Pipiripau Sky: from the tragedy of commons to water sustainability

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Abstract:

This research pursued to understand environmental perception use to improve environmental planning. Research field was in one of three major Federal District's watersheds to Brasilia's water supply: the Pipiripau creek basin (PCB). Methodological scheme was based on two methodologies to evaluate social actor's perceptions on PCB's water scarcity and its solutions: strategic matrix method and environmental perception analysis. Research outcomes showed similar water sustainability factors to farmers and officers: institutional empowerment, and environmental education. This study developed a perception methodology scheme applied to participatory environmental planning.

1. Introduction:

The article's title "Pipiripau sky" was borrowed from a Brazilian Portuguese expression used by small landholders from Minas Gerais state. It means a blessed territory where free common resources are available to all depend on how users share its resources. This expression origins are in Spanish language expression "Tierra de Pipiripao" that has a similar meaning, a place where people are invited to share and commemorate abundance of a flourishing richness, but users only think about enjoying than in something else (Rae, 2014). By its turn, the old English language word "commons" represents a land where farmers create rules to govern its common resources (Hardin, 1998). Indeed, Commons is similar to these expressions in Portuguese e Spanish languages. In the same way, Japanese word "Iriai" used in the industrial era in Japan means parts of nature where customs and norms entailed community respect (Illich, 1983). Otherwise, some authors believe the word "Pipiripau" has an origin in the indigenous language Tupi-Guarani meaning a river with few water (Bertram, 2011). The dispute over these meanings is part of the perceptions process around Pipiripau creek and its water scarcity (see figure 1).

In 1892, the Cruls's expedition, led by Belgian astronomer naturalized Brazilian Louis Ferdinand Cruls arrived where is today the Federal District (FD). He organized a group of scientists with best research instruments of that time to explore Brazilian central plateau with the main objective of finding a territory with the best features to establish the new capital, Brasilia (Cruls, 1894). As a result, he drew the boundaries of a 14,400 square kilometers territory what included Pipiripau creek basin (PCB). The "Pepiripau" from that time, with "e", was a river that showed off surveyed region second biggest water flow, 9450 liters per second in October 1892. in October 2013, the regularized Pipiripau creek flow was 988 liters per second, or approximately 10% first flow.

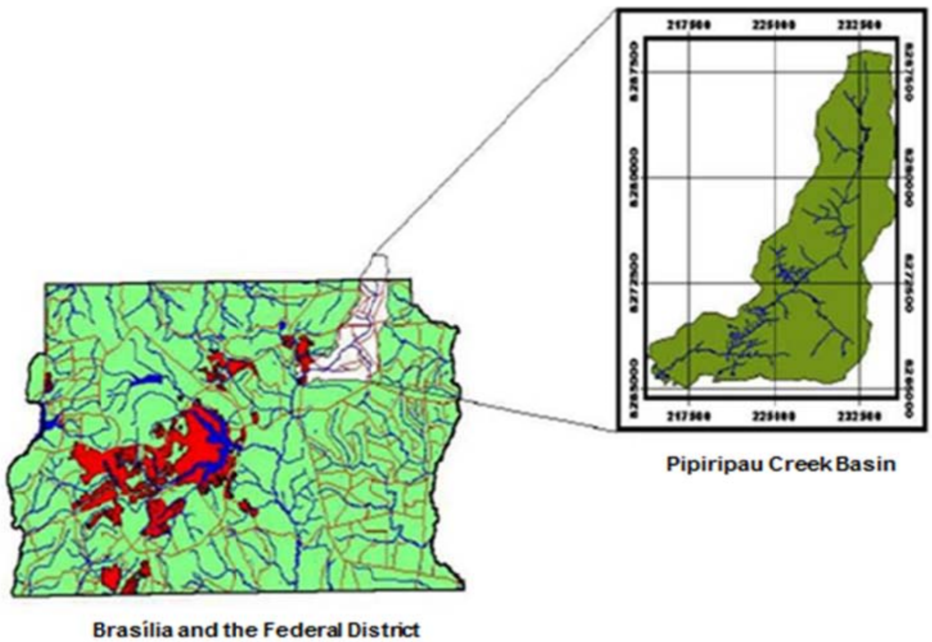

Figure.1 HGEO, 2001 (CAESB, 2001)

