1

DOCUMENTOS DE TRABAJO | WORKING PAPERS

Diversity of Water-Based Benefits in the High Andes Range

Germán Escobar

Rubén Darío Estrada

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The project **On designing and implementing benefit-sharing mechanisms** (Project A1) deals with approaches to improving water usage in order to increase productivity and alternative water allocation and create conditions for designing and operating Benefit-Sharing Mechanisms (BSMs) among water users in the Andean basin. A design condition for BSM is that benefits resulting from water will contribute to alleviate poverty within selected working sites.

Methodologically, this project proposes to identify socioeconomic hydrological response units (SEHR) to select working sites in Colombia, Ecuador and Bolivia. This approach is based on the assumption that there exist territories and watersheds in the Andes with conditions for generating water benefits either by modifying the use of land/water to increase water surplus for other users or, by creating positive externalities appropriable by water users in different sites of these territories.

The analysis of about 5 million ha searching for SEHR has revealed a number of issues from which the A1 Project team derives several lessons. This analysis is aimed at determining areas and territories where potential water services[1] and water externalities offer alternatives to design mechanisms to distribute benefits originated by changes in water/land utilization in such a manner that those benefits have a positive impact on poverty within the selected territories. The analytical model utilized for this search is based on land/water production potential and on the capacity to assign priorities to SEHR units and to production activities within those units. A synthesis of these issues is as follow:

- Areas with significant water externalities and where these externalities represent an attractive value to potential beneficiaries are difficult to find in Andean regions higher than 3700 m.a.s.l. For this reason, compensation to water providers is either not possible nor is it relevant for poverty alleviation purposes, due to the value of water use. These circumstances have a direct effect on the traditional concepts and bases used to design schemes of payment for environmental services, particularly when those payments are intended to relieve poverty.
- Exceptions to the former case are territories where infrastructure and water regulation systems change water disposal to make it available for production/consumption in scarce periods. The typical cases correspond to dams for electricity production, reservoirs for land irrigation districts or water catches for human consumption. In most cases, water users are clearly identified and the price of water utilization could include a proportion to compensate water providers. These physical territories are easy to identify and water users often belong to structured organizations and well-designed consumer systems. Nevertheless, these water regulation projects work quite differently in practice: most often feasibility analysis does not include payment for storage of water nor does it

[1]Water services are targeted under numerous PES schemes. Mayrand and Paquin (2004) list water services provided by forest ecosystems that are considered under existing PES schemes as follows: Water flow regulation: maintenance of dry season flows and flood control; Water quality maintenance: sediment load control, nutrient load control (e.g. phosphorous and nitrogen), chemical load control, and salinity control; Erosion and sedimentation control; Land salinization reduction/water table regulation; and maintenance of aquatic habitats (e.g., maintaining water temperature, shading rivers/streams, ensuring adequate woody debris in water).

embrace potential water price for other use, such as agricultural production. Omitting this information in the investment analysis results in a more profitable project which becomes easier to finance. One of the direct consequences of this type of design is that when the water regulation system is working, landlords located above the storage site frequently claim a payment for the water they provide to the system, and the enterprise administering water asks lowland agricultural water users to compensate the upland water providers[2]. Conflicts of this kind are difficult to solve and often require legal regulation, subsidies and long negotiation periods.

