The federal program of Payment for Hydrological Environmental Services in the context of Climate Change: case of Mexico City

María Perevochtchikova y Adrián Vázquez Beltrán

CEDUA, El Colegio de México[1]

Abstract

This work discusses the possibility of considering the federal program of Payment for Hydrological Environmental Services (PHES), implemented by National Forest Commission in Mexico since 2003, as an alternative instrument for the Environmental Public Policy in order to contribute to the Integrated Water Resources Management in the basin of Mexico City that has very high relevancy in the context of Climate Change and environmental, technical and social vulnerability of this zone. This is the most important urban area of the country that faces serious problems in providing water in sufficient quantity and quality to its population. The main objective of the PHES is to provide economic incentives to the owners of the territories that are situated in the mountains and have forest resources. Particularly, there are 13 areas of PHES on the Conservation Land of Mexico City which are very important from the point of view for the preservation of hydrological cycle on the regional scale and that also provide many other ecosystem services: such as climate regulation, carbon retention, reduction of land erosion and biodiversity protection. After three years of investigation we discuss the hydrological importance of PHES in the basin of Mexico City, the vulnerability in the context of Climate Change and the experience of rural population in the application for this program.

Key words: Hydrological Environmental Services, Environmental Public Policy, Hydrological Basin, Climate Change.

Introduction

The fact of environmental degradation caused by irresponsible use of natural resources was first internationally recognized in the 1970s and opened path to the creation of new methodological concepts of environmental public policies aimed at bringing to life postulates of Sustainable Development, searching for balance between objectives of economic progress, social well-being and biophysical functioning of ecosystems; that provide environmental services to the people through technological and scientific development of both social and natural sciences using integrated interdisciplinary ecosystem approach (Andrade, 2004; Perevochtchikova y Arellano, 2008).

In Mexico, despite many attempts, it has been impossible to adopt integrated water resource management (IWRM), due to several limitations, such as: i) lack of political coordination in territorial planning; ii) weak cooperation between and within institutions, society, government and scientists; iii) negligible public participation in decision-making; iv) weak environmental legislation; v) lack of reliable information on which to base public policies, as well as vi) weak public education system in the country, to better manage, use and preserve natural resources (Perevochtchikova y Arellano, 2008).

The importance of including ecosystem approach to IWRM is explained by country's mega-diversity; as because of its orography, geology and climate 70.2% of its territory has almost all types of climate and is home to almost 12% of existing species of flora and fauna. According to the National Forest and Land Inventory 2004-2009, 33% of the territory is covered by forest and jungle; 29% - Xerophyte thicket and 8.2% - other forest areas; while 29.74% of country's territory is used for agriculture, livestock farming, cities, etc. (CONAFOR, 2010a).

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Forests play a role of utmost importance in preservation of life-cycles, (carbon, and biological, hydrological, among others); nevertheless, the forestry industry in Mexico is facing a grave problem of deforestation of those ecosystems, which is the result of the change in land use to agricultural, livestock farming and urban growth. According to CONAFOR, (2006) the deforestation rate in the country is calculated between 200 thousand y 1.5 million ha per year.

To be able to carry out IWRM, through the ecosystem approach, besides the engineering vision of water resources, it has to be complemented by actions and programs that consider this approach, including interaction among biotic, abiotic and anthropogenic elements, within the interdisciplinary studies' frame. An alternative way to carry out Integrated Water Resource Management is Payment for Hydrological Environmental Services (PSAH).

Background

The methodological concept of IWRM was internationally consolidated in the early 1990s after several international agreements were signed. In this integral ecosystem management framework the water is considered as the fundamental connection between human development and nature, the one that includes complex interrelation of physical factors that are part hydrological cycle (air – water – soil) with the biodiversity that it supports (flora – fauna); that means, hydric resources (natural resources associated with water), including, also, anthropogenic factors related to its transformation. Despite positive effect on environmental preservation, this approach has faced many limitations in application (Hinrishen *et al*, 1999), and frequently only stayed on paper, in official speeches and documents, and national development plans. Political, administrative, cultural and even educational factors contribute to its incorrect application. Those factors are country-specific, but mostly notable in developing countries, such as those of Latin America and the Caribbean (Andrade, 2004).