The Federal District (FD) has 5,789,16 square kilometers which 91% are composed of environmental protection areas Its rural area is 5,553.91 square kilometers or 95% of the total area. Agriculture between the years 2008 and 2010 represented only 0.4% of DF's GDP compared to 82% of the services sector. Environmental and rural areas have a strong interconnection in FD´s territory. Planaltina administrative region in FD's northeast encompasses PCB. The average altitude is 1065 meters, and maximum altitude is 1225 meters. Planaltina is FD's central agricultural area focused on vegetable production. PCB's area is 23,527 hectares (235,27 square kilometers). It has 10,181 hectares of extensive agriculture mainly soybean and corn crops (43%), 5,050 hectares of pastures (22%), 4,327 hectares of original cover (18%), and 3,968 hectares with other usages like irrigated fruit farming. 424 agriculture properties occupy 71% of PCB's area (ANA, 2010). FD has 31 administrative regions and 2,977,000 inhabitants (IBGE, 2016).

Until the 60's of the last century, subsistence agriculture occupied most of PCB's area. It had not significantly altered basin hydrological processes. Today, PCB has two primary uses: agriculture and water supply. PCB is one of the three most important water sources for FD's population where is the capital of Brazil, Brasilia. In fact, PCB is responsible for Planaltina and Sobradinho cities water supply. These cities around Brasilia have FD´s highest population growth rate. PCB has a rather pronounced dry season, which requires command and control tools to manage water resources use by urban and rural users (see figure 1).

In the 1970s, FD's government invested public resources in planting Eucalyptus trees extensively in PCB in order to supply wood and firewood to the new capital. In the 1980s, with federal government aid, agriculture stepped up over areas of permanent environmental preservation. The environmental degradation of water structures occurred rapidly and promoted by governments. In the period from 1971 to 1988, the mean annual mean of BRP flow was 3380 liters per second and the average minimum was 1450 liters per second. In the period from 1988 to 2003, the maximum and minimum average flows were 2400 and 810 respectively. From 1971 to 2003, flow decrease both in the flood season (29%) and in the dry season (44%) may be linked to the various increased uses of water (agriculture irrigation, domestic use, poultry industry, mining), degradation of water resources structures and also global climatic processes. In 2000, the local water company, CAESB, inaugurated the Pipiripau dam to regularize the flow and to pump water to domestic use.

In 2010, National Water Agency (NWA) introduced a payment for environmental services program (PES) in PCB called "Water Producers" program, which integrates 22 governmental and nongovernmental organizations in the program management unit (PMU). This program aimed to curb water shortage through vegetation cover regeneration by compensating farmers for their actions to regenerate water ecological structures. 2011's PES goal was 300 farmers to have signed the voluntary participation form. In the year 2013, 10 farmers signed first contracts, and have made their property implementation plans (PIP). Indeed, farmers' voluntary adherence pace has been slow. Recently, it got momentum with new officers in PMU. Now, 100 farmers are enrolled officially.

A complicated consensus process exists based on different perceptions of administrative officers and farmers around how to curb water scarcity problem in PCB. This research sought to understand stakeholders' environmental perceptions about the water problem, and how these perceptions and behaviors determine response capabilities to alleviate it.. It means to reforest basin mainly in its water rechargeable areas and to optimize agriculture water use. Research goals were to understand PCB´s history regarding water scarcity and its conflicts, past solutions and results, and environmental perceptions that have shaped those solutions.

2. Methodology:

Strategic Environmental planning is generally composed of 3 basic steps: diagnosis, future scenarios, and strategic actions. In this study, the environmental perception had a role to clarify the first two steps using a methodological scheme composed by two methodologies: environmental perception analysis (EP) and strategic matrix (based on swot matrix). Besides strategic matrix and EP, this study methodological scheme was completed by participant observation method and qualitative research techniques (Sabourin, 2013; Creswell, 2010).

This methodological scheme was used to guarantee the following environmental policy goals (goal-oriented):

- Harmonize knowledge from within and outside environmental system under analysis to achieve rational use of resources;
- Improve understanding of different environmental perceptions;
- Increase local participation in analysis and planning processes as a way of appropriation;
- Rescuing the rich perceptions about nature that are disappearing from rural world, and areas where populations have their livelihoods dependent on nature resources;
- Act as an educational tool and a change agent (Whyte, 1977).

Environmental Perception is the understanding of the environment human consciousness. According to Whyte (1977), resource managers who participate in resources exploitation act and decide based on how they perceive "the work of things": use rules, rewards, and conflicts over resources use. The central point is to ensure communication between specialists and local actors understanding because they are both resource managers independent of social origin and their cultural representations. The difference between them is the scale of impacts generated by decisions of each group.