- There are other areas where some alternatives to design and introduce changes in water utilization at the farm level to improve water/land productivity exist. In a number of cases, these alternatives do have the capacity to generate opportunities to increase demand for labor. Furthermore, former changes may offer room for adding value to primary agriculture production, in which a proportion of poor population can directly or indirectly participate. These cases produce private and social returns attractive to investors, particularly in cases where other production services are available[3].
- Other particular areas are *páramos* (moorland) that correspond to areas above 3700 m.a.s.l. in Ecuador and 3200 in Colombia. Most often, these areas are not suitable for competitive agricultural or livestock production due to restriction in temperature, solar radiation, slopes and land utilization. *Páramos* are frequently reserved areas for water sources conservation, but they are also repeatedly populated areas with some production activities usually for own consumption since competitive production is usually null. Yet, *páramos* may be a source of water externalities, particularly when production activities deteriorate fragile ecosystems, produce soil degradation or diminish water sources. These conditions offer room to design mechanisms that could contribute to alleviating poverty of *páramos* population.
- Analyzing poverty in the high Andes, it is possible to identify territories with great natural capital represented in abundant water availability as natural endowment. These are areas where the amount of available water exceeds the utilization capacity of the territory, leaving significant amount of water for utilization in lowlands for either production or human consumption somewhere else. This requires that water users pay for the service in order to transfer a proportion of this payment to the water provider territory through institutional arrangements capable of directing funds to satisfy basic needs and guarantee family income above the poverty line. Decisions on payments and compensations are

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[2]Public owned land sold to private parties in Peru after a granting of water to build a dam for electric power generation makes an interesting empirical case. The electricity company paid for highlands water storage in lagoons whose owners (original ethnic groups) are claiming for a payment for their water and, low desert lands sold by the government to private individuals at a high price, included the water coming from the dam. Since water is already paid for, no incentive exists to make a rational use of this water. However, maximization of water use is plausible by actual landlords by introducing technological change into irrigation systems, generating a water surplus to enlarge the actual irrigation district, with new users who could internalize the externality created through technical change.

[3] Similar cases are reported in other areas. In fact, Wunder states that "… if the desired land use is already privately more profitable than the non-desired one, it normally makes no sense to apply PES. PES is thus most useful in the intermediate range of positive but numerically small opportunity costs: degraded pastures, marginal crop lands, forests in slow-moving agricultural frontiers, etc." (Wunder, 2005).

usually subject to negotiations which go beyond imputed prices, particularly when water uses do not create a perceived externality due to the available volume.

All these water-related alternatives widen the scope to design mechanisms to pay for either hydrological/environmental services generated by internalizing water externalities, preserving water-producing areas, increasing productivity through water maximization schemes or compensating territories for sharing its natural capital. The pending challenge focuses on utilizing this payment to alleviate poverty under the different schemes resulting from the alternatives already described.

The CPWF Project A1 has derived some lessons applicable to designing BSMs, based on the analysis of the aforementioned alternatives. This process is under implementation through field applications and, as a consequence, subject to ratification as long as additional field evidence validates expected results or, on the contrary, subject to rectification if new field results reject these lessons. New lessons will probably appear along the implementing process. A summary of these lessons is the following:

- Searching for water externalities susceptible of being internalized within the water distribution/usage system in a territory and capable of having a positive impact on poverty, should not be the only approach to design BSMs in the Andes range. As mentioned, there are other alternatives to value and maximize the use of water that could impact positively high poverty levels of the Andean population. The application of the SEHR analysis in a watershed or a territory should explore several of the existing possibilities in order to design water-related benefits applicable to poverty alleviation strategies.
- A number of conditions and circumstances seems to be associated to each of the water/land use possibilities. The incorporation of these conditions to the analysis of SEHRs and BSM potential design constitutes the bases of the watershed or territorial management design intended to alleviate poverty, based on water-related environmental services[4].
- The combination of water benefit alternatives and the conditions associated to each of those alternatives form a matrix from which two major issues are apparent: there are different approaches to design water-based benefits which could contribute to poverty alleviation and, policy decisions to design BSMs need responses to basic questions related to strategies of focalization for natural capital derived compensation as well as methodologies for area and investment prioritization.
- Associated to the mentioned possibilities matrix is the need to redefine the conceptual approach to utilizing water as the basic environmental element to alleviate poverty in selected territories. Payment for environmental services (PES) based on water externalities or *páramo*s devoted to water conservation typically intends to compensate

[4]There is a long discussion about projects and initiatives labeled as PES. For example, Robertson and Wunder (2005) report in their assessment of PES initiatives in Bolivia, that no single case met all five criteria, as defined by Wunder (voluntary, conditional transaction with at least one seller, one buyer, and a well-defined environmental service). Conditions mentioned in this text correspond mainly to field experience and conversations with qualified informants in some of the analyzed zones for the purpose of accomplishing A1 project activities, but by no means do they intend to be exhaustive.

individuals who provide services that are water related[5]. PES based on natural capital represented in water availability intends to compensate population living in territories providing water for uses in other territories, through mechanisms in which individual compensation is difficult to focalize[6].

