

Water Use and Protection in Rural Communities of the Peruvian Amazon Basin

Michael E. McClain, Member, IWRA, Florida International University, Miami
Florida, USA, Luis Miguel Aparicio and Carlos A. Llerena, Universidad Nacional
Agraria La Molina, Lima Peru

Abstract: *Inhabitants of the Peruvian Amazon enjoy plentiful water and other aquatic resources that enhance their well-being in many ways. However, the intimate and generally unbuffered connection between the region's inhabitants and their water resources leads to complex negative feedbacks when these resources are mismanaged. Due to severe water problems in other, more populated, parts of the country the Peruvian government currently devotes little attention to water management in the Amazon. Thus, organized management is mainly left to individual communities and households. This study reports on the results of 351 interviews of households in the Pachitea Basin of the central Peruvian Amazon. Our aim is to quantify the use of water and other aquatic resources among different social groups and within different geographical settings of the region. With these data, we evaluate and identify priorities for community-driven water management in the region. We found that 50 to 90 percent of households take their water directly from primary sources, 35 to 94 percent transport it manually to their homes, and 50 to 75 percent practice only the simplest form of treatment (boiling). Indigenous households tended to rely less on water infrastructure and water treatment. Fish and an assortment of other aquatic and riparian resources were important inputs to all social groups and in all geographic settings. Disposal of wastes in nearby water bodies was also found to be widespread. We conclude that water management efforts in the Pachitea Basin should focus on the protection of water quality in rivers and streams through careful disposal of wastes away from water bodies and the preservation of natural water purification features such as riparian forests and wetlands. We also recommend developing a basin-wide master plan, which empowers end-users and integrates more detailed plans developed at community and association levels.*

Keywords: *Water use, Peruvian Amazon, community water management, preservation.*

Introduction

Water is abundant in the Peruvian Amazon and contributes to rural people's physical, social, and economic well-being in multifaceted ways. When traveling through the region, one notes that surface and ground waters satisfy basic needs for human consumption, cooking, washing, waste removal, and rain waters crops. Likewise, personal observations and a limited amount of previous research show that rivers and lakes are sources of fish, crustaceans, and plants that contribute significantly to the dietary needs of the population. Local people also harvest riparian plants and hunt semi-aquatic animals and water-seeking animals along riverbanks. Rivers transport products to and from rural communities in roadless areas, they serve as recreational areas, and they often take on spiritual importance, especially within indigenous groups. These close and often unbuffered linkages between people and surrounding water resources, furthermore, have major implications for human health. Pathogens linked to cholera

and amoebic dysentery are transmitted to river waters with animal and human wastes, and insect vectors for malaria and dengue fever thrive in the habitat that abounds in these humid landscapes.

Despite the multifaceted importance of water in the Peruvian Amazon, water resources management in the region receives little attention from national agencies and policy makers. This inattention is in fact systemic and may be attributed to a geographical mismatch of people and water in the country. More than 90 percent of Peru's population (as well as its capital and virtually all of its large cities) exists along the arid Pacific coast and in the high Andean cordillera where only two percent of the country's water resources occur (INRENA, 1996). Consequently, water shortages and conflicts over equitable water distribution for irrigation and other uses dominate the psyche of water managers and policy makers (McClain and Llerena, 1998). Efforts to address these issues also consume the vast majority of funds, expertise, and labor allocated for the implementation of sound water management

plans and activities. Formal water management in Peru is organized according to irrigation districts, wherein technical administrations interact with user groups to develop and implement water-use plans. In the Amazon portion of the country, however, irrigation districts have not been defined and thus no coordinating bodies exist to manage the use and protection of water resources. The task of managing water and aquatic resources in rural portions of the Peruvian Amazon is, therefore, left in the hands of local communities and individual users.

