Managerial Analysis of a Mixed Basin and its Future Scenario

Danicler Bavaresco 1, Cristiano Poleto 1
1 State University of Maringá
Maringá, Brazil

Abstract

In recent decades, Brazil advanced juridically with the creation of specific legislation for water resource management in the country. But, in spite of this Law being from 1997, the States of the Confederation are still confronting difficulties in implanting its plans and projects, principally in regard to territorial planning with due environmental zoning and environmental protection activities. The area under study is a hydrographic basin of 41 km² in Maringa county, state of Parana, more specifically, the Morangueira River (Ribeirao Morangueira) basin. Approximately 45% of the area is urbanized and the rest is used for agricultural purposes (soybeans, wheat and corn). This study elaborated an environmental diagnosis based on field studies, water quality analyses and hydrological analyses of the current situation and of the future scenario, seeking to determine the fragilities presented by the area. Throughout recent years, the basin has been undergoing constant degradation arising from the urbanization process that is advancing in an unplanned way and, in addition, the agricultural areas that make up part of the basin use agricultural chemicals in an intensive way. Future projections show great hydrological imbalance in the area with the possibility of flooding and erosion processes and which, therefore, make management efforts necessary which are capable of implanting sustainable systems, principally in the urban drainage system.

Keywords: *water resources management, basin, antropic action.*

Morangueira River Basin

Introduction

In 1997 Brazil approved the Law 9433, named Water Law. Since then, the country has been developing a national policy of hydric resource aiming better protection to its vast resource. In this Law, water is refered as a limited natural resource, endowed with economic value and as a public property which must have a discentralized management to provide its multiple use. The Water Law aims a racional and integrated use of the hydric resources, assuring water to the current and future generation with adequade quality patterns for its use. For Machado (2007) (president-director of the Water National Agency at the time), the instruments conceived by Law 9.4333/97 are essential to assure knowledge about the Brazilian water and its management. For him, advances can be observed in the elaboration of the Hydric Resources Plan in its different levels; in the dissimination of the Basin Committees all over the country; in the Grant of hydric resources use rights; and in the Information System about Hydric Resources.

For Kettelhut and Barros (2001) this Law was the result of a long and intense politic, social and institutional negotiation based in essential principles of common interest, broadly accepted by the society, in the understanding of what would be necessary to have a racional management of the Brazilian hydric resources, adopting modern principles in the management of the hydric resources, as the Dublin Declaration and the Agenda 21 expected.

In regard to the legislation, Brazil is advanced; however there is the need that the counties apply it efficiently, realizing the necessary measures for preservation, maintainance and utilization of its hybrid potentials, and also that the governamental organs cooperate for the implantation of hydrographic basin committees.

Another difficulty found by the water administrators is the public pressure for the urban expansion, as cited by Poleto et al. (2009). The territorial planning with the correct enviromental zoning and the potentials of each region is despised because more importance is given to the need of urban increase.

Study Area

Maringá is a city with approximately 335 thousand inhabitants, based in the south of Brazil (Figure 1a), known for its life quality and urbanization. It is a planned city that started being populated around the fourties and attracted migrants because of the high quality soil, causing deforestation. Nowadays agriculture continues being fundamental, however the distinction are the commerce sectors and the service contribution. For basic sanitation, the rates of sewage collection are 91.06%, being 100% treated sewage, and the expectations are to reach 96% in 2010 (Sanepar, 2009).
The Morangueira River is located in the northeast of Marigá, and its source is in the Alfredo Niffler park. It is a tributary of the river Sarandi (Figura 1b). Consisting of 41km2 the basin has approximatey 45% of its total area urbanized, with paved streets, garbage collection, sewage system and treated water.