The principal objective of the ecosystem approach to the management of natural resources, particularly hydrological resources, consists in changing their sector-restricted management and substituting it with a new inter-sector scheme, which embraces urban, rural, social and economic development plans in the framework of human-nature interrelation in the integrating ecological and territorial context (Perevochtchikova y Arellano, 2008). In this case, the concept of ecosystem as a complex and open system (García, 2006), becomes a foundation for understanding this process of coordination that exists in the flow of matter and energy between nature's and mankind's systems. Territorial dimension of this interrelation associated with the flow of water is equal to the concept of hydrological basin (Arellano, 2005).

The approach to water as a natural resource in public use and material goods was proposed at the Water and Environment Conference in Dublin, Ireland, 1992. Later, at the UN Conference on Environment and Development that took place in June of 1992, in Río de Janeiro, Brazil, specific actions for instrumentation of the action plan were analyzed (Andrade, 2004) and motivated the creation of Agenda 21, Action Plan for Sustainable Development, accepted on the international level (CNUMAD, 1992). It defined that water management must be based on integral ecosystem vision, within the territorial dimension of the basin (Arellano, 2005). Latin American Congress on Hydrographic Basin Management, Arequipa, Peru, 2003 confirmed the relevance of the implementation of Integrated Water Resources Management (IWRM) in hydrographic basins of Latin America, considering it a fundamental territorial unit for planning of natural resources associated with water.

Environmental Services (ES) are understood as "A benefit in the form of biological processes and physicochemical functions that the environment (ecosystems) provides to living forms, in particular, mankind" (Torres, 2006). The official definition of Semarnat (2007) mentions that they are "All benefits that people receive from ecosystems, including provision services (food and water), regulation services (of weather, water, disease), cultural services (spiritual, aesthetic, recreational)". Hence, the ES can be divided into: provision services that are involved in soil formation, bio-geochemical cycles, primary production and that include: i) supply services (food, water, fuel, fibers); ii) regulation services (climate regulation, disease control, water regulation); iii) cultural services (spiritual and religious, recreation and ecotourism, aesthetic). These services produce certain environmental goods used by man, such as fruit, crafts, medicines, etc. These are tangible natural resources that are used as raw material or final product, spent or transformed during the process (MEA, 2005).

There are several recognized types of ES:

- Carbon Capture (production of oxygen reduction of negative impact of natural phenomena, climate regulation);
- Biodiversity and Landscaping (protection of biodiversity, ecosystems, protection and recovery of soil, natural beauty and recreation);
- Hydrological Environmental Services (sustaining replenishing capacity of aquifers, maintaining quality of water, reduction of sediment, preservation of springs, lowering the risk of flooding).

According to CONAFOR, (2010a) Payment for Environmental Services (PES) was created as an economic incentive for owners of forest lands where these services are generated, with the objective of compensating the cost of conservation and expenses incurred while managing the territory correctly. The central idea of PES scheme implementation is to add environmental, social and economic value to Environmental Services and create markets by providing payment from funds (international, federal, mixed) to the owners of forest zones for preserving forests in the mountains in the upper parts of basins that contribute to preservation of the hydrological cycle.

There is a great number of international publications on the subject of Environmental Services (ES): scientific articles, work documents, works of popular science, protocols, technical evaluation reports, etc., where Costa Rica, USA, Brazil, Mexico and China are featured (*Table 1*). Nevertheless, on the national level there are few publications on the subject; the majority of those are works of popular science, work documents, and technical reports (INE, 2005; Pagiola *et al*., 2003; INE-TCCCR-CONAFOR, 2007; Colegio de Posgraduados, 2005 y 2008; Collado, 2006; Bonfil y Madrid, 2006).

