Utilizing an Untapped Resource; Manure Use in The Bolivian Altiplano as a Means to Increase Overall Production

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05/05/07

Bolivia is a landlocked country locate in west central South America along the Andes Mountain chain. The country is approximately 1.1 million sq/km (about 3 times the size of Montana) and has a population of just under 9 million people (CIA factbook). The majority of Bolivias' population reside in the urban areas in and surrounding the countries two largest cities, Santa Cruz, and the capital La Paz; with the remainder of the population residing in rural areas. Geographically the regions in Bolivia vary greatly in altitude, climate, and ecosystems ranging from the steep slopes and plateaus of the Andes mountains the lowlands of the Amazon basin.

Among the slopes of the Andes mountains nestled on a plain between the East and West range lies the Altoplano; A region unique in climate, season, and altitude which has over the centuries been cultivated with varying success by the native population. The study of this almost isolated population of people and their agricultural techniques has opened a door from which with caution and discern we can all learn from. Throughout this paper I will focus on the ability of farmers in this region to adapt to increasing economic pressure, climate change, environmental concerns, and the overall rugged conditions of the Altiplano. I will also attempt to illustrate the ways in which the altiplano farmer has historically managed these problems and present relatively new methods and ideas that could possibly help manage various problems; including the use of manure as a fertilizer source, of rotational grazing, an increasing current crop production/family income.

The Bolivian Altiplano is known for its harsh conditions, with altitudes ranging from 5,200 to 3,500 meters. There is a high variability in climactic conditions. Average temperatures range between 7-11 degrees centigrade with frost possible 200 days per year; making agricultural management a particularly dynamic challenge for farmers in the region (FAO 1994). More recently the climactic challenges have been exacerbated by a phase of El-Nino-Southern

Oscillation (ENSO) which intensifies equatorial Pacific Ocean weather patterns (Rowe 2002). Historically the rainy season on the Altiplano fell between October and April, but more recently the pattern has shifted to December through March with an increase in shorter more violent storms. Bolivian farmers are also challenged with low soil fertility making sustainable farming practices very difficult (FAO 1994).

These factors combined with the impoverished nature of Bolivia's rural population and the limited access to markets present Bolivian farmers a daunting management challenge. Thus far the farmers in this area have met this challenge by using mixed livestock cropping systems and diversification as a risk management strategy (Valdivia 2004). Traditionally farmers raised potato, quinoa, barley, oats, grasses, and herds of llamas, sheep and alpaca. The herds mainly graze on the endemic Tola shrub (*Parastrephia. bacharis*), bunch grasses, and alfalfa which has recently been introduced because it is semi-resistant to the adverse climactic conditions. Since the arrival of Europeans to this region cattle and poultry have also been incorporated into the livestock system and have given rise to new management strategies.

On the altoplano it has been found that livestock is the key to long term sustainability in that, they provide fertilizer to improved crop yields, fuel for a barren landscape, and transportation to local markets. Moreover, livestock provides capital insurance in case of hardships providing money or food which can be critical for survival. The use of rotational grazing, legumes, and a mixed cropping system; along with the implementation of livestock production is essential to the continued sustainability of the altiplano farmers. One major drawback to this solution is that livestock production requires a fairly large area of land and in Bolivia the distribution of landholding is skewed. The majority of farms (68%) has an area less then 5 hectares and only covers 1.4% of the total area while 85% of the farm land is owned by

3.3% of the farmers that cultivate 500 hectares or more(FAO 1994). The smaller the farm the more difficult herd management decisions become; which can mainly be attributed to the absence of land that can be left for fallow. Leaving land for fallow is of crucial importance to the Bolivian farmer because of the general lack of vegetation in the altiplano. Having fallow land allows for recuperation of the soil organic matter, slows erosion and increases overall vegetation. Without fallowed land one can expect overgrazing, depletion of soil nutrients, soil erosion and an overall decrease in crop production. Fallow periods on the altiplano generally range from 3-6 years but in areas where the land is available it could be up to 30 years (FAO 1994).

Because the majority of farmers have little to no land, small community co-ops have begun to spring up in which land and resources are shared for a common goal. One such community is in San Jose Llanga located 116 km south of La Paz at an altitude of around 3800 meters. This community comprises 7,200 hectares and is home to 118 households (Materer and Valdivia). These communities allow farmers to graze animals on larger areas and also to have more fallow land. Farmers also share risks together instead of taking on the risks independently. Utilizing this land properly could lead to increasing production and incomes for the whole community.

Soil fertility is one of the most important aspects in any plant production scheme second only to water. The percentage of organic matter, the availability of macro and micro nutrients, and the soils cation exchange capacity are all factors in soil fertility. Increasing the soils organic matter through the use of fertilizers such as manure greatly increases the soil properties and also provides a complete fertilizer with traces of various micro nutrients. Bolivia is a nation that is plagued with low fertility soils with the exception of some volcanic deposits in certain regions. The overall organic matter content in Bolivia's soil is a meager 2% and it has one of the lowest

mineral fertilizer use rates in the world with current consumption of N-P-K at only 3 units per hectare; for comparison in Colombia another South American nation current consumption is 139 units per hectare. The use of mineral fertilizer in Bolivia amounted to 15,000 metric tons and global estimates put the minimum requirement for Bolivia at 130,000 metric tons(FAO 1994).