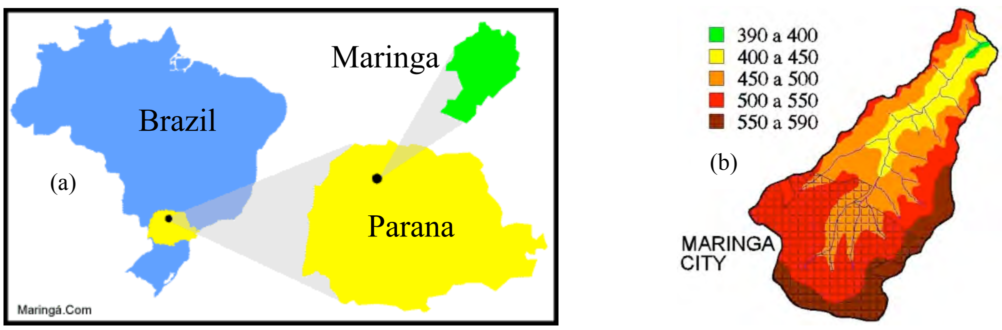

Figura 1. (a) Localization of Maringá (Adapted from: Maringa.com); (b) Hipsometric map.

Physical Characterization of the Morangueira River Basin

The characteristics of the Morangueira River basin are in Table 1 and Figures 2a e 2b.

Table1. Characteristics of the Ribeirão Morangueira basin

CHARACTERISTICS		VALUE	UNIT
Basin area		41.17	Km²
Length of the longest stream of water		11,39	Km
Basin shape	Kc	1.4	
	Kf	0.32	
Drainage System	Order	3	
	Density	0.78	Km/Km²
	Medium Length of the superficial flow.	0.321	Km
	Sinuosity of the stream	0.994	
Average Elevation of the Basin		502.99	m
Alveus Declivity	S1	0.011	m/m
	S2	0.009	m/m
	S3	0.011	m/m

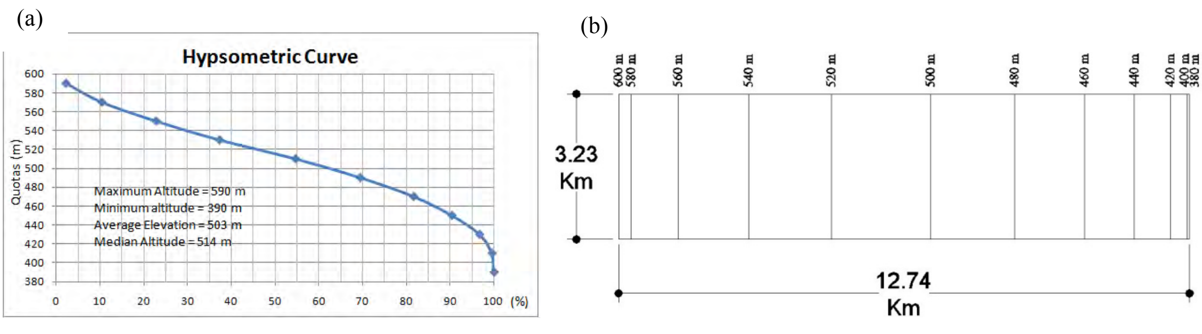

Figura 2. (a) Hipsometric Curve; (b) Equivalent Rectangle.

Considering the basin form, it is not liable to flood because of its elongated shape. For the low density of the flow and elevated medium extension of the superficial flow there is not a tendency of flooding. However, considering the levels of ramification, sinuosity and slightly high declivity the contrary is observed. In general, this slightly high declivity accelerates the drainage, contributing to the erosive process and, consequently, generating silt up problems in the lower parts of the basin, what is potentized for the lack of vegetation and small, or none, extension of riparian forest.
Through analysis of the characteristics of the Morangueira River (Table 1. Fig. 2a and 2b) it is observed that it is naturally not liable to floods, not presenting elevated outflow peaks. However, there is an increase of the flow speed and the volume of superficial drainage, which increases the outflow peaks.

Analysis of the urban growth

Analysing the evolution of the urban environment in Maringá collected by Teixeira *et al.* (2009) (Fig. 3a), it is possible to measure the urban advance in the Morangueira River (Fig. 3b), obtaining its growth tendency (Fig. 4).