Specific conditions associated with water-related benefit designs

As mentioned before, all water-related issues found in the high Andes are associated with specific conditions that have been identified along the on-going analytical process. This section includes a summary of those conditions, as understood by the A1 project technical team.

Conditions associated to benefits derived from water externalities

The current analyses indicate that major conditions under which water externalities produce environmental services useful to producers in lower lands are the following:

(1) Water availability in high lands with a positive hydrological balance is the first basic condition. In general terms, for a positive balance, precipitation should be at least 600 mm/year, since minimum evapotranspiration is about 400 mm/year. This water is cheap in land over 3.400 m since few crops grow in these lands due to the lack of thermic times (TT). Under these circumstances, it is possible to have a surplus of about 1500m^3/ha/year. In areas under 3.400 m, the water opportunity cost increases at exponential rates since TT liming factor relaxes and it is possible to grow alfalfa at 3.300 m to feed two milky cows/ha, which makes it attractive for the farmer to use available water in his own farm.

(2) Potential water surplus users should be located at least at 300m below the water provider site. At this altitude, they receive 1095 degrees additional TT which is transformed into 5000k of dried biomass/ha/year. With these TT, water is suitable to growing crops such as potato, barley, alfalfa and pasture (ray grass or kikuyo) and substantially decreasing the probabilities of frozen.

(3) Water surplus users should have a water deficit of at least 1 m^3/Cº degree of TT with an ideal scenario of one dry semester/year. With a water deficit of less than 1m^3, lowland producers may not be willing to compensate the high land water provider due to the capacity to produce with his own limited resource[7]. Likewise, in this ideal scenario the water provider would have land

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[5]The improved management of the upper watershed for maintenance of water services is a strategy implemented in several countries of Latin America and the Caribbean, including Brazil, Colombia, Costa Rica, the Dominican Republic, Ecuador, Honduras and Panama. (Mayrand and Paquin, 2004).

[6]Watershed-based PES schemes are increasingly used and have been put in place in several countries, including the United States, Mexico, Colombia, Ecuador, Costa Rica, Honduras and Brazil. For example, in the Cauca Valley in Colombia, farmer associations initiated a PES system to address concerns regarding the sustainable supply of water for irrigation. Since its inception, this scheme has led to the adoption of conservation measures in over one million hectares of land (Mayrand and Paquin, 2004).

[7] PES schemes will tend to work best when the value of environmental services is high for beneficiaries and the costs of providing the services is low. If the value of services and the cost of their provision are low, the transaction costs associated with a PES scheme might be higher than its value-added in terms of environmental benefits (Mayrand and Paquin, 2004)

extension 10 times greater than the water user in order to receive a compensation that could make it attractive to provide water for a lowland user.

Conditions associated to benefits derived from water flow regulated systems

Changes in water availability through major infrastructure works bring about at least two scenarios that affect any PES scheme: water and individuals located in lands above the collecting site (dam, reservoir, water catch, etc.) and individuals and other users receiving services with the technical specifications allowed by the characteristics of the water regulation infrastructure and any other legal and agreed upon regulations[8]. These two scenarios have particular requirements for water benefits to take place as will be mentioned in the following paragraphs.

(4) Water availability in the area above the collecting infrastructure needs to be abundant enough to allow water collection and storage. This depends of many variables (size, use of water, infrastructure characteristics, etc.) that make it measurable only for each specific case. For the same reason, any compensation scheme for water providers becomes unique. However, the identification of the area and, eventually, individuals contributing to water collection is possible and so is the development of a BSM. In principle, stakeholders are the water collection enterprise (public or private) and water providers; however, for the purpose of the A1 project, a significant proportion of water providers should face poverty conditions.