In this paper, we present the results of the first household survey of water use patterns in rural portions of the central Peruvian Amazon. Our goal is to provide basic information and preliminary interpretations required to support emerging community-driven plans for water management. This study was also carried out in conjunction with an ongoing research program to investigate the hydrology and water quality of the basin. Effort was made to distinguish between water-use patterns among indigenous communities, colonist farmers, and townspeople, as well as between people living in different geographical settings in the basin.

Study Area

The Pachitea watershed lies in the Departments of Pasco and Huanuco of the Selva Central of Peru and occupies an area of approximately 29,000 km². The watershed consists of broad undulating lowlands covering approximately 19,000 km² and a series of montane and high alpine valleys covering approximately 10,000 km². These two regions differ in natural characteristics such as ecosystems, topography, and climate, and they also differ in socio-economic and demographic terms.

According to estimates of the Peruvian National Institute for Natural Resources (INRENA, 1996), precipitation across the entire watershed averages 2,809 mm/yr, of which 2,153 mm/yr (or 77 percent) runs off in the Pachitea river. Precipitation tends to be highest in the lowland portion of the basin near the foot of the mountains, and precipitation generally decreases with increasing elevation (SENAMHI, 1999). Elevations range from nearly 5,000 meters above sea level (masl) in the headwaters along the Cordillera Oriental to slightly less than 200 masl at the mouth of the Pachitea river. Three other smaller mountain ranges also divide the watershed into distinct subbasins (Figure 1). The strong elevational gradient of the watershed translates to a similarly strong gradient in natural ecosystems. Eleven ecological life zones of the Holdridge classification system occur in the region, ranging from very humid tropical forest to humid steppe (ONERN, 1976). Humid tropical forest dominates the lowland portions of the watershed but grades quickly into humid montane forest and cloud forest as elevations surpass 1,000m. In the highest portions of the basin, alpine steppe, known locally as puna, predominates.

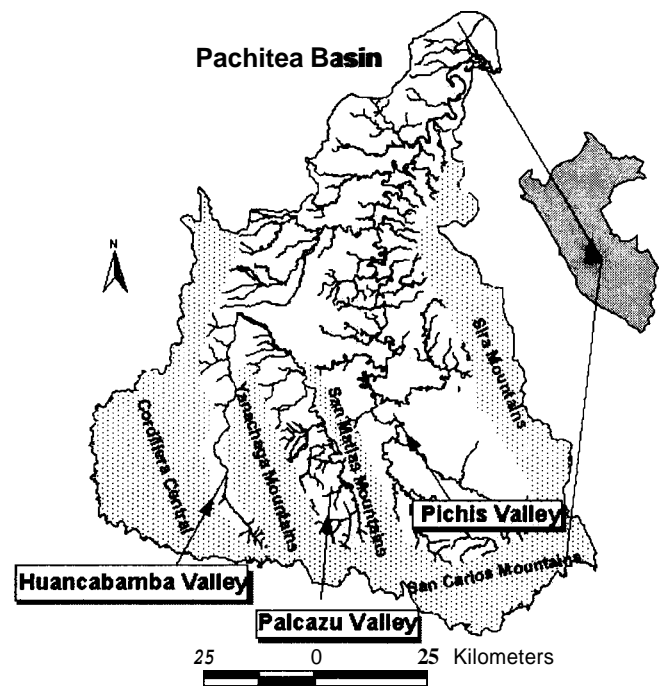


Figure 1. Physiographic map of the Pachitea Basin indicating the location of the basin within Peru and its main mountain ranges, valleys, and rivers.

Census data from 1996 place the population of the Pachitea at 145,966 individuals distributed among 26,876 households (INEI, 1996). This translates to a population density of 4.8 people/km² in the area of the census, which is slightly larger than the area of the watershed. Population density is much higher (9.4 people/km²), however, in the montane and alpine portion of the watershed where 65 percent of the population lives on 31 percent of the land. The majority of both the lowland (86 percent) and mountain (79 percent) population is rural, and agriculture is the main economic activity of between 73 percent (mountain) and 80 percent (lowland) of the population 15-years-old or older. The most common crops are manioc, bananas, corn, and rice (Aparicio, 1999).