In regions of the altiplano the availability of mineral fertilizers is very limited due to the distance to markets and Bolivia's general lack of fertilizer. However, the farmer in the altiplano has the ability to utilize the animals that are being grazed as a source of fertilizer. The general analysis for manure resources in Bolivia are shown on table 1.

CAL ANALYSIS OF ANIMAL MANURES AND COMPOST IN BOLIVIA
Mean value for different sources

(TYPE OF MANURE)	NUMBER OF SAMPLES	pH	%D.M.	% DRY MATTER						C/N Ratio
				N	P	K	Ca	Mg	O.M.	
CATTLE	42	8,1	71	1,24	0,39	1,65	1,16	0,44	37,2	17,4
SHEEP	6	7,5	87	1,35	0,59	1,70	1,40	0,30	58,7	25,2
CHICKEN	14	7,5	76	2,04	1,04	1,44	2,07	0,42	44,7	13,0
LLAMA	2	8,7	-	1,08	0,24	1,71	2,05	0,37	30,1	16,2
COMPOST (Veget. resid. + animal manure)	14	8,4	-	1,13	0,34	2,30	1,43	0,93	43,4	22,3

"Boletin" F.A.O: "El reciclaje de materias organicas en la agricultura de América Latina -Roma" -1983

Bolivia has an annual potential manure production of 14,251,100 metric tons which is nearly 10 times the estimated minimum requirement (FAO 1994). This manure is a virtually untapped resource for poor farmers in the altiplano. When we divide total production by the number of livestock gives us a per head amount of fertilizer with cattle providing 1.46 metric tons/ head, sheep .25 metric tons, and camelids including the llama and alpacaup to .68 metric tons annually.

This means a peasant subsistence farmer with 1 dairy cow, 5 llamas and 8 alpaca can produce 10.3 metric tons of organic fertilizer per year(FAO 1994). These are fairly conservative livestock numbers as compared to the community in San Jose Llanga where the mean per household number of livestock is around 25. However, the standard deviation was greater than 25, with the lowest number of livestock per household being 0 and the highest being 166. (Valdivia2000).

These fertilizers can be used to substantially increase local soil fertility an therefore the productivity of farmers. Productive soils for barley can be achieved with the application of 3 metric tons of manure per hectare (Saska gov). One could surmise that for hardier plants such as quinoa and potato the application rates will be less with this application of 3 metric tons of manure a year poor farmers could access up to 4 highly productive hectares of crops annually. If these efforts were made at a community level the results could be substantial according to calculations. A shared herd of 100 llamas could produce enough fertilizer for 23 hectares of land.

If community partnerships are not available a single farmer still has the ability with the right management practices to be productive. A single subsistence farmer using simple rotational grazing techniques could manage a small herd of livestock on as little as 4 hectares. While managing the livestock the farmer can grow the traditional crops of potato and quinoa on other areas of land. It has been demonstrated that if rotational grazing is implemented the same area

can be twice as productive and if the most profitable crop is chosen the productivity and returns on the farm can grow quickly (Beetz 2004). It has been shown that organically grown quinoa can produce up to 1400 kg per hectare and with the fair trade price of quinoa at $861/ metric ton, So a farmer just 1 hectare could produce $1205 annually (Fairtrade). This means with 2 hectares farmers has potential to more than double his income and surpass the mean income of the farmers in San Jose Llanga which is approximately $1199/ year (Valdivia). This is of course if the farmer has utilized the available 10 metric tons of organic fertilizer from the available livestock in the above example. It is also assuming the farmer has found a market for the quinoa. However, the market for quinoa is growing in the US, Europe, and Asia where the demand is several thousand tons per year above current production levels which offers exportable demand for Bolivian quinoa (Jacobsen 2003). It should be noted however, that data collected from the nearest market town indicated a 50-60% weather related failure (Valdivia, Dunn, Jette 1996).

The use of livestock is of vital importance to this whole strategy. They are the source of the organic matter that provides good fertility which leads to good production and increased capital. Livestock does however, utilize resources that are already scarce, but if managed properly should never cause a burden. With proper management the flow of nutrients should be very cyclical. The crops remove the nutrients and the livestock redistribute the nutrients back into the soil.

These strategies have to be implemented for the greater good of the Bolivian farmer and agricultural extension is of vital importance. Through extension with farmers the best management for the farmer can be identified and the specific needs of each household met. The farmer should be completely involved in research and decision making on implementing new technologies. It has been shown that farmers do not adopt complete technology packages but rather adopt components of the packages (Quiroz, 1994).Ultimately it is the farmer who decides

what course of action to take and the decision is generally based on survival issues if the farmer is impoverished. Figure 1 shows the cycle of the impoverished farmer.

