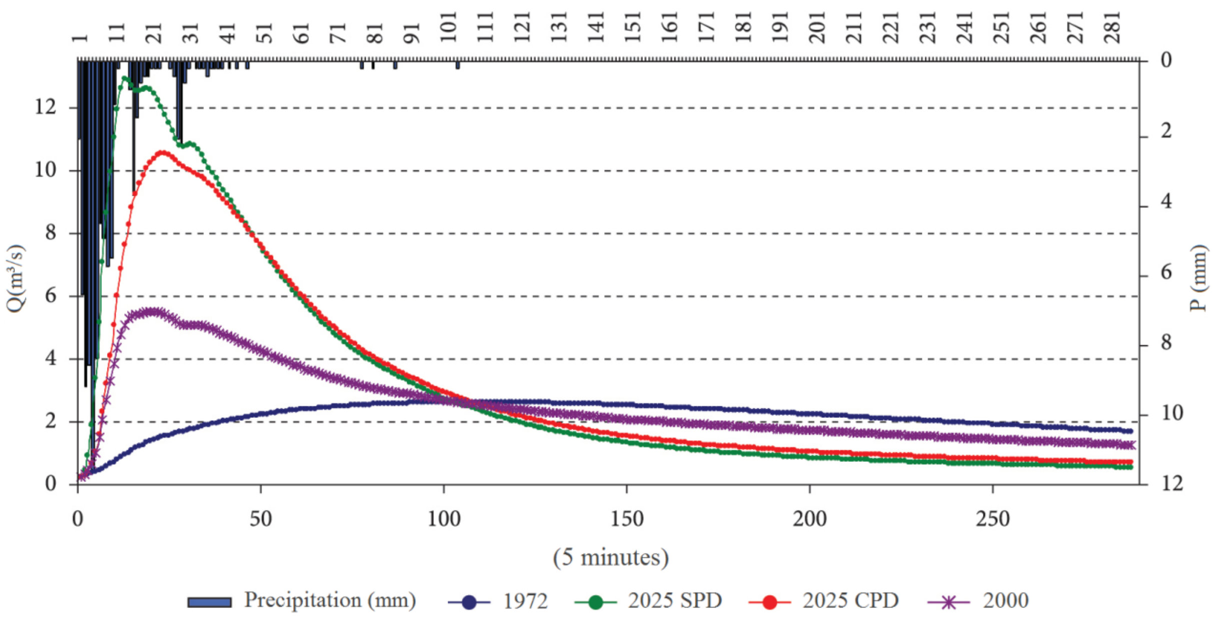

Figure 6 - Hydrograph simulation with different scenarios in Mineirinho creek Basin, São Carlos municipality, Brazil. SPD and CPD mean the scenarios with and without the Master Plan, respectively. Source: Benini and Mendiondo (2015).

This type of problem related to a Master Plan results from the lack of urban storage concept. Considering only riparian area as permanently-preserved area is not sufficient for a Master Plan of Urban Drainage – MPUD. The water storage capacity of the basin is related to the soil type and land use. Regarding this use, one basin can have human-activity areas (croplands, leisure lands, commercials, industries, residential area, etc.) and preserved ones (forests, wetland, etc.). As the MPUD affects the land use, it must contain the urban storage concept. The MPUD that takes into account the storage concept will be able to keep slow speeds and water storage condition over time, independent of urban growth. In this sense, the introduction of distributed (decentralized) structural measures into an urban storage system can contribute to the Hydrologically-Zero Impact (HZI) on urban context. The HZI refers to a condition where any human activities in a basin maintain its mean capacity of water storage (KOBIYAMA; MOTA; CORSEUIL, 2008), and analogically has the sense similar to a zero-emission action, proposed by Pauli (1998) for sustainable development.

5.2. Rain water harvesting and use

One of the distributed (decentralized) structural measures is the rainwater harvesting and utilization system. The rainwater utilization techniques are characterized with smaller scale and fairly simple structure. Making rainwater storage, they reduce the flow speed of the hydrological cycle in urban areas. Analyzing these systems as a case study in Florianópolis municipality, Brazil, Kobiyama and Hansen (1998) demonstrated its positive effects on the social, economic and hydrological aspects. Thus, the rainwater harvesting and utilization techniques should be inserted into the urban storage system.

These techniques are not new in the world. However, it can be said that their significant disclosure took place with Group Raindrops (1994). This Japanese book was translated into various languages, including Portuguese language in 2002. In Brazil, these techniques have been widely diffused, for example, Dacach (1979), Silva et al. (1984), Daker (1987), Silva, Brito and Rocha (1988), Azevedo Netto (1991), Tomaz (1998), Kobiyama, Checchia and Silva (2005) and Kobiyama et al. (2007). Now many municipalities, especially large cities in Brazil, have municipal law that mentions a certain obligation of rainwater harvesting system. In the case of the state of São Paulo, the Law No. 12.526/2007 establishes the mandatory capture and retention of rainwater in lots that have an impermeable area larger than 500 m^2, with the purpose of reducing the flow velocity and controlling the flood occurrence (SÃO PAULO, 2007).