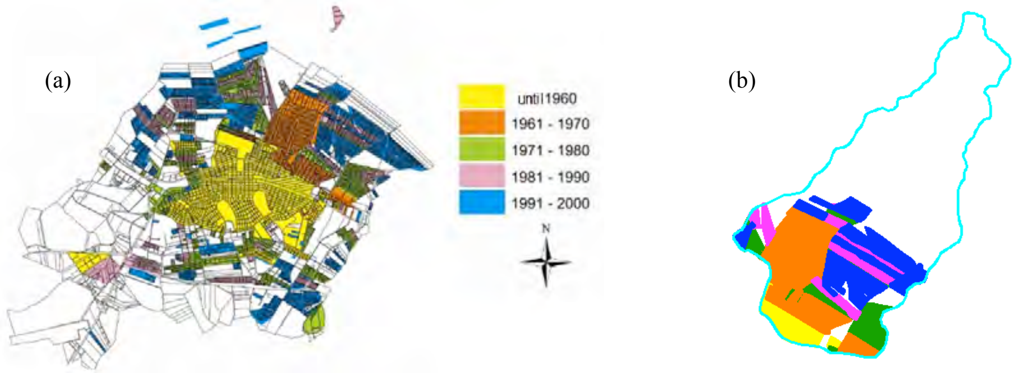

Figure 3. (a) Map of the urban enviroment of Maringá (1960 a 2000); (b) Expansion only in the analysed basin.
Fonte: Teixeira *et al.* (2009)

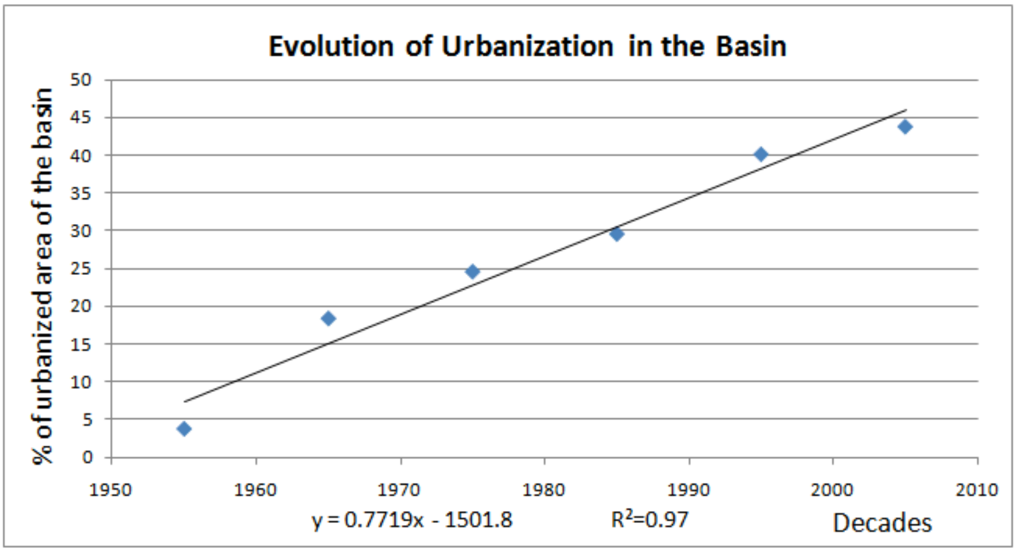

Figura 4. Evolution of the urbanization in the basin.

This graphic shows that the city is expanding towards the basin with a rate of 0.77% per year. If we project these data to 2030 and 2050 we have 65% and 85% of the area ubanized respectively.