EP is central to understand complex man-environment relations. Groups of human beings make decisions about the environment based on a set of elements perceived and selected by them. These elements may or may not be in agreement with science. Conflicts over the resources use involving specialists on the one hand, and farmers on the other can happen based on this simplifying differentiation of reality.

Environmental perception analysis (EP) is a methodology based on cognitive psychology (Whyte, 1977). In this study, perception variables helped to understand stakeholders' water scarcity perception. These variables are of 3 types: state, process, and decision. State variables were individual aspects, group characteristics, identity, personality and effectiveness, experience (time), values systems and territoriality. Process variables were: categorization and judgment, attitudes, and communication and information. Finally, Decision variables were choice and behavior, human use systems and decision processes. The systemic interaction and feedback between state and process variables generate decision variables (see figure 2).

Cognitive-based variables defined as structures to perception processes and designed to aid field research methodologies may limit environmental knowledge interpretation. Whyte (1977) argues this analytical effort is not a point of arrival but a starting point for environmental perception studies. To reduce researcher influence over results interpretation is necessary to use of other research tools. Thus, this study presents a methodological scheme that captures a strategic view on stakeholders´ perception.

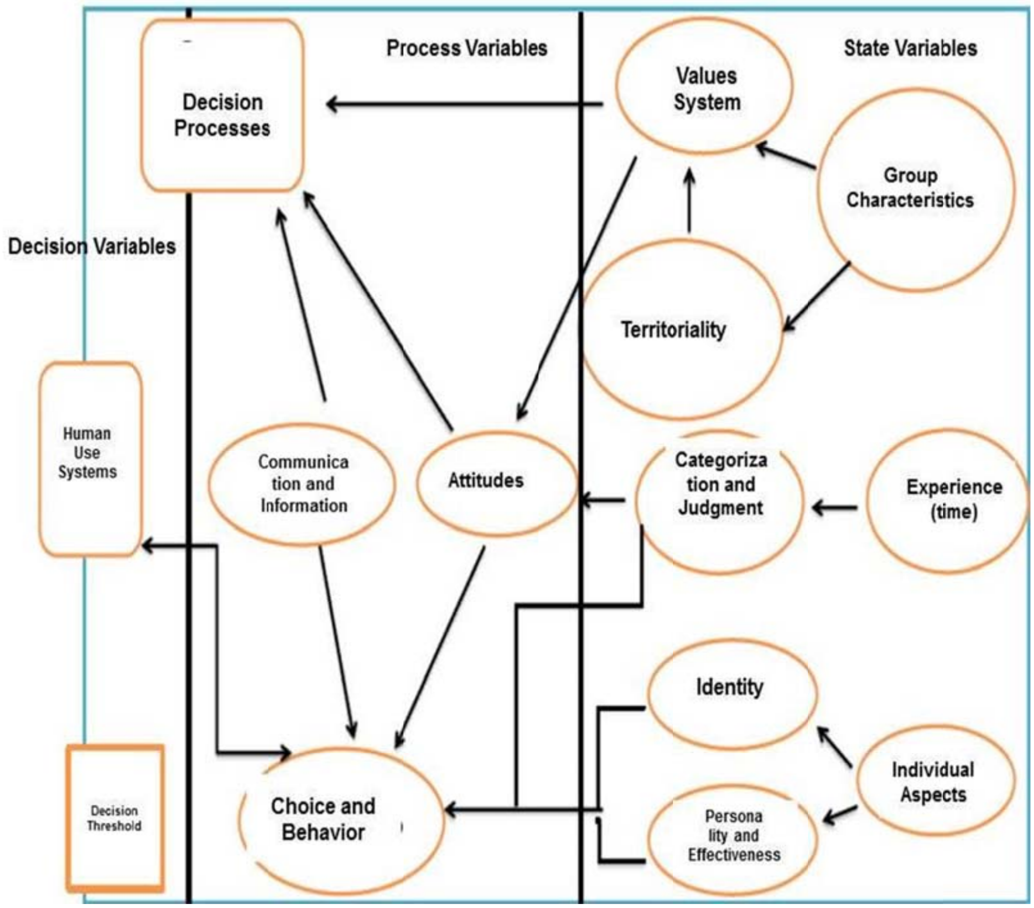

Figure 2. Perception variables and systemic behavior

Public and private sectors have widely used swot matrix in situational analyses together with other instruments. However, it does not have the capacity to make a diagnosis (past) or to provide future scenarios (Helms et al., 2010). Thus, the proposition of modifying swot matrix was necessary for two reasons. The first, it was necessary to go beyond situational analysis to build actors' pre-strategic objectives (future scenarios). Thus, actions of achieve, face, spur, protect were part of 2 x 2 matrix composed of systemic interactions among