(5) Depending on the use of water down land the storage site, specific infrastructure could increase water price for final users. Legislation, user organization, water quota allocations, farm additional facilities, etc. are usually needed and constitute conditions for the water system to operate.

(6) For water intended for land irrigation, a condition is the user faces a water deficit for agricultural production. This deficit should affect production potential in such a manner that price paid for water will increase producer’s profit by an amount bigger than water cost.

Conditions associated to benefits derived from changes in productivity

Changes in water utilization at the farm level to improve water/land productivity are possible when any water surplus is utilized on site rather than being allocated for some other alternative use within a watershed. Conditions for this type of case are the following:

(7) The principal condition for utilizing water at the farm level is that externalities attributable to that water are not significant in terms of amount of water or in terms of the potential value that the provider would obtain for making that water available for alternative uses. In other words, the use of water surplus should produce interesting returns to water provider unless management of water at the farm level produces equal or higher revenue.

[8]According to Mayrand and Paquito (2004), demand for water services mostly originates from downstream water users, including farmers, hydroelectric producers, and domestic water users in urban areas. Given the local nature of demand and the presence of a limited number of well-organized beneficiaries (e.g., water or hydroelectric utilities, irrigation commissions), it is relatively easy to mobilize downstream beneficiaries and involve them in PES schemes.

(8) Temperature and radiation in the territory should allow alternative cropping systems or the intensification of actual cropping schemes, in such a manner that biomass productivity increases, maximizing water use. In either case, private profit must be greater than actual profit levels.

(9) For the purpose of project A1, changes in productivity and water use modification should bring in new opportunities to decrease poverty in the territory. To fulfill this condition high productivity should go along with other changes such as a higher demand for labor, the introduction of byproducts in the market or the transformation of the original product through value added activities.

Conditions associated to benefits from páramo areas

Some of the conditions to derive water-related benefits from *páramo* areas are the following:

(10) *Páramo* areas must provide significant water services either in terms of water volume or conservation of water sources. Externalities attributable to intervention in these areas or the lack of action, originate very often benefits/spill overs that would generate benefits if someone is willing to internalize them.

(11) As in other cases, benefits stemming from *páramos* must be greater than costs incurred to internalize *páramos*-related externalities and made them available to potential users. To fulfill this condition, it is quite frequent that public subsidies and/or international funded projects take place in *páramo* areas.

(12) The identification of water or externalities providers in the *páramo* areas is a condition to compensate them either for taking action or for stopping it, depending on specific conditions and circumstances in each area. For Project A1, expectations are that either *páramo* population or services/externalities users located out of these areas belong to the poor strata and improve their livelihood as a result of sharing this type of water benefits.

Conditions associated to natural capital

When water surplus in a territory is abundant, communities and individuals living in that territory can receive compensation for the amount of water. Conditions to make it possible are the following:

(13) For water to represent a natural capital for the territory the first condition is water abundance at the entire watershed level (otherwise it would typify a case for water externalities). Typical examples are watersheds where precipitation and water availability is greater in lowlands than in highlands. This is the case, for instance of the Quijos watershed in Napo, Ecuador where precipitation in the head of the watershed is about 1.300 mm/year and in the low lands reaches around 6.000 mm/year (Estrada, 2010).

(14) For the purpose of A1 Project, a significant proportion of the population in the territory with natural capital needs to face poverty conditions. Compensation for water would contribute to alleviating poverty conditions.

(15) Another condition is to identify water users. In most cases, the demand for water comes from outside the watershed, but a clear identification of such a demand would facilitate the negotiation of any eventual compensation. Keeping the same example, the Quito municipal aqueduct is actually catching 5-7 m^3/sec. from the high Quijos watershed for human consumption. In countries where water is considered a public good, it is difficult to formally sell it, but it is still possible to design a mechanism to compensate for the use of that water.