Analysis of the urban impact in the basin

Maringá is located on the Gurani aquiferous, the biggest deposit of fresh water in the world, and it needs care so that no contamination of theses resources occurs.
Oliveira (2008) indicates two problems caused by the urbanization of the Morangueira River. One of them is the intense erosion process of the thalweg and in the stream border, caused by the construction of avenues parallel to the superficial and subsuperficial hydric flows, as well as the inadequate tubes and lack of power dissipators. The other is the development of disease conductors ocasioned by garbage storage and degradation of the riparian forests.
Cassaro & Neto (2003) observe the dificullty of water percolation and reload, caused by the increase of impermeabilization. This problem has caused significant environmental impacts, such as urban erosion and liquid and solid residues transport in pluvial gallery systems and on the stream borders.
The problem with the solid residues thrown in the river, borders or carried by the rain water is serious (Fig.5). The lack of awareness of some citizens causes serious damages to the bodies of wate and high costs with cleaning and disobstructionm that is peleative measures that do not solve the problem.

Figura 5. Solid residues carried by the rain water making roads impossible to transit (Photo: Cleber França/Flamma Comunicação).
Fonte: Giandotti (2009)

Peruço *et al.* (2003) also observes that the intense use of pesticide in the plantations along all the year (soybeans from November to March; wheat from April to September ; corn from March to August) indicates contamination by agrotoxics because of incorrect use.
Analysis done by the Paraná Sanitation Company (SANEPAR) in 2007 shows much higher quantities of fecal coliforms than it is reccomended by the Resolution 020 of the National Environmental Board (CONAMA) (Table 2). The quantity of fecal coliforms shows clearly the launch of “in natura” domestic effluent in the water of the river. These launches are a result of the inadequate connection of the domestic sewage to the pluvial water collecting system, fact which also is pointed by Cassaro and Neto in 2003.

Superficial flow alteration

To get the superficial flow alteration caused by the increase of urbanization in the basin was applied the methodology suggested by the Soil Conservation service (SCS) adapted to São Paulo state, that is well adapted and can be applied all over Brazil. The methodolody was applied in 5 sceneries:

I – Situation without human influence;
II – Situation without urbanization influence;
III – Current scenario;
IV – Urbanization Projection in 2030;
V – Urbanization Projection in 2050.

The Brazilian scenerio for an only agricultural area with a rich soil such as the the one of the region is 80% cultivated and 20% native forest (legal limit). The use of the soil of the basin in 2005 is shown in Figure 6 and its respective table (Tab. 3), in which we can see that the area of native forest is bellow the legal limit, showing only 8 % of the total (15% of the not urbanized area). The projection for 2030 and 2050 of the current scenerio was done taking in consideration the maintenance of the current native areas, increasing only the urbanization in the agricultural regions. The percentages of each simulation are shown in Table 4.

Table 2. Physical-chemical data of the Morangueira River water

Analysis of Ribeirão Morangueira upstream from the point of release of treated effluent by Station Sewage Treatment													
PARAMETERS		**jan/07**	**feb/07**	**mar/07**	**apr/07**	**may/07**	**jun/07**	**jul/07**	**aug/07**	**sep/07**	**oct/07**	**nov/07**	**dec/07**
pH		6.2	7.7	7.6	7.1	7.1	6.5	6.4	6.9	6.4	7.1	7.4	6.6
T °C		23.0	27.0	26.0	NS	17.0	20.0	16.0	19.0	16.0	25.0	22.0	24.0
Color (mg pt/l)		50.0	150.0	100.0	100.0	100.0	150.0	37.0	10.0	37.0	25.0	50.0	15.0
Turb. (NTU)		34.0	56.4	30.6	54.0	53.6	43.5	24.0	10.0	24.0	4.1	14.0	12.9
Floating. Foam., etc.		AB	AB	AB	AB	AB	AB	PR	AB	PR	AB	AB	AB
DBO5 (mg/l O2)		5.0	5.0	6.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
DQO (mg/l O2)		24.0	5.0	5.0	7.0	8.0	5.0	6.0	5.0	6.0	5.0	8.0	9.0
Sed. S. (mg/l)		0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.1	0.1	0.1
Sus. S. (mg/l)		9.0	14.0	5.0	28.0	18.0	1.0	8.0	7.0	8.0	2.0	6.0	6.0
Ó. e G. (mg/l)		AB	AB	AB	AB	AB	AB	AB	AB	AB	AB	AB	AB
Tot. S. - STD (mg/l)		189.0	196.0	96.0	242.0	190.1	222.0	190.0	198.0	190.0	167.0	185.0	206.0
MLTCB / 100 ml	CT	53.0	25.0	24.0	NS	NI	NI	157.0	97.0	570.0	800.0	190.0	7.5
	CF	1.0	7.0	11.0	NS	NI	NI	0.0	4.0	0.0	180.0	900.0	1.9
Tot. Am. N (mg/l)		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tot. P (mg/l P)		0.025	0.118	0.063	0.092	0.130	0.130	0.006	0.048	0.006	0.023	0.042	0.035