***Table 1**. Publications on the subject of PES.*

Scale	FOCUS		
	Natural Sciences	Socio-economic	Interdisciplinary
International	-Costanza *et al.* (1997) -Low *et al.* (1999) -Postel y Thompson Jr., (2005) -Naidoo y Ricketts (2006) -Wallace, (2007) -Fisher y Turner, (2008) -Naidoo *et al.* (2008) -Rogers, (2010)	-Costanza, (2000) -Kerr, (2002) -Turner y Daily, (2008) -Turner *et al.* (2008) -Vatn, (2009) -Kemkes *et al.* (2009) -Fisher *et al.* (2009) -Kontogianni *et al.* (2010)	-Tianhong *et al.* (2008) -Biao, (2008) -Nelson *et al.* (2009) -Wendland *et al.* (2009) -Crossman *et al.* (2010) -Fisher *et al.* (2010) -Jogo y Hassan, (2010) -Zhang, (2010)
Latin America	-Pagiola, (2002) -Pagiola *et al.* (2004) -Landell-Mills y Porras, (2002) -Mayrand y Paquin, (2004) -Sánchez et al. (2007)	-Chomitz *et al.* (1998) -Rosa *et al.* (1999) -Miranda *et al.* (2003) -Nelson y Chomitz, (2004) -Echavaría *et al.* (2004) -Zbinden y Lee, (2005) -Kosoy *et al.* (2007)	
National		-Merino (2005) -Muñoz-Piña *et al.* (2008) -Alix-García *et al.* (2008)	

Analysis of publications on the subject of ES highlights the obvious lack of development of many topics, particularly understanding, and conceptual and methodological definition of its physic-biological functioning (capture, transfer and discharge of surface and subterranean water under the concept of hydrological cycle and hydrological basin; as well as ecosystems associated with the said cycle); determination of the demand and the subsequent absence of studies of feasibility of establishing self-sufficient local markets, where the flows of the hydrological resource are determined and quantified, its connection to the socio-economic dynamics related to HES. Thus, the challenge to be dealt with is highly relevant, and intends to contribute to conceptual discussion of combining two theoretical frameworks - IWRM and HES, in the practical context of applying instruments of Public Environmental Policy in Mexico; also, considering the context of climatic change.

Problematic

In recent years the demand for water resources in Mexico City has been on the rise, while the supply of quality water for human consumption has decreased. National Population Council (CONAPO) has estimated that by 2007 the population of Mexico City's metropolitan zone would surpass 21 million of inhabitants, and in 2030 - 23.7 million (CONAGUA, 2010).

The challenge currently faced by the governments of Mexico City and Estado de Mexico as well as the federal authorities consists in providing the second biggest city of the world with sufficient quantity of water of adequate quality (*Figure 1*). In 2007 average per capita potable water availability in the region was calculated at 143 m^3/inh/year, and based on the forecast for 2030, it will be at 127 m^3/inh/year. This indicator is a sign of alarm, as internationally the threshold for low water availability was established at below 1,000 m^3/inh/year, reflecting crisis and shortage of water (UNESCO, 2003).

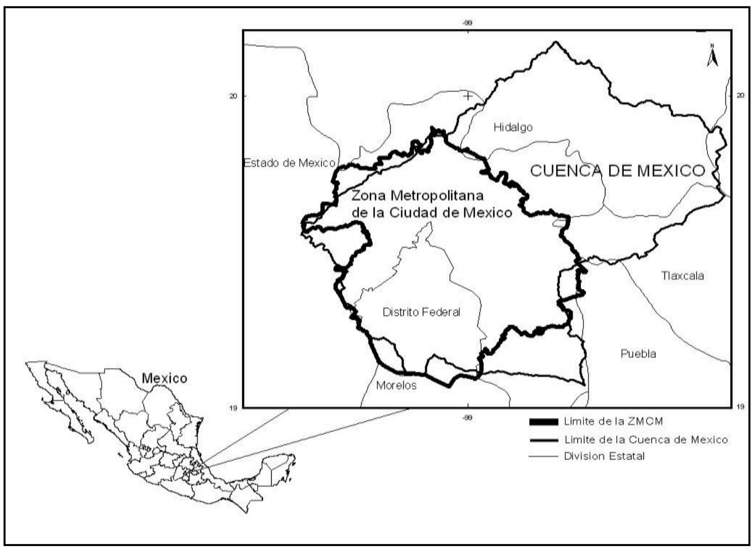

Figure 1. *Location of Mexico City metropolitan area, and Mexican Basin.*

The government of Mexico City constantly carries out hydraulic engineering works on its territory (extraction systems, storage and distribution) in order to obtain water from the local aquifer and other sources. Nevertheless, despite comprehensive infrastructure, the water supply system of Mexico City is highly inefficient; the most important indicators of which are: physical, equivalent to 40% (through losses in the distribution system); economic, 30% (due to high operating costs, elevated energy consumption and subsidies); social (due to conflicts caused by unfair distribution in quality and quantity of the resource) and environmental (degradation of aquatic, and associated with them, ecosystems). That is why, in the future, when Integrated Water Resource Management is introduced, the use, management and distribution of the water must be concentrated inside the Basin (Perevochtchikova y Arellano, 2008; Perló y González, 2009; Escolero-Fuentes *et al.*, 2009).