Yanesha' and Asháninca indigenous groups live in dispersed communities in the basin and make their livelihood through farming, cattle raising, and occasional logging. The Yanesha' are small in number and live mainly within a communal reserve in the Palcazu valley. The Ashaninca are larger in number and occupy a larger area within the lowland Pichis valley. The earliest colonists to enter the watershed were Austro-Germans who arrived in the 1850s and settled primarily in mountain valleys. Mestizo colonists have been growing in numbers in the watershed since then, but the greatest increase in colonist numbers came during the second half of the 20th century (Smith, 1983). In 1980, the Peruvian government announced an ambitious program of road building and colonization in the region. Over the following decade, roads were constructed into the Palcazu valley and along the main channel of the

Pachitea river, and the colonist population has grown in response. Road construction is continuing in the region, and the number of colonists is likely to continue to grow as well.

Methodology

In order to better understand the relationship of the region's population to its water resources, water use and related data were gathered through interviews of 351 households. Each interview consisted of an identical set of 35 individual or compound questions printed on a survey form, which was filled in by interviewers. Two interviewers moved through the region simultaneously and met each day to discuss any questions or problems that arose during the day and to ensure that the interview content remained consistent. All 351 interviews were conducted by these same two interviewers. Severe logistical challenges imposed by the size and remoteness of the region surveyed, the dispersed locations of households, and a lack of reliable maps of human distribution prohibited a rigorous randomization of sampling sites. Interviews were conducted in eight towns, along four sections of road, five reaches of river, and in three indigenous communities (Figure 2). Interviews were conducted continuously over a period of 30 days and at all times of the day.

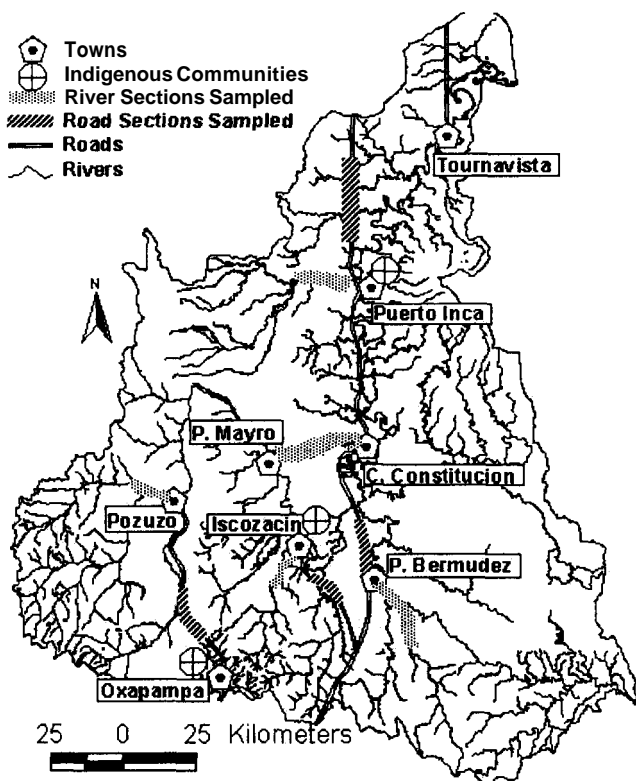


Figure 2. Map of the sites where interviews were made, including eight towns (with names shown), three indigenous communities, four sections of road, and five reaches of river.

Interviews were structured to distinguish water use and protection between different social groups and between inhabitants living in different geographic settings of the region. The three social groups considered were: colonists living in towns (132 interviews), colonists living on farms (122 interviews), and indigenous inhabitants (97 interviews) living within villages or farms. Respondents were distinguished geographically according to whether they lived in the lower, mainly flat portion of the watershed or in the higher montane valleys. In addition to questions addressing water use, a number of questions also addressed the use of aquatic resources and land use practices which are relevant to water quality.