Legend: NS = Not Specified, NI = Not Implemented; AB = Absent; PR = Present T = Temperature; Turb. = Turbidity; Sed. S. = Sedimentable solids, Sus. S. = Suspended Solids; O. and G. = Oils and Greases, Tot. S. = Total Solids; MLTCB = Maximum likely thermotolerant coliform bacteria; Tot. Am. N = cn, Tot. P = Total Phosphates

Font: SANEPAR (2009)

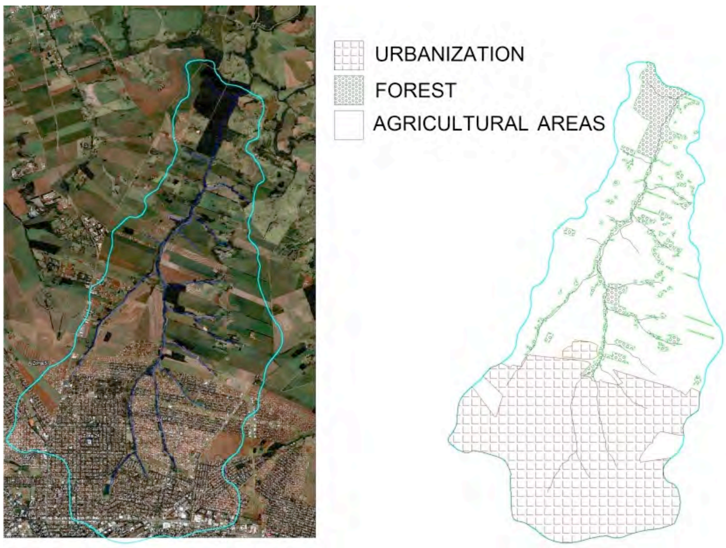

Figura 6. Use of the soil in 2005.

Table 3. Data of soil use in the basin

Area	Km²	%
Basin	41,17	-
Urbanized in 2005	17,99	44
With forest in 2005	3,38	8
Cultivated in 2005	19,80	48

Table 4. Soil use in each simulation

Soil use	Without human influence	No influence of urbanization	Current Scenario	Scenario in 2030	Scenario in 2050
Urbanized	0%	0%	44%	65%	81%
Natural vegetation	100%	20%	8%	8%	8%
Cultivated area	0%	80%	48%	27%	11%

Applying the method, the precipitation, infiltration and superficial flow blades in each simulation are obtained (Figures 7, 8, 9, 10, 11).

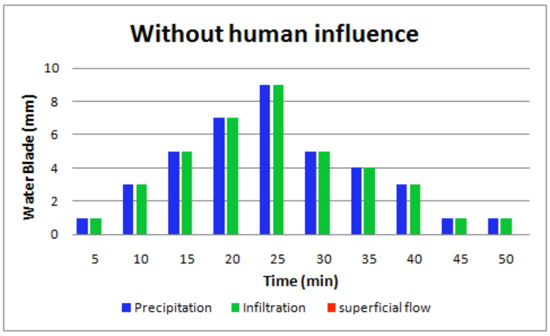

Figura 7. Simulation of soil use without human influence.