Conservation Soil (CS) of Mexico City is of vital importance for the urban and rural populations of the area as it provides various Environmental Services (ES). Among others, there's maintaining of hydrological cycle (SMA-DF, 2008). Morpho-edafological characteristics of Conservation Soil (CS) of Mexico City permit replenishing the aquifer (Cram *et al.,* 2008); hence are indispensable for the hydrological cycle of the entire Mexico Valley Basin. It is one of the most important Environmental Services. The local aquifer provides 70% of the potable water required by the population of Mexico City (CONAGUA, 2010).

Urban expansion intensifies the loss of forest on CS, causing misbalance to ecosystems and environmental degradation accompanied by loss of ES. During the past four decades 30% of forest disappeared in the metropolitan zone and native populations of wild flora and fauna declined to critical levels. It contributed to reduction in bodies of surface water and replenishing of the local aquifer (Libreros-Muñoz, 2004; SMA-D.F., 2008).

Case Study

In Mexico City National Forestry Commission (CONAFOR) reimburses owners (common lands or ejidos, communities, small private owners) of lands located on Conservation Soil in the upper part of the Mexico Valley Basin, under the federal program of Payment for Hydrological Environmental Services. It contributes to the preservation of land and vegetation, and hence aids environmental conservation, including hydrological cycle, - specifically, replenishing the aquifer that provides about 70% of the total potable water used by the inhabitants of Mexico City (*Figure 2*).

SOURCES	INTERNAL	EXTERNAL	TOTAL
Underground	Mexican Basin (39.7 m^3/s)	Lerma Basin (5.1m^3/s)	73.5%
Surface	Mexican Basin (1.1 m^3/s)	Cutzamala Basin (14.7 m^3/s)	26.5%
TOTAL	67%	33%	100%

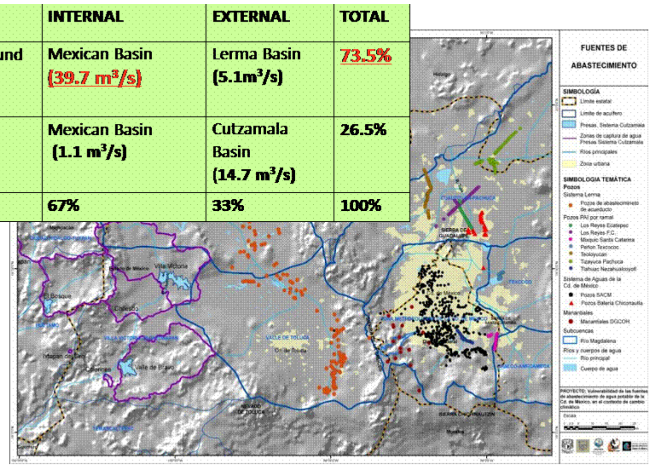

Figure 2. *Location of sources of potable water in Mexico City.*

It is worth mentioning, that according to various climate change scenarios, by 2050, the supply of potable water will reduce by 10-17%. Thus, in the nearest future it will be crucial to apply measures of adaptation: maintaining and reshaping infrastructure, protecting and restoring capture areas, reducing consumption of water – culture of water, taking advantage of non-conventional sources (not large hydraulic structures), and strengthening inter- and intra- institutional actions; all part of the Integrated water management approach, focused on the inside of the basin.

We are interested in the development of the Program of Payment for Hydrological Environmental Services in Mexico City, particularly on Conservation Soil. Locations of the zones that receive payment for ES during 2003-2009 are represented in *Figure 3*.