(16) Like in all of the cases already mentioned, another condition to receive a compensation for sharing the natural capital in a territory is that water user should make a profit (or provide a public service) in order to build the financial capacity to compensate the territory that provides the water. BSM design requires negotiations based on parameters different from imputed value to water externalities.

Some implications of water benefit possibilities

As explained above, by combining water benefit alternatives and their conditions it is easy to create an array of possibilities for the A1 Project to design BSMs. Table 1 summarizes these combinations.

Table 1. **Water benefits and conditions**

Water-related benefits	Conditions		
Benefits derived from water externalities	Water availability in high lands with a positive hydrological balance	Potential water surplus users located at least at 300m below the water provider site	Water surplus users should have a water deficit of at least 1 m3/Cº degree of TT with one dry period/year
Benefits derived from water flow regulated systems	Water availability in the area above the collecting site needs to be abundant enough to allow water collection	Upland water availability may require particular care and treatment of *páramos* and water sources, in addition to runoff going to the storage infrastructure	For land irrigation, the user faces a water deficit for agricultural production, and the price paid for water will increase producer's profit by a bigger amount than water cost
Benefits derived from changes in productivity	Water externalities must be not significant in terms of amount of water or in the potential value for letting water runs for alternative uses	Temperature and radiation should allow alternative cropping systems or intensification of actual cropping schemes to increase	Changes in productivity and water use should bring in new opportunities to decrease poverty in the territory

		biomass productivity increases, maximizing water use	
Benefits derived from *páramo* areas	*Páramo* must provide significant water services either in terms of water volume or conservation of water sources. Externalities in these areas often originate benefits/spill overs.	Benefits stemming from *páramos* must be greater than costs incurred to internalize *páramos*-related externalities and made available to potential users.	The identification of water availability or the generation of externalities in the *páramo* areas is a condition to compensate generators either for producing externalities or for not producing them, depending on specific conditions in each area
Benefits associated to natural capital	For water to be considered natural capital, it has to be abundant in the entire watershed. A significant proportion of population faces poverty conditions	Water users need to be clearly identified	Water users should make a profit (or provide a public service) to compensate the territory that provides the water

The first column of Table 1 displays different approaches and criteria to design water-based benefits in the Andes, found in the process of determining SEHR units in some of the Andean countries. These approaches are applicable under different circumstances that characterize each potential working area and all of them intend to relieve poverty conditions of target human groups. The other columns of the table point out some prerequisites for each approach, but it does not mean that additional requirements may not manifest when implementing field work.

Table 1 also indicates different possibilities for the Andes BDC projects to implement the applied research they intend to accomplish. Some of these possibilities relate to assumptions about water utilization, PES, target population, economic surplus directed to easing poverty and, policy decisions. The combination and/or relaxation of these assumptions open the nature of BSMs and multiply possibilities to design better water utilization schemes.

In terms of water utilization, it seems important to recognize that the traditional top down water runoff/infiltration or water storage strategies are not the only possibilities to derive water-based benefits. According to the information from zones already analyzed, these areas are not very common; cases where significant dams and other water storage infrastructure exist are few very easy to identify (Mayrand and Paquito, 2004). Changes in land/water productivity, *páramos* conservation or the utilization of water as the natural capital in some regions are real possibilities for designing water benefits that could help fighting poverty in the Andes range. Actually, the higher proportion of SEHR units identified by Project A1 through the application of the Growing

Degree Days methodology (TT) up to now, are subject to changes in productivity to derive benefits from water.

The principle of PES is that those who provide environmental services-water service in this case-receive a compensation for the cost of doing so, regardless whether there are direct costs associated to specific land use practices or indirect opportunity costs for avoiding certain activities or types of land use. Such a payment could be monetary or in-kind and take place at local, national, and global levels. However, the expected transaction between private parties is not the only payment alternative. Actually, more compensation projects are government funded, very often with a significant participation of international donors and multilateral agencies (Gutman, 2003). These facts open possibilities for BSMs design. A direct example concerning the A1 Project is the Tungurahua Livestock Fund created by the regional government with important shares from GIZ and the *sierra* farmers' organization.