Table 1 shows the advantages and disadvantages of these techniques in the social, economic and environmental (hydrological) aspects, where it is clearly noted that there are few disadvantages. Among a lot of advantages, their contribution to environmental education for inhabitants is considered the most important advantage.

Table 1 - Advantages and disadvantages of rainwater harvesting and utilization.

Aspect	Advantages	Disadvantages
Economic	• reduction of monthly expenditure of water and sewage • increase in the monthly family income after return of the initial investment	• depending on the employed technology, there can be high initial cost • it can increase the cost of electricity
Social	• life quality assurance for the certainty of no shortage of water • improved image in society, environmental agencies, etc. • environmental awareness	no
Environmental (Hydrological)	• preservation of water resources, mainly from surface water sources • reduction of peak hydrograph • flooding reduction • elevation of the water table	no

Source: modified of Kobiyama, Checchia and Silva (2005).

5.3. Urban agriculture and urban agroforestry

The urban agriculture can be defined as "an industry that produces, processes and markets food and fuel, largely in response to the daily demand of consumers within a town, city or metropolis", and could still be performed by economically-different people and with different objectives (SMIT; RATTA; NASR, 1996). Skar (2020) mentioned that there are various definitions about urban agriculture and that there are various technical terms which possess similar meanings, for examples, aquaponics, indoor agriculture, vertical farming, rooftop production, edible walls, urban farms, edible landscapes, school gardens, and community gardens. Considering various opinions, the present work defines urban agriculture as human activity to produce food, medicine and fuel in urban areas by using natural resources. In this case, urban agriculture is considered as the principal activity of ruralization in urban area.

Agriculture can be performed anywhere. According to Montgomery (2007), it has been practiced sporadically in the world over the last 13000 years. In modern times, it is generally thought that agriculture is practiced in rural areas and urban areas are where commerce and industry take place. Agricultural withdrawal from urban areas, or urbanization without agriculture can be one of the factors to create socioeconomic and environmental problems in urban areas.

Some of these problems can be seen in Figure 7, being that various measures to solve these problems are strongly related to urban agriculture. Significant contribution of urban agriculture to minimizing effects of climate change was affirmed by Skar (2020). Kobiyama, Minella and Fabris (2001) recommended vermicomposting application for recovery of degraded lands. Since urban areas produce organic waste, vermicomposting is very effective in agricultural and environmental issues, which certainly improves sanitation in urban areas.

Problems in urban areas	Measures
Water shortage	Water regime mitigation
Food shortage	Food production
Health inhibition	Medicine production/geotherapy
Isolates state of individual	Solidarity (agro-solodarity)
Land degradation	Composting and vermicomposting
Frequent flooding	Land-use change
Hydrological extreme events	Local climate change mitigation

Urban agriculture

Figure 7 – Relation between some problems in urban areas and urban agriculture.

One of social problems in urban areas is that many persons feel isolated. If one citizen participates in agricultural practices in an urban society, he (or she) will surely consolidate his (her) solidarity. Hence, this type of solidarity is herein called agro-solidarity or pedo-solidarity which is analogically similar to hydrosolidarity proposed by Falkenmark and Folke (2002) and extended by Falkenmark (2007), Gerlak, Varady and Haverland (2009) and Lima et al. (2012).

In order to improve the urban agriculture, based on the ecosystem services that forest executes, the implementation of agroforestry system must be increasingly encouraged in urban areas. However, it is very important to know positive and negative functions of forest depending on various natural phenomena (KOBIYAMA; MICHEL; GOERL, 2012). In any case, the urban agroforestry will be certainly very useful action in ruralization.

5.4. School catchment implementation

The "school catchment" refers to an experimental catchment that serves for environmental education activities of local people and scientific research (KOBIYAMA et al., 2009). Addressing issues related to (socio-)hydrology, (socio-)geomorphology, and so on, it can be efficiently and properly used for education and training related to the integrated management of water resources and natural disasters (KOBIYAMA et al., 2020b). Kobiyama, Michel and Goerl (2019) suggested the implementation of school catchments to manage debris flow disasters.

Analyzing the landslide disasters, Petley (2012) and Sepúlveda and Petley (2015) demonstrated a trend where countries with the higher number of scientific papers publications on landslides suffer less from these disasters. It implies that the Brazilian society also needs to go further in the studies about the social, economic and environmental problems in urban areas in order to minimize them. This argument makes the school catchment more important.

Figure 8 shows the use of the school catchment as the starting point for the water resources management. In each city, it is necessary to carry out, with school catchments, the hydrological monitoring of the rainfall, discharge, etc. to understand the hydrological processes and cycle. Based on data obtained in such catchments, the society can conduct education, awareness, training for inhabitants and also can exercise the structural measures, flood forecasting, hazard area mapping, and other measures. School catchments are, therefore, indispensable not only for local communities but also for the communities of hydrologists. They are fundamental fields for the hydrologic research achievement.