Data are reported as proportions of the total responses according to social class or geographic region. The margin of error (ME_p) of each proportion was calculated as follows

$$ME_p = 1.96 \sqrt{\frac{\pi(1-\pi)}{N}}$$

where π is the proportion and N is the number of responses. The upper and lower 95 percent confidence values may be calculated as $[\pi + \pi(ME_p)]$ and $[\pi - \pi(ME_p)]$, respectively.

Results

Water Use

The 351 households surveyed have an average family size of 5.4 individuals, with little difference between social groups or geographic regions (Table 1). Slightly smaller average family sizes were encountered among the townspeople interviewed (4.9), while slightly larger average family sizes were encountered among indigenous people interviewed (5.8). Households use an average of 82 liters of water per day for drinking, cooking, and washing (Table 1). This amounts to 15 liters per person per day. Indigenous households use, on average, less water (73 l/d) than colonist and townspeople households (89 and 84 l/d, respectively). Likewise, households of the montane valleys use, on average, less water (65 l/d) than lowland households (95 l/d).

Indigenous households take most of their water for human consumption from streams (44.3 percent) and springs (39.2 percent), while colonist households take most of their water for human consumption from streams (39.3 percent) and rivers (30.3 percent) (Table 2). The largest proportion of townspeople take their water from the public supply system (49.2 percent), but other sources are also important. Colonist households take more water for human consumption from rivers than other social groups, and townspeople make the most use of groundwater (18.1 percent) (Table 2). Outside of towns, indigenous households (9.3 percent) make more use of groundwater than colonist households (4.9 percent). Households in the low-

Table 1. Household Water Use

	<i>Indigenous</i>	<i>Colonist</i>	<i>Townspeople</i>	<i>Montane</i>	<i>Lowland</i>
# Family Members	5.8	5.6	4.9	5.2	5.6
lt/day/family	72.7	88.7	83.4	64.8	95.0

Reported as average of total responses.

Table 2. Water for Human Consumption

<i>Source of Water for Human Consumption</i>	<i>Indigenous</i>	<i>Colonist</i>	<i>Townspeople</i>	<i>Montane</i>	<i>Lowland</i>
River	19.6(4.2)	30.3(4.8)	6.8(2.6)	15.5(3.8)	22.0(4.3)
Lake	1(1.0)	0(0.0)	0(0.0)	0.0(0.0)	0.6(0.8)
Stream	44.3(5.2)	39.3(5.1)	9.8(3.1)	21.9(4.3)	38.4(5.1)
Spring	39.2(5.1)	22.9(4.4)	14.4(3.7)	25.6(4.6)	22.6(4.4)
Rain	11.3(3.3)	10.7(3.2)	13.6(3.6)	16.6(3.9)	6.7(2.6)
Public Supply	8.2(2.9)	18(4.0)	49.2(5.2)	47.1(5.2)	4.3(2.1)
Public Spigot	1(1.0)	0.8(0.9)	13.6(3.6)	1.6(1.3)	10.4(3.2)
Well	9.3(3.0)	4.9(2.3)	18.2(4.0)	2.7(1.7)	20.7(4.2)
Other	0(0.0)	0.8(0.9)	2.3(1.6)	1.1(1.1)	1.2(1.1)
<i>Means of Delivering Water to Household</i>					
Pipe	13.4(3.6)	34.4(5.0)	55.3(5.2)	60.9(5.1)	8.6(2.9)
Open Canal	9.3(3.0)	3.3(1.9)	0(0.0)	5.3(2.3)	1.8(1.4)
Manual	82.5(4.0)	62.3(5.1)	48.5(5.2)	35.3(5.0)	93.9(2.5)

Reported as percentages of total responses/margin of error in parentheses.

land portions of the watershed make greater use of river and stream water (22.0 and 38.4 percent, respectively), while households of the montane valleys make greater use of rainwater and water from public supply systems (16.6 and 47.1 percent, respectively). Lowland households also make greater use of groundwater (20.7 percent) than do montane valley households (2.7 percent) [Table 2].