swot matrix fields. The second, in order to avoid circular logic when data interpretation arrives in zero sum logic about two internal opposite fields of variables (strengthens and weaknesses or, opportunities and threats). It means that sometimes results from these fields are logically contrary to each other (Helms, 2010; Shields et al., 2002). These new fields are expressed by verbs that represent pre-future scenarios (see figure 3). Government officers and farmers pre-strategic objectives (values) are strategic to understand the stakeholders' ability to manage future resources and sustainability (Sen, 2011; Hansen, 1996).

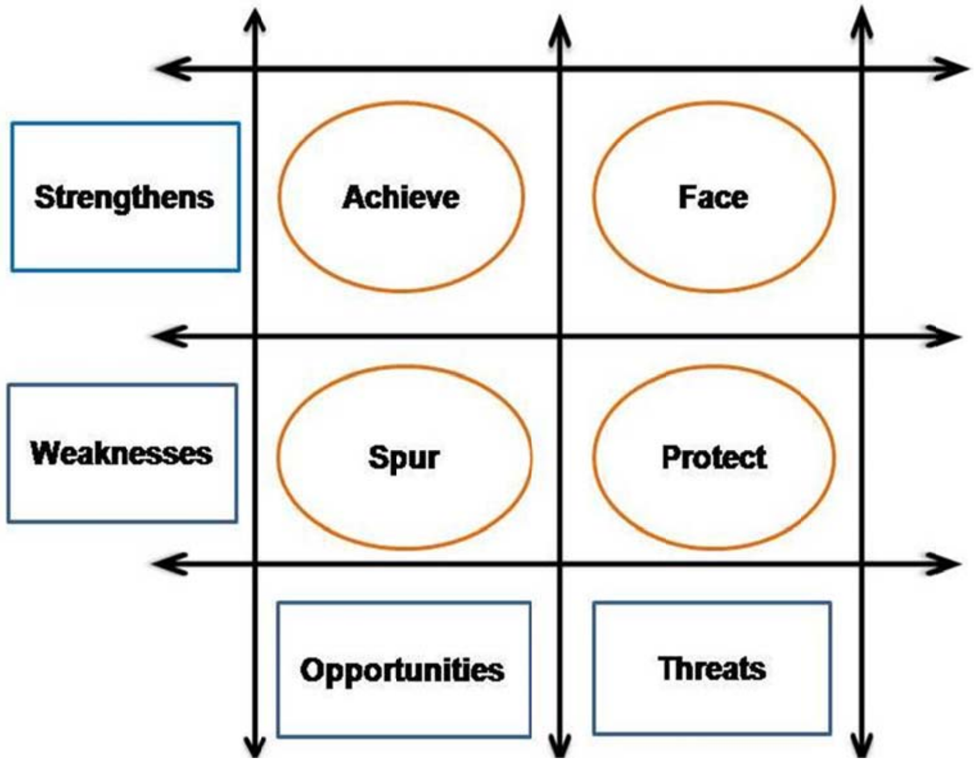

Figure 3. Swot matrix and modified Swot matrix in systemic relationship

This study needed a water sustainability definition to guide the building of a water integrated management which PES is one tool. To this end, it is necessary to have first a sustainability definition. This study opted to use a definition where sustainability is considered a group of probabilities of a system, or process, to keep its goals over time. This definition considers the inherent system characteristics and its internal and external vulnerabilities both expressed by their probability density functions (Hansen, 1996). Thus, sustainability is presented here as a system state variable described according to expression (1) and (2),

(1) $S(t) = 1 - V(t)$, $S(t)$ is the sustainability probability density function at a time t, and $V(t)$ is the system's vulnerabilities probability density function.

(2) when $t = 0$, $S(0) = 1$, 100% probability to remain sustainable if $S(t) = 1$, however when $t = t'$ and $S(t') = 0$, the system will collapse at time t'.

Strategic matrix method comes from modified swot matrix applied to the sustainability definition above. It aids to understand how stakeholders perceive sustainability in terms of planning and strategic variables. Swot matrix variables fields (strengths, weaknesses, opportunities and threats) are the probability densities functions in the expression (1),

(1) $S = 1 – V$;

(2) (St, Op) = 1 – (We, Tr), where St, strengths; Op, opportunities; We, weakness, and Tr, threats;

(3) R= [(St,Op); (We,Tr)], where R represents future scenarios grid 2 x 2, or Strategic matrix.