Target population of water-based benefits varies according to the type of benefit derived from the water. However, in all cases target population is associated with demand and supply of water services. The most important issue is the condition to clearly identify water benefit provider and users, particularly in the case where any mechanism for sharing benefits include private payments. There are cases in which the identification of water providers is not essential. This is the case of water catches from territories where water is the natural capital. Any negotiated compensation would go to the territory through proper or agreed upon channels, independently of individuals or specific sites in which there is water catching. Similarly, there may be cases of public subsidies for water services or water use that go to the territory or the community in the form of public services or common use infrastructure, for example. In any case, it is important to have target population identified as much as needed.

For the particular purpose of Project A1, the target population includes territory's poor strata. The idea is to focus on at least a proportion of payment or compensation to the poor, if they provide water or water services or target them if they are water users whose income could increase. Nevertheless, this is not always possible in some modalities of water-related benefits identified up to now and shown in table 1. Particularly, benefits derived from changes in land/water productivity and benefits associated to natural capital are very difficult to focus on poor population that very often have limited access to land and other production inputs and are not individuals who collaborate with high proportions of natural capital in a territory.

In consequence, there are cases where direct target population may not include a high proportion of poor and, other cases in which all territory inhabitants or all community members are the target population. In the former case, it is important to clearly define how benefits will reach a proportion of the poor. For example, in Nariño, Colombia, where benefits derive from improving alfalfa productivity, increasing demand for labor would offer wages for rural poor. When benefits originate in territorial natural capital, negotiations for compensation should include poor strata as beneficiaries or any other arrangement that ensures a benefit share for the poor.

Policy decisions are difficult to predict in the absence of specificities of each case. It is particularly true when compensation originates in the use of natural capital since it becomes a matter of negotiation among actors and stakeholders with little help of value dimensions estimated through analytical procedures. In general terms, policies should apply to mayor issues related to PES and compensations and should contain incentives to preserve water as a basic natural resource, guarantee water quality, encourage high profit and competitive production and inspire byproducts or transformations which add to the territorial economic flows and provides opportunity to less endowed population.

Some methodological implications

Findings and lessons mentioned in this document have some methodological implications for the CPWF A1 project. The initial approach to determine SEHR units through applications of thermic times (TT) analyses and SWAT modeling in the high Andes, complemented with the application of an analytical integration of climatic, biophysical, economic and social factors (CBES) for decision makers to allocate resources, assign priorities and promote investments, is no longer applicable to all territories where potential water services offer alternatives to design mechanisms to distribute benefits. When water becomes a territory's natural capital, determination of water users is important, but there are no particular water providers given that natural capital of the territory is a common property and respond to the notion of public good, at least in a flow range in which water supply is abundant with no opportunity cost. Any resulting compensation to the territory for taking a portion of its natural capital would probably stand on negotiations, ability of actors to press for an agreement or any other factors of this kind, far away from technical-based analysis or imputed costs to internalize/prevent externalities.

Similarly, the premise of prioritizing territories and investment within those territories is not applicable when water benefits generate as compensation for using the natural capital of a given territory.

The analysis of *páramo* areas may have particular characteristics to which the project methodology is not applicable. In cases where *páramo* conservation is not financed by water services users or by individuals internalizing specific externalities but are rather subsidized with public or donor funds, there is no point in trying to assign priorities nor is it necessary to develop additional benefit sharing mechanisms. In this situation, the target group at the *páramo* is known, but beneficiaries/users out of this area are not identified since they become takers of a free service or a positive externality. These cases frequently correspond to the idea of conserving water sources, avoiding damage to sensible ecosystems or enforcing the law in countries where *páramos* are located in conservation areas.

A1 Project methodology should also change emphasis to clearly highlight data and conditions of hydrological balances, water flows, water surpluses and country legislation applicable to territories searched for SEHR and CBES conditions. These are major methodological contributions to determining those cases which may yield water benefits and positive externalities applicable to poverty alleviation schemes.

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