In the lowland portion of the watershed, greater than 90 percent of households manually collect water for human consumption, while only 35 percent of montane valley households manually collect water. When viewed across social groups, indigenous households (82.5 percent) rely most on manual delivery of water for human consumption while townspeople households (48.5 percent) rely least on manual delivery. Slightly greater than 60 percent of montane households received water for household use via pipes, while less than 10 percent of lowland households had water piped into them (Table 2).

The majority of households in the region apply some sort of treatment to water prior to consuming it (Table 3). Nearly 87 percent of households in montane valleys boil their water, while approximately 70 percent boil their water in the lowlands. Townspeople households are most diligent in that slightly more than 90 percent treat water prior to consuming it. In contrast, only 70 percent of indigenous households treat their water prior to consuming it.

Greater than 80 percent of indigenous and colonist households and 34.8 percent of townspeople households rely on rain to water their agricultural fields (Table 4).

These values are very near the number of total households that practice agriculture (Aparicio, 1999). Thus, rain accounts for nearly 100 percent of water applied to agricultural fields in the watershed. Irrigation is nearly non-existent in the portions of the watershed surveyed. The majority of households that have animals responded that their animals drink from rivers and streams (Table 4). Animals from a significant number of households also drink from springs. In the montane valleys 4.8 percent of households responded that their animals drink water from the public supply system and 5.5 percent of lowland households responded that their animals drink water taken from wells (Table 4).

Rivers were the main water body used for transportation in the watershed (Table 5). Indigenous households make the greatest use of rivers for transportation (54.6 percent), and transportation of people in particular (59.8 percent). In addition, 37.1 percent of indigenous households interviewed transport products by river, and 17.5 percent transport wood. Rivers were less important for transportation in montane valleys, and this was particularly true in the higher Huancabamba valley (Aparicio, 1999). Colonists and townspeople make slightly less use of water for transportation, but the percentage is still notable (Table 5). Rivers and streams are also important sites of recreation for families of the watershed. Greater than 50 percent of all households across all social groups and geographic regions make use of rivers for swimming (Table 5). A significant percentage also use streams as recre-

Table 3. Water Treatment Prior to Consumption

	<i>Indigenous</i>	<i>Colonist</i>	<i>Townspeople</i>	<i>Montane</i>	<i>Lowland</i>
Decanting	5.1 (2.3)	6.6 (2.6)	5.3 (2.3)	2.7 (1.7)	9.2 (3.0)
Filtration	0 (0.0)	0 (0.0)	1.5 (1.3)	0.5 (0.7)	0.6 (0.8)
Boiling	70.1 (4.8)	82 (4.0)	83.3 (3.9)	86.9 (3.5)	70.1 (4.8)
Chlorine	13.4 (3.6)	7.4 (2.7)	15.1 (3.7)	8.0 (2.8)	16.5 (3.9)
Other Chemical System	6.2 (2.5)	3.3 (1.9)	0.8 (0.9)	2.1 (1.5)	4.2 (2.1)
Other Natural System	0 (0.0)	0 (0.0)	1.5 (1.3)	0.0 (0.0)	1.2 (1.1)
No Treatment	30.9 (4.8)	17.2 (3.9)	9.1 (3.0)	14.4 (3.7)	22.0 (4.3)

