

Water harvesting: A promising climate change adaptation option for traditional Andean agriculture in Bolivia

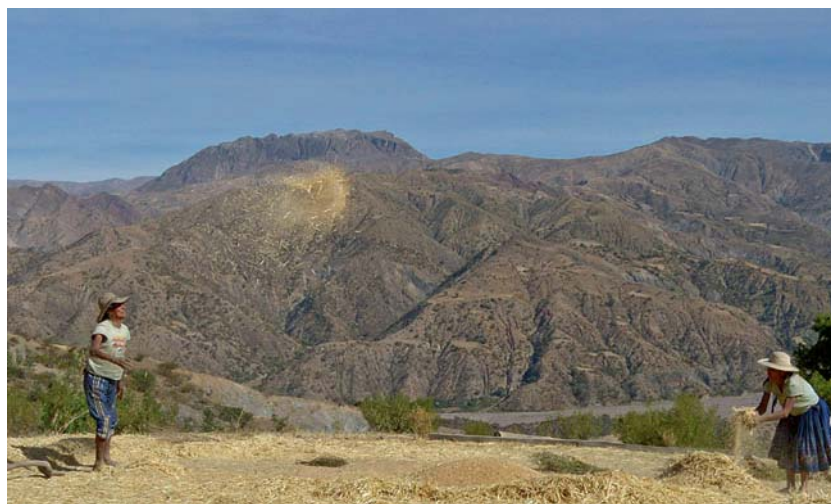
by Johanna Goetter¹

The Bolivian Andes are characterized by small far-flung settlements of subsistence farmers who belong to the indigenous cultures of Quechua and Aymara. In the rough highlands there are only some flocks of llama and alpaca that build evidence of human activity, but in the lower regions and the so called inter-Andean valleys (approx. 1800-3200m altitude), farmers practice a small scale traditional Andean agriculture, based on crops like potato, maize and wheat, and some livestock such as goats and sheep. Agriculture in these semiarid regions is often 100% rain fed, with a rainy season of only four to five months per year. Because of current changes in climate, the dependency on rain has resulted in an increasingly negative impact on the agricultural production. Due to frequent droughts, part of the livestock even dies of thirst or hunger (as there is no hay making or fodder storing) and farmers are increasingly faced with harvest losses. In the last decades, more and more farmers thus started to search for additional irrigation water for their fields. Discussions about benefits and techniques of water harvesting, especially rainwater harvesting, gained momentum in regional rural development organizations, international cooperation and governmental institutions.

Climate has always framed the Andean agriculture in an extreme way. With higher altitude and lower

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*Couple threshing wheat in San Pedro de Buena Vista Potosi Department
(Photo: Johanna Goetter)*

temperatures, the shortened growth period limits the cultivation of many crops, and frost and hail regularly destroy parts of the yield, while in the lower areas droughts are a bigger threat. Insolation and evapotranspiration of the plants are high. Eight months of the year, from April to December, there is a hydrological deficit, which is to say that the actual evapotranspiration of plants is much lower than their potential evapotranspiration.

With ongoing climate change, the vulnerability of the Andean agriculture further increases. Today, the farmers complain that the weather has become 'crazy'. The rainfall is not predictable anymore. It seems that the rainy season starts too late and ends too early and that even during the rainy season, more and more dry periods emerge, alternating with torrential precipitation events. The farmers therefore have difficulties to cultivate according to their traditional crop calendar, especially to find the right time for sowing. On the one hand crops suffer from water shortage during the dry days, while on the other hand the crops cannot

absorb the surface run off from the torrential rains that furthermore causes a lot of gully erosion.