In the expression (3), strengthens and opportunities are fields of variables that represent sustainability (S). Weaknesses and threats are fields of variables that represent vulnerabilities (V). Swot matrix creates a systemic feedback relationship among its variables fields. It produces a modified swot matrix or, strategic matrix, formed by future scenarios in a 2 x 2 grid. This matrix has four areas of actions: achieve, face, spur, protect (see figure 2). The strategic matrix categories expressed social actors pre-strategic goals or pre-future scenarios what represent social actors values or intentions to perform actions with strategic purpose (Coelho, 2014; Helms, 2010).

The Systems theory was used to interpret connections and feedbacks among perception variables and show new interpretive possibilities. In the perception models, it helps to draw reinforcement and buffering feedbacks. In order to interpret collected data, systemic archetypes were used in perception interpretation. They are logical structures that rank and group events to identify behavior patterns. Two systemic archetypes were chosen: growth limits and responsibility transfer. Growth limits archetype defines behaviors and perceptions which their growth comes under natural or institutional boundaries. It identifies what are limiting conditions to growth of particular behavior and perception. Otherwise, this archetype controls the conditions that limit a previous behavior or perception to change. Responsibility transfer archetype describes actions that express palliative solutions applied to behaviors and perceptions as well as it identifies fundamental solutions to address causes. Based on these two types archetypes, two types of structures can be seen in the observed perceptions: the systemic event and the systemic structure (Senge, 2011; Folledo, 2000; Bertalanffy, 1968).

According to Senge (2011), systemic structures are created historically and reproduce themselves by generating behavior patterns. Systemic events identify a new behavior emergence, and act as an equilibrium structure for systemic structures. In fact, a systemic event is a control mechanism to a systemic structure reproduction. For each proposed data analysis level (social, intermediate and individual scales, see figure 3), systemic structures were identified using growth limits archetype, and systemic events were determined using responsibility transfer archetype. Individual scale reflects perception process of individuals while intermediate scale shows processes that build social scale perceptions from individual ones.

In the perception model diagrams, social, intermediate and individual scales display both interpret data collected from strategic matrix and EP methodologies in terms of systemic archetypes. Systemic structures (square shape) and systemic events (rounded shape) interact through reinforcement or buffering. They model each group perception system (see figure 4,5,6). PES's officers model has only individual and social scales due to particular institutional role those individuals have. A transition between individual scale and social scale is done directly through regulations and norms.

The social scale represents institutional space where decision variables operate. While intermediate scale is a transitional area where process variables work on state variables. The time dimensions were used to separate systemic structures (past) from systemic events (present, future). EP methodology data generated systemic structures in present and past time. Swot matrix fields were expressed in terms of systemic events in present time while strategic matrix fields were positioned in future time, both in different social aggregation scales.

Perceptions patterns were identified considering frequency of appearance in stakeholders' answers and importance to the research goals. Once identified, they were categorized as strategic event or strategic structure to be set in social and time dimensions. Perception patterns were summarized and organized in environmental perception models (figures 4,5,6). They are cognitive cartographies where the systemic structures are more stable due to their historical influence while systemic events are in present and future times because they can create new environmental perceptions.

In the field study, the main methodological tool was semi-open questionnaire applied to PES officers and two different rural communities farmers. Questionnaire questions were representations of methodological scheme variables. Each questionnaire applied to a particular group may, or may not use all variables, depend on complexity of actions performed on environmental resources. The questionnaire had two versions. The first version aimed to farmers had 40 questions in its first part (environmental perception) and 6 questions in its second part (swot and strategic matrices). The second version aimed at PES's officers had 14 questions in its first part (environmental perception) and 6 questions in its second part (swot and strategic matrices).

Interviewed stakeholders had a role of leadership in their associations and agencies, or NGOs. Farmers were from two rural areas: Oziel III landless peasants settlement, a low wage rural community, and Pipiripau village, a developed agricultural area connected to supermarket chains. PES's officers were from 12 agencies like National Water Agency (ANA), National Agricultural planning and extension service agency (EMATER) and NGOs like Word Wild Foundation (WWF). . They were 12 farmers from farmers associations and 12 PES's officers.