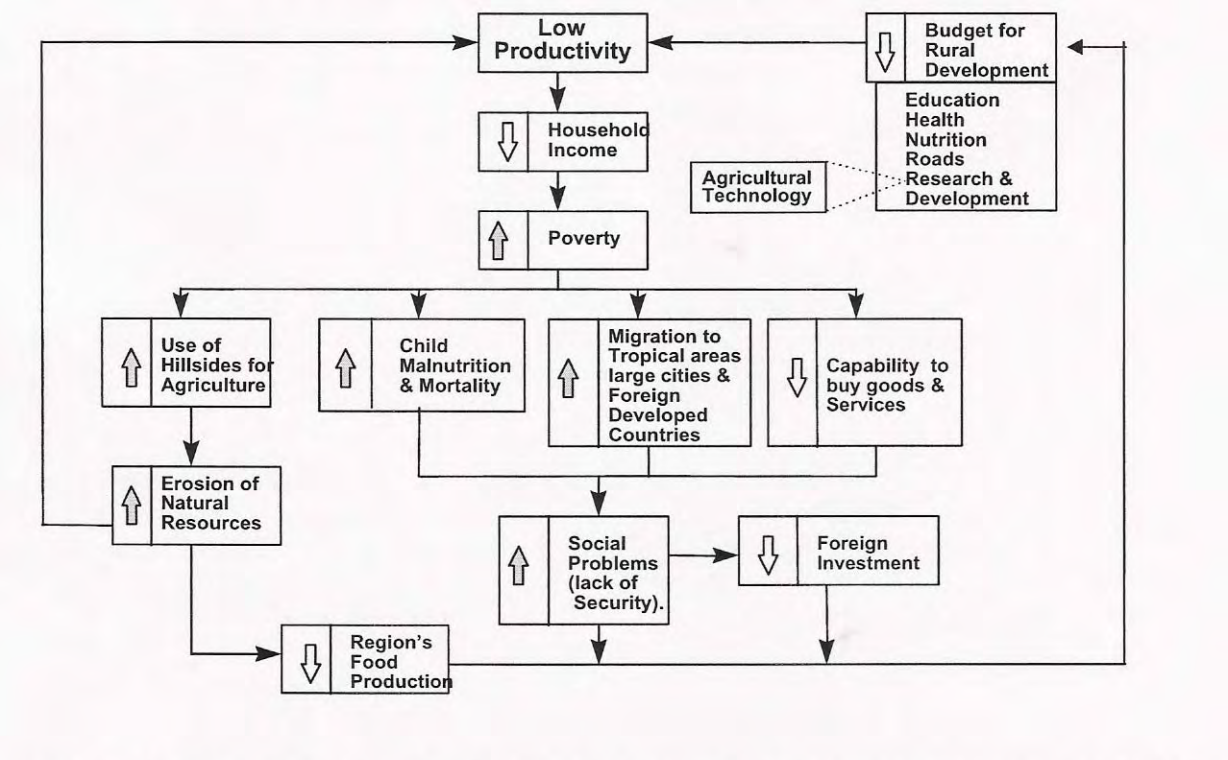

Figure 1. The vicious cycle of deterioration of natural resources, low agricultural productivity, poverty and violence. (Adapted by R. Quiroz from PISA and PRODASA, 1993.)

Having good relations with farmers and supporting their best interest should be of utmost importance to the researcher based on this model. Research should be objective in the sense that the hypothesis proposed and data collected should not be biased or presented based upon ones personal beliefs. Research, however, should be subjective in the sense that allows flexibility to handle people's specific needs. There has been much research conducted in the past, and presently which has filled many books and journals about soil properties, ways of increasing organic matter, livestock production systems, soil erosion problems and sustainable agriculture. There has also been extensive research in the field of agricultural economics, collecting data on various topics including; risk management strategies, price forecasting, availabilities of markets

and so on. One has to keep the altiplano farmer in perspective when considering the findings of all their research. This research is a fairly recent phenomenon considering research has been conducted in Bolivia for less than a hundred years. The altiplano farmer has been around for quite a longer time than this growing quinoa, and potato and moving herds of alpaca and llamas. In fact, quinoa has been cultivated in the Andean region for 7000 years (Jacobsen, 2003). In this time period the farming system of the altiplano has evolved into what it is today. Of course, over this time period there have been various socio-economic changes that have also shaped the farming system.

One should take the historical context into account and realize that what researchers have is facts and ideas that can possibly help the farmer but not the reality that has faced altiplano farmers for centuries. Now these facts and ideas can be of great value to the farmer and to the greater good, but this research should not become presumptuous believing our ideas and research are superior. We need to maintain a clear understanding of the farmers' techniques, ideas, and needs based on their goals. It has been noted that research should be oriented to produce results that solve problems prioritized by the farmers as opposed to the imposition of new technologies based on the results from experimental stations (Velarde 2000). As we continue with this and other research let us keep the farmers interest and participation throughout the process so that the fore mentioned ideas of manure use, livestock production, and improved crop production can manifest themselves to the farmers management strategy.

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