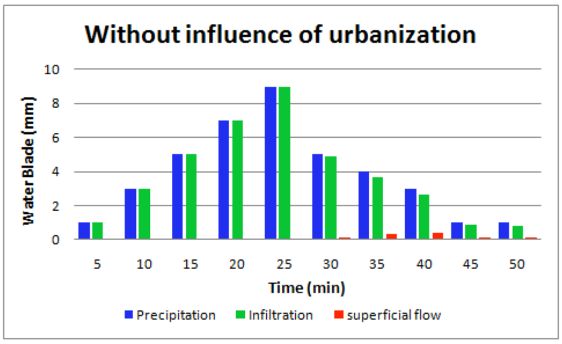

Figura 8. Simulation of soil use without human influence.

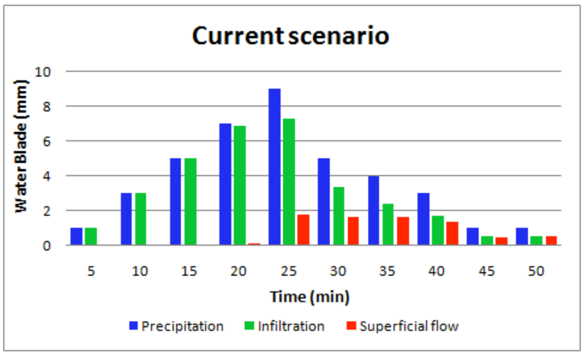

Figura 9. Simulation using the current scenario.

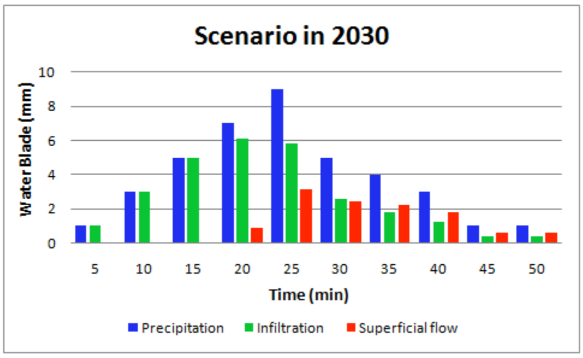

Figura 10. Simulation using the soil projected for 2030.

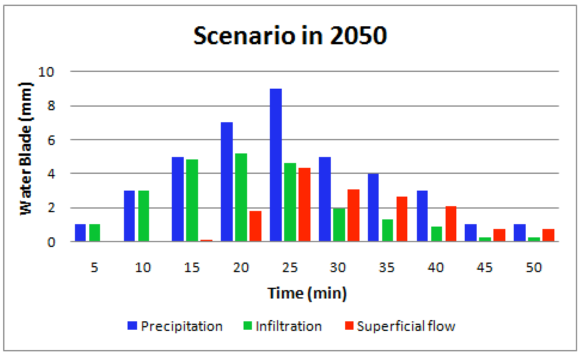

Figura 11. Simulation using the soil projected for 2050.

In the graphics above it can be observed that the increase in the superficial flow is directly related to the urban growth, and that the rural area does not show any significative influence.

Conclusions

Brazil has an advanced legislation for the management of hydric resources. It only needs a more efficient application of it.
The Morangueira River basin presents problems of water contamination because of domestic sewage and agrotoxics launch, erosion of the thalweg and stream margins, storage of solid residues and

degradation of riparian forests caused by the use of the soil without any territorial planning with the adequate environmental zonig.
Comparing the five scenerios it can be clearly observed that there is an increase on the superficial flow parcel because of the urban growth in the basin, which raise the floods and the erosive processes.
In this context, is verified the need of a management that presents lower impacts in the region with the accomplishment os sustainable systems, specially in the urban drainage system.

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