3. Results and discussion

This study interpreted water scarcity environmental perception data from PES' officers and farmers leaders based on questionnaires and local observations. Results allowed us to understand perception systems that influence decision making processes and PES's implementation problems, as well as environmental perception conflicts that are relevant to PCB (Ostrom et al. 1999). The results analysis from perception models were made mainly looking at interactions among systemic structures and events (reinforcement and buffering feedbacks) in each one of social scales (individual, intermediary and social) by time scales. Taking time scales analysis first (past, present, future), it shows how systemic structures and events evolve from an individual scale to a social one.

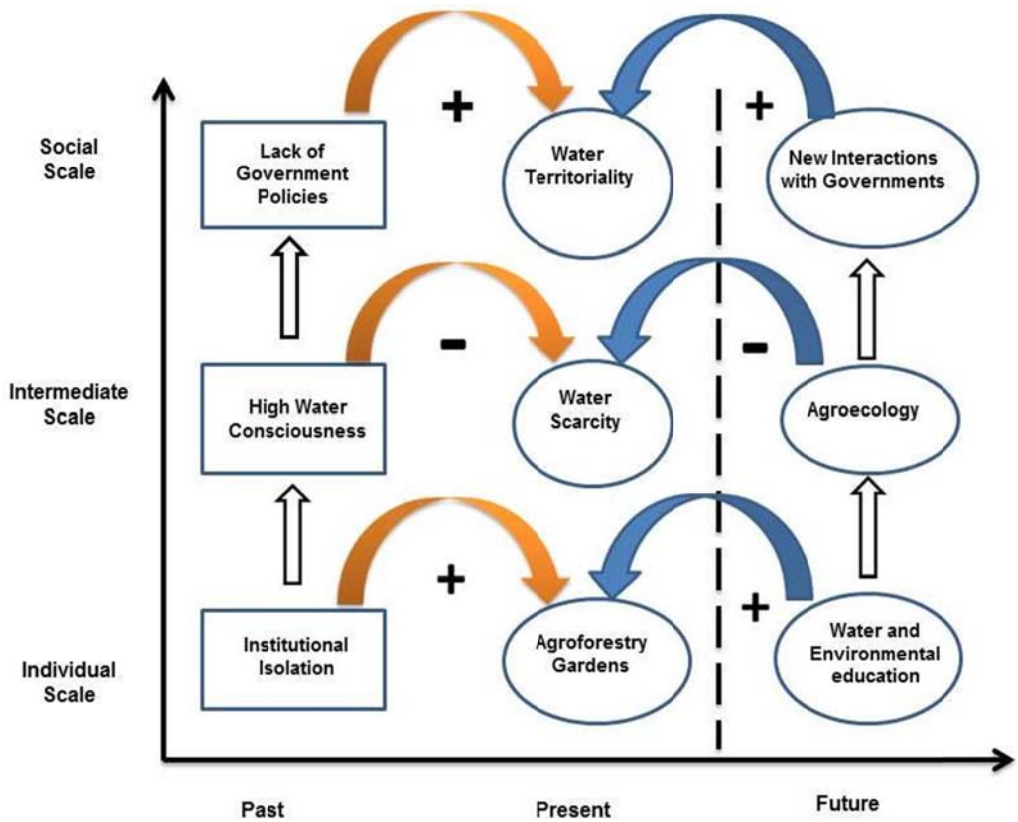

Figure 4. Environmental perception model: Oziel III settlement

In the individual scale, Oziel III settlement farmers environmental perception model shows a present systemic event called agroforestry gardens that are part of farmers' survival strategies. Institutional isolation is a past systemic structure represented by the lack of public policies access to support water supply. It inserts reinforcement feedback (+) to agroforestry gardens. These gardens strengthen familiar agriculture tenure as well as food and water security. Water and environmental education future scenario is a future systemic event that also establishes a reinforcement feedback (+) to agroforestry gardens.

In the intermediate scale, water scarcity systemic event receives a buffering feedback (-) from a past systemic structure called high water consciousness that was developed by long-term water shortages in PCB. Future systemic event called agroecology also insert a buffering feedback (-) to water scarcity once it helps to produce food with a low water footprint. In the social scale, present water territoriality systemic event receives a second reinforcement feedback (+) from past systemic structure called lack of government policies and from future systemic event represented by new interactions with governments that came thought new tenure status that came with property rights and public policies access.