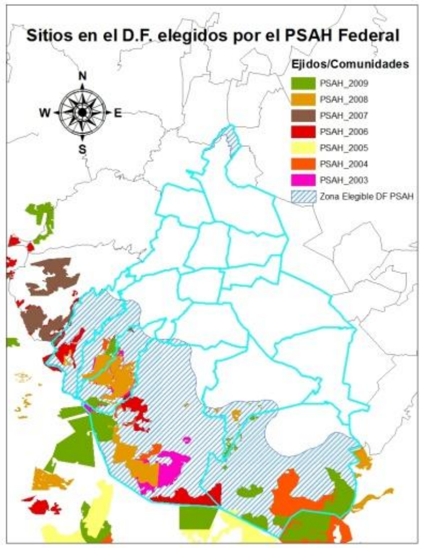

Figure 3. *Location of zones that receive payment for HES in Mexico City, 2003-2009 (Source: CONAFOR, 2010b).*

It is necessary to mention that the number of common lands and communities that participate in the program has been varying, though always with a tendency toward increase. By 2009 the total of 13 plots joined the program. New territories are incorporated through signing 5-year contracts. *Figures 4* and *5* represent the number of beneficiary communities and the territory incorporated, respectively.

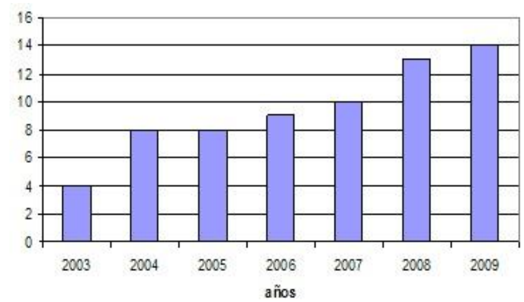

Figure 4. *Number of areas receiving payment for HES in Mexico City2003-2009 (Source: CONAFOR, 2010b).*

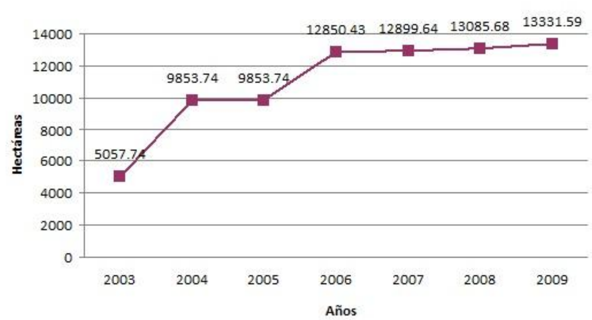

Figure 5. *Surface of lands receiving payment for HES in Mexico City, 2003-2009 (Source: CONAFOR, 2010b).*

Based on the information presented above, nearly 13 000 ha of forest lands are protected, and MEX $30,142,645 are paid to 18 agricultural units (CONAFOR, 2010b). It confirms the growing interest on the part of land owners towards the program's resources and possible interest toward protection of soil natural resources that influence the quality and quantity of produced water and vegetation associated with it. Yet, the numbers are not too high due to the fact that the procedure to join the program is complicated, the payment is lower than possible incomes from other activities and local markets are not regulated. It all affects the determination of participants in a negative way.

In order to analyze the local problematic of the case study, several interviews with decision-makers and beneficiaries of the program were carried out. See *Figure 6*.

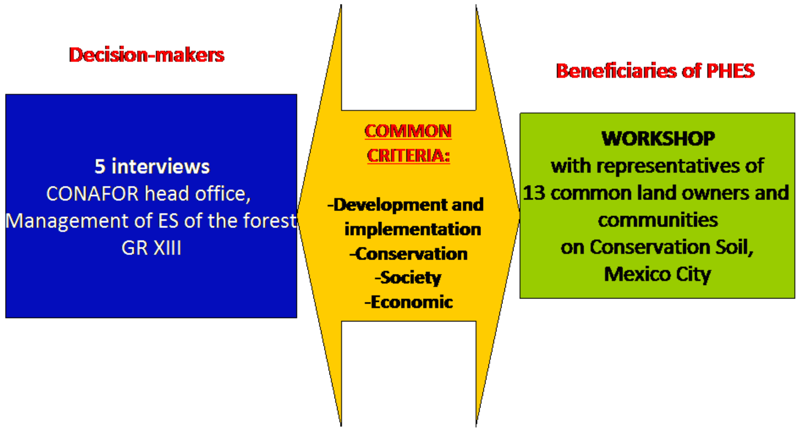

Figure 6. *Realized interviews, 2009.*

During the interview process the following points were highlighted in regard to the functioning of the PHES program in Mexico City:

- Design and implementation

  A clear, well-planned instrument of Public Environmental Policy (Rules of Operation). There is a possibility of introducing changes and citizen participation by means of Technical Councils.