Nevertheless, climate change does not present a uniform development within the Bolivian Andes. A recent study (Goetter/GTZ-PROAGRO, 2010) comparing precipitation and temperature data from the south of the Department of Cochabamba shows that the precipitation regime differs significantly between the five analyzed meteorological stations. In some cases the rainfall indeed seems to change according to the farmers' observation, in others however, the number of precipitation events in the rainy season has even increased since the year 2000 and rainfall events have become steadier. In contrast, there are uniform, well-observed increases in the detectable medium temperatures for all stations. The raise in temperature may be seen as a positive development for farmers as it allows the extension of the zone for traditional crops like maize and wheat and also the cultivation of new plants for own consumption or sales at regional markets. For such there is partly high demand, like in the case of peaches or strawberries. The down-side of it, however, is that fruit-growing as well as horticulture requires irrigation. With rising medium and especially maximum temperatures, evapotranspiration and with it water demand of all crops increases and also pest control becomes more difficult. Furthermore, data from higher altitudes confirm more cold weather events with hail and frost that will threaten the yield if it occurs in the most vulnerable period (between January and March). Summarizing, climate change brings some new opportunities for the agriculture in the Bolivian Andes, but the disadvantages prevail. In most regions, the traditional agriculture will hardly survive when remaining rain fed. While it will be extremely difficult to diminish the vulnerability to extreme weather events, water shortage can be combated with irrigation systems.

The benefit of irrigation first of all is boosting the productivity of the clod. It enables the farmers to save their crops from droughts within the rainy season and therewith ensure the yield of potato and maize for securing their families the daily basic diet and maybe producing some surplus for sale. But it means a lot more: Families get the opportunity to upgrade their aliment with vegetables – interestingly, after imple-

menting water harvesting systems, the first action of women is to plant carrots, onions and lettuce. The families may decide to advance the date of seeding for some weeks in order to have more developed and bigger plants at the time hail events will start. In some regions, the independency from rain allows the families to have up to three harvests per year with great opportunities at the regional market in some periods.

For the rural population, irrigation is not just a small plus for their survival, but it changes their daily lives. On the one hand, their fields start to have a higher productivity, meaning more food and even cash. A well managed production and irrigation system can reduce the dependence on additional income sources such as temporal migration. On the other hand, the new type of agriculture demands more work and care. Nearly all crops require regular irrigation and especially the cultivation of products with high market value demands very constant work like pulling out weeds. This means that the farmer can not stay away anymore from the clod for weeks, which contradicts with the common strategy of many men to seek temporal work in close by cities or the lower regions. Interestingly, due to these circumstances it can be observed that for example the most successful producers of strawberries are women.

In order to have water available for irrigation, in Bolivia, two different types of water harvesting systems can be distinguished: In some regions, small retaining dams operated by communities or farmers associations are quite common. In addition some farmers individually manage to collect water from small streams or springs in a small pool that are directly connected to their fields. Some organizations for rural development support these efforts by improving the existing and mainly quite simple dams and pools (for example rebuilding the channel system or giving the pool a membrane) or finance the construction of additional ones. This type of water harvesting with a permanent water source is not that expensive (around 1400US\$ for one constructed pool) and does not cause many problems regarding the management. Nevertheless, facing ongoing climate change affecting the local hydrological situation, at present it is unclear what changes in currently used springs and watersheds are to be expected.



Water harvesting system with permanent water source in Toro, Department of Potosí (Photo: Johanna Goetter)

However, there are also regions, where there are no permanent water sources at all and watersheds and springs are only filled in the rainy season. In this case, the construction of so called 'atajados' has become quite popular. 'Atajado' means 'embanked' and describes a big earthen reservoir on a slope that collects the surface run off of the rainwater from a prepared catchment area (3-5ha) above the reservoir. The construction typically consists of a simple earthen ditch dug with spade to collect the run off. Some technically more ambitious constructions additionally consist of an open concrete channel that leads the water into the reservoir (including a retention basin for sediments), a concrete overflow and a drainage with long tube that ends in a valve to be connected with hosepipes for the irrigation system in the field (min. 0.2ha, max. 1ha) or a drinking trough for cattle. Often, a ring fence prevents children from accidentally falling into the reservoir or the cattle damaging the construction. Since organizations have started to implement rain water harvesting projects with 'atajados' in the end of the seventies, the design has become more and more sophisticated and the storage capacity has increased from originally 300m³ to maximum 4500m³. As experience has shown that big community or multifamily 'atajados' often cause conflicts regarding water rights

and management duties, actually most 'atajados' have a volume of around 1300m³ and serve only one or two families.