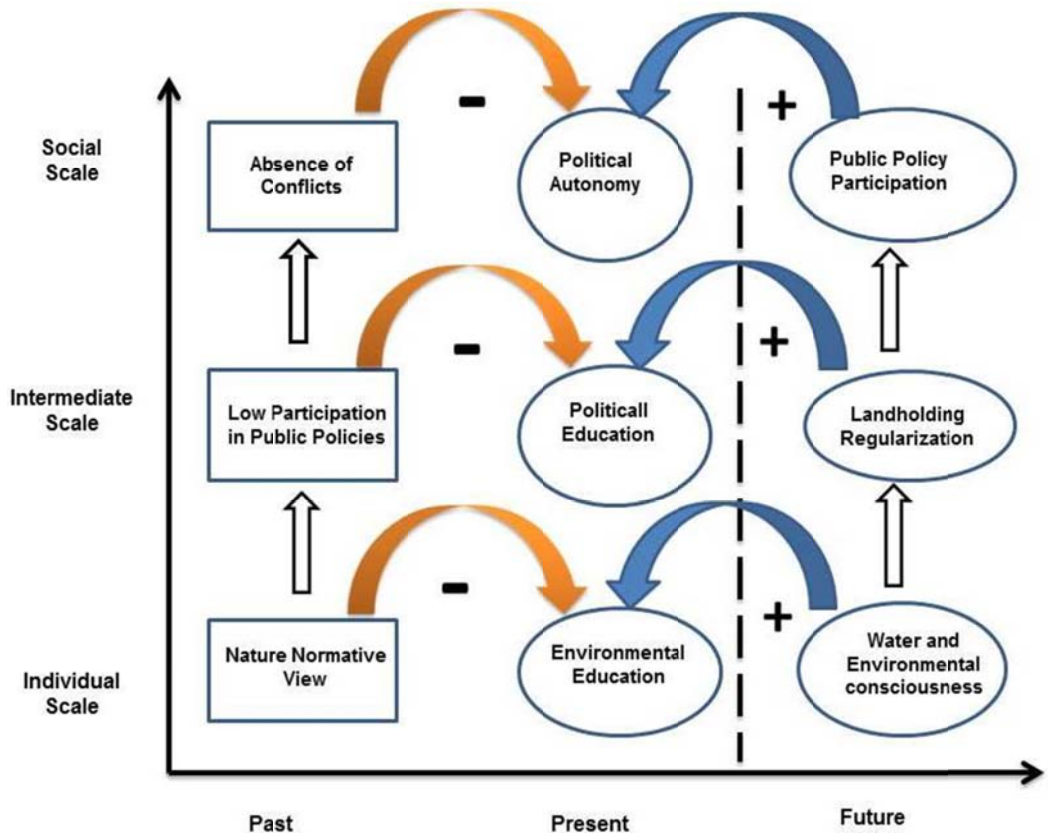

Figure 5. Environmental perception model: Pipiripau village

Environmental perception model from Pipiripau village farmers shows in its individual scale a present systemic event called environmental education. It has been growing recently with water scarcity aggravation even though with better life conditions and better wages. This event receives from a past systemic structure called nature normative view a buffering feedback (-). Villagers used to trust in the disciplinary knowledge embodied in agriculture techniques to manage environmental resources. It means a normative view on nature processes that blocks an environmental education increasing. At the same time, a future systemic event called water and environmental consciousness also drives by increasing water scarcity creates a reinforcement feedback (+) to environmental education.

In the intermediate scale, a present political education event receives a buffering feedback (-) from a past structure called low participation in public policies.

Pipiripau village has been receiving government aid in different ways what creates a type of political paralysis. At the same time, a future event called landholding regularization draws a reinforcement feedback (+). Brasilia's local government owns most of village lands. It decided to set a property purchase schedule with priority to actual occupants. In the social scale, present event political autonomy receives a buffering feedback (-) from past structure called absence of conflicts. Due to the strong presence of government agencies, it avoided the strengthening of political structures of representation. Otherwise, public policy participation is a future event that represents a future scenario that draws reinforcement feedback (+) over political autonomy (see figure 5).