In studies about catchment hydrology, pure scientific interests coincide with water resource management practices to support sustainable development (UHLENBROOK, 2006). The community awareness on hydrology can be intensified with the use of school catchments (KOBIYAMA; LOPES; SILVA, 2007).

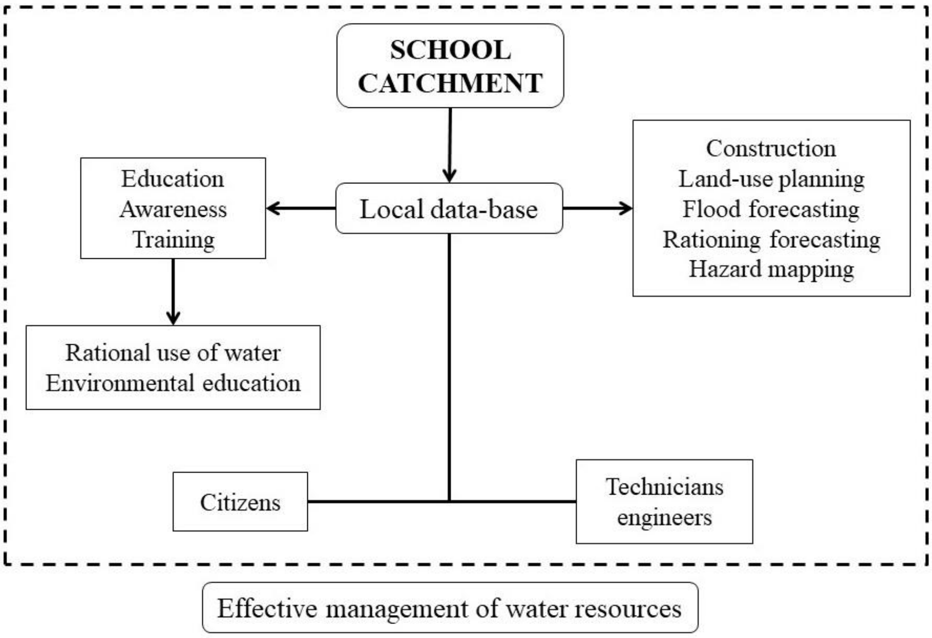

Figure 8 - Contribution of school catchment to the water resources management.

The hydrological processes depend on the catchments' size (PILGRIMA; CORDERYA; BARONB, 1982; LAUDON et al., 2007). Therefore, school catchments should be constructed at different scales for understanding better these processes. Following this thought, Kobiyama et al. (2009) proposed an implementation of the school catchments network to perform water resources management in different catchments. The integrated management becomes more feasible and effective through the joint participation of researchers and local inhabitants.

In any case, the success of ruralization practices in urban areas depends on how the society understands hydrological processes, i.e., hydrology. And the knowledge about hydrology relies on the school catchments' use. In other words, the ruralization practices in urban areas strongly require school catchment implementation.

6. FINAL REMARKS

The present work briefly showed the institutional and scientific aspects of hydrology. It is clearly observed that hydrology is increasingly closer to society, discussing the interactions between society and hydrological processes. Thus, the socio-hydrology has been more popular and necessary. Hydrology and society are paying more attention to the urban area, because this area has larger demographic concentration and consequently a higher social vulnerability and a greater intensity and quantity of social, economic and environmental problems.

An urban area constantly receives urbanization processes. From a hydrological point of view, there are various negative problems with urbanization. Considering the urbanization as a set of removal (rejection) of vegetation, soil and rainwater, Kobiyama (2000) proposed the ruralization in urban areas. As science, technology and also philosophy have advanced during the last two decades, the present work reevaluated this concept with up-to-date visions based on such science, technology and philosophy, concluding that the definition can be still now maintained, i.e., actions to coexists with vegetation, soil and rainwater and also to carry out processes that go against modern urbanization. Ruralization practices should be sustained by the philosophical aspects: “Small is Beautiful”, “Slow is Beautiful”, “Simple is Beautiful”, “Soil is Beautiful” and “Science is Beautiful”.

Although there are several ruralization practices in the urban environment, urban storage, rainwater ruse, agriculture and agroforestry system, and decentralized sanitation are of utmost importance. In any case, all the practices must be supported with hydrological data obtained in school catchments. Thus, it can be said that the school catchment is the starting point for integrated managements of water resources, basins, the environment and natural disasters.

As Hillel (1991) and Montgomery (2007) described, human history has been showing that human beings initially executed civilization and that their civilization was over when they did not respect the nature (vegetation, soil and water). Considering urbanization as an advanced stage of civilization, the sustainability and development of urban areas should be correctly planned and managed. It is quite important to remember a fairly common story: “There was forest before civilization. After civilization (excess urbanization), there will be the desert.” The ruralization in urban areas should be studied and practiced with interdisciplinary and holistic approaches. It supports local and world societies to achieve the Sustainable Development Goals – SDGs established by UN (2015).

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