  Deficient regulations for financing; needs improvement of Rules of Operation (Technical Advisors).

- Conservation impact

  Promotes conservation practices; does not apply to all ecosystems

- Society impact

  Payment stimulates and encourages better practices; generates employment.

  Insufficient dissemination of information about HES' benefits to raise environmental awareness among rural and urban communities, and increase their participation.

- Economic impact

  Self-financing, concurrent funds, long-term contracts insufficient to enhance local initiative for reinvestment into integrated use of the forest by communities.

  Lack of determination and promotion of local HES markets (offer-demand of the water resource and benefits brought by forests).

This shows the enormous potential of PES, particularly Hydrological, and Mexico City Conservation Soil services. Besides, there is a growing interest in the program on the part of communities that occupy those territories for the economic benefit it brings, even though it is rather insubstantial, considering urban pressure, high opportunity costs of forest-agricultural lands and other interests involved. On the other hand, there is a growing knowledge of environmental issues and importance of Mexico City's Conservation Soil for water protection. This motivates owners of forest lands to look for funding to help preserve and maintain them. This need must be met by combining various sources of funding, such as Concurrent Funds supported by local and federal government, as well as by private initiative. Nonetheless, carrying out these actions does not guarantee the best utilization of the hydrological or forest resources, and even less so, reinvestment in conservation activities and sustainable use of water and forest resources in common use.

Conclusions

As it has been mentioned, starting from 2003, a new strategy has been developed that allows to value environmental services that are provided to the population by the forest, which, besides timber, contributes to water infiltration, carbon capture and preservation of biodiversity. The Payment for Hydrological Environmental Services Program (PHES) is intended to become a market mechanism that compensates owners of lands located in the upper parts of basins for contributing to protection and increases of forest coverage, and, at the same time, guarantees availability of sufficient amount of quality water (Perevochtchikova y Ochoa, 2010).

As Pagiola *et al*. (2005) and Ochoa, (2009) state, Payment for Hydrological Environmental Services can be a functional and efficient market mechanism if there is enough information available to the involved parties. Still and all, currently many of them are unaware of the importance of ES. The vast majority of the population takes water for granted, seeing it as public property and free. This erroneous perception affects the ES market in a highly negative way.

The analysis shows that during its implementation during 2003-2009 the PES program faced plenty of operative, legislative, institutional and economic impediments (Colegio de Postgraduados, 2005 y 2008; Ochoa, 2009; Hernández, 2009):

- PHES has been managed as a federal subsidy that attempts to stimulate production and maintenance of ES.
- Lack of comprehension and scientific research to determine ES.
- Insufficient monitoring to study actual benefits of ES (such as compromised quality and quantity of water).
- Lack of control and supervision of the program.
- Weak legal definition of PHES and its payment mechanisms does not ensure continuity or stability for the duration of the program.
- Poorly determined demand (who is willing to compensate for the benefits received from ES). Unestablished self-sufficient local markets.
- Low public awareness of cultural and economic value of ES, due to their public character and free access.
- The PHES model currently in use in Mexico gives preference to social interests at the expense of environmental interests.
- Exclusion of small land plots. Exclusive and not integral programs.
- Peculiarities of land ownership in Mexico are not taken into consideration: 70-80% of forests are administrated by 7000-8000 ejidos and communities.

These are the reasons why it has been impossible to achieve environmental and social objectives established initially, such as reduced loss of forest coverage and better water capture, poverty reduction by way of protecting forests and creating self-sufficient ES markets.

Nevertheless, the benefits of PHES are reflected in improved performance of the basins that provide such services as supplying water and replenishing aquifers, preventing and mitigating socio-anthropological risk caused by meteorological phenomena (Burstein, 2002 cited in Ochoa, 2009). Consequently, when combining the concepts of the basin and ecosystem vision, the PHES Program can be considered an important instrument of IWRM as a climatic change adaptation measure.

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