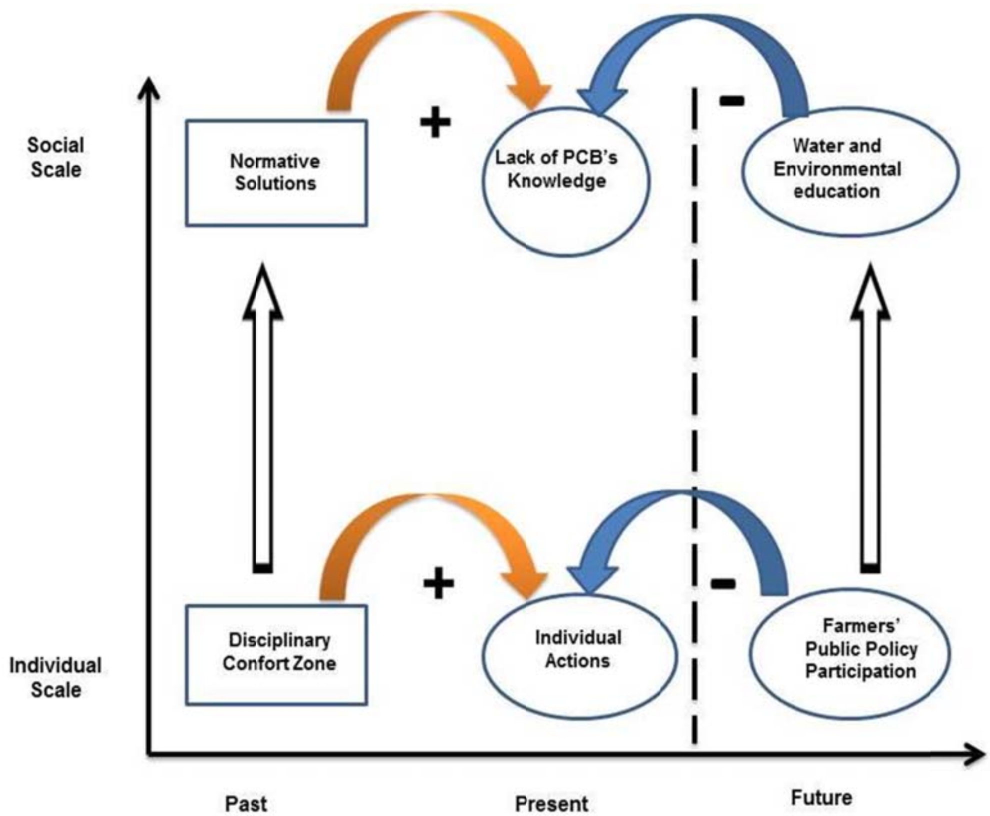

Figure 6. Environmental perception model: PES's officers

PES's officers environmental perception model shows a present systemic event called individual actions in its individual scale. Actors that know how to navigate through lack of state agencies institutionalization have been responsible for most of PES's implementation actions. Political and institutional problems, as well as economic ones, have thwarted PES's efforts. This present event receives reinforcement feedback (+) from a past structure called disciplinary comfort zone. Officers and farmers perceived this comfort zone as an obstruction to a collective and interdisciplinary learning process.

On the other hand, future event (future scenario perception) called farmers' public policy participation draws a buffering feedback (-) over individual actions event. Some officers have a perception that increasing farmers participation will push a better institutionalization process over government decision making. It can break comfort zones and integrate institutional agendas and different environmental perceptions.

In the social scale, a present event called lack of PCB´s knowledge receives a reinforcement feedback (+) by past structure called normative solutions. They do not dialogue based on interdisciplinary fields of knowledge. Differently, a future event called water and environmental education draws a buffering feedback (-) over this present event. PCB's education program has to be aimed not only to farmers but also officers. This training process should be based not on just disciplines but in a learning process informed by participatory approaches promoting integration among officers and farmers.

Based on complex systems theory interpretation process, farmers and officers have two common sustainability factors: environmental education and the institutional empowerment. These sustainability factors can aid watershed integrated management by removing blockages that prevent PES's implementation. Stakeholders perceive institutional weaknesses to deal with watershed complexity that encompasses adaptive social, economic, and environmental aspects. Institutional internal conflicts prevent a better negotiation performance among water users increasing water supply disputes. The PES's program management unit would be more efficient if allows farmers participation in decisions on Pipiripau's watershed issues.

Finally, this study methodological scheme enabled an operational water sustainability definition to guide watershed integrated management:

"Water Sustainability is a state variable created by environmental perceptions, and their systemic reinforcement and buffering feedbacks that build stakeholders' perception patterns representing their response capabilities to face vulnerabilities in water resources governance systems".

4. Conclusions

The PCB and its PES program offer a reflection on farmers and officers decision making processes to implement an integrated water management aimed to alleviate water scarcity. These processes are entrenched in stakeholders' perceptions and behaviors. Methodologies used in this study permitted to point out issues for stakeholders' efforts integration. But, these issues are part of a broader "watershed feeling" formed by emergent issues that aroused from stakeholders' interviews. The "watershed feeling" is an agenda of emergent issues like the land market, agrochemicals and farmers participation that need further study and research in order to consolidate an integrated water management.

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