According to the use of machineries like caterpillar vehicles in the construction of this modern 'atajados', this type of rainwater harvesting project is not cheap – the construction costs approximately 3500 US\$. The challenge for the projects is hence to maximize the benefit-cost ratio, i.e. to achieve maximum support for the agricultural activities of the rural population through this measure.

First of all, it has to be guaranteed that the water harvesting system functions and will do so for at least 12 or 15 years. Most problems are caused by extremely high losses of water due to exfiltration. If the 'atajado' shows high exfiltration rates after the first period of filling, it has to be made impermeable with clay. It is also the duty of the implementing organization to make sure that all installations like pipes, valves etc. are completed and functioning. As the farmers mainly live far away from the next town, they do not have the possibility to buy and complete lacking or damaged material themselves. The organization should not only provide all the material, but supervise and monitor the installation. , Secondly, it is very important to ensure a high productivity of the agriculture



Farmers watching the construction of atajados in Berengela, Department of Potosí (Photo: Edmundo Navia)



*Rustic water harvesting system in the south of the Department of Cochabamba
(Photo: Johanna Goetter)*

supported by the irrigation system and an efficient use of the water. As most farmers never had contact to irrigation systems before, it is necessary to assist them for at least two growing periods to give them the chance to become familiar with the new production system and the use of sprinklers. They should be advised in the decision of what species to plant, at what time and for which purpose. It is worth to calculate the financial revenues of the different crops at varying seeding/harvesting times and compare it to the acreage for irrigation and the value of the water. With remarkable water losses due to exfiltration and especially evaporation, the later the farmer begins to use the water after the rainy season, the less water is at his disposal. This means, that the remaining water becomes more 'expensive' if relating every cubic meter of water to the invested costs for the 'atajado'. A complete rainwater harvesting project for an 'atajado' of 1300m³ costs between 5000-5500US\$ including not only construction, but also measures for farmers assistance in irrigation and protection of the catchment area. Dividing these 5000US\$ between the annual 1300m³ (for the life time of the 'atajado' of 15 years), one cubic meter corresponds to 0,61US\$. But, as between mid March and mid April approximately 124m³ are lost due to evaporation and exfiltration, the 'price' for every cubic meter of the remaining 1213m³ rises up to 0,67US\$. If the farmer decides to store the water till mid June to use it for the hibernal sowing, he has to be aware that in these three additional months, losses can rise up to 327m³ and

the cost of one cubic meter increases to the value of 0,81US\$ (for more details regarding the calculation see Goetter/GTZ-PROAGRO (2010)).

Thirdly, as climate change leading to an increase of torrential rainfalls will have a negative impact on the landscape, especially on the already eroded slopes with naturally few or degraded vegetation, it is important to allocate enough financial and human resources within the rainwater harvesting projects to activities to protect the irrigated fields and the water catchment area. Erosion above the 'atajados' will cause high sedimentation rates that can make the reservoir collapse. In order to avoid this, measures as tree and grass planting should be taken into account. At the same time, a balance between the lowest erosion and therefore surface run off causing damages and the minimum surface that fills the reservoir and ensures the productivity of the fields should be found.

Concluding it is to say that already today there is a high need to adapt the traditional Andean agriculture of Bolivia to impacts of climate change and that water harvesting, in case of need even the more expensive rain water harvesting, should be further promoted. They are highly effective instruments if a couple of requirements like the ones mentioned in this article are fulfilled.

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