Reported as percentages of total responses/margin of error in parentheses

Table 4. Source of Water for Agriculture and Animals

<i>Agriculture</i>	<i>Indigenous</i>	<i>Colonist</i>	<i>Townspeople</i>	<i>Montane</i>	<i>Lowland</i>
River	0 (0.0)	3.3 (1.9)	0 (0.0)	0.5 (0.7)	1.8 (1.4)
Lake	0 (0.0)	0 (0.0)	0 (0.0)	0.0 (0.0)	0.0 (0.0)
Stream	2.1 (1.5)	0.8 (0.9)	3.8 (2.0)	2.7 (1.7)	1.8 (1.4)
Spring	1 (1.0)	3.3 (1.9)	1 (1.0)	2.2 (1.5)	1.8 (1.4)
Rain	83.5 (3.9)	82.0 (4.0)	34.8 (5.0)	59.3 (5.1)	70.7 (4.8)
Public Supply	0 (0.0)	0 (0.0)	1.5 (1.3)	1.0 (1.1)	0.0 (0.0)
Public Spigot	0 (0.0)	0 (0.0)	0 (0.0)	0.0 (0.0)	0.0 (0.0)
Well	0 (0.0)	0.8 (0.9)	0.8 (0.9)	0.0 (0.0)	1.2 (1.1)
Other Animals	0 (0.0)	0.8 (0.9)	0.8 (0.9)	0.5 (0.7)	0.6 (0.8)
River	19.6 (4.2)	25.4 (4.6)	12.1 (3.4)	16.8 (3.9)	20.7 (4.2)
Lake	1 (1.0)	2.5 (1.6)	1.5 (1.3)	1.6 (1.3)	1.8 (1.4)
Stream	36.1 (5.0)	45.9 (5.2)	18.2 (4.0)	32.1 (4.9)	33.5 (4.9)
Spring	13.4 (3.6)	9.8 (3.1)	6.1 (2.5)	9.1 (3.0)	9.8 (3.1)
Rain	3.1 (1.8)	3.3 (1.9)	2.3 (1.6)	0.5 (0.8)	5.5 (2.4)
Public Supply	1 (1.0)	1.6 (1.3)	4.5 (2.2)	4.8 (2.2)	0.0 (0.0)
Public Spigot	0 (0.0)	0 (0.0)	1.5 (1.3)	0.5 (0.8)	0.6 (0.8)
Well	1 (1.0)	0.8 (0.9)	5.3 (2.3)	0.0 (0.0)	5.5 (2.4)
Other	0 (0.0)	4.1 (2.1)	1.5 (1.3)	3.7 (2.0)	0.0 (0.0)

Reported as percentages of total responses/margin of error in parentheses.

Table 5. Use of Water for Transportation and Recreation

<i>Transportation Media</i>	<i>Indigenous</i>	<i>Colonist</i>	<i>Townspeople</i>	<i>Montane</i>	<i>Lowland</i>
River	54.6 (5.2)	37.7 (5.1)	42.4 (5.2)	27.8 (4.7)	62.8 (5.1)
Lake	0 (0.0)	0 (0.0)	0 (0.0)	0.0 (0.0)	0.0 (0.0)
Streams	3.1 (1.8)	1.6 (1.3)	1.5 (1.3)	1.1 (1.1)	3.0 (1.8)
Material Transported					
People	59.8 (5.1)	41.8 (5.2)	48.5 (5.2)	31.5 (4.9)	69.5 (4.8)
Products	37.1 (5.1)	28.7 (4.7)	17.4 (4.0)	15.0 (3.7)	40.2 (5.1)
Wood	17.5 (4.0)	10.7 (3.2)	9.8 (3.1)	9.0 (3.0)	15.9 (3.8)
Recreation					
River	61.9 (5.1)	59 (5.1)	61.4 (5.1)	66.3 (4.9)	54.3 (5.2)
Lake	0 (0.0)	0 (0.0)	0 (0.0)	0.0 (0.0)	0.0 (0.0)
Stream	21.6 (4.3)	16.4 (3.9)	9.1 (3.0)	5.9 (2.5)	25.6 (4.6)
Springs	2.1 (1.5)	0.8 (0.9)	4.5 (2.2)	0.5 (0.8)	4.9 (2.3)

Reported as percentages of total responses/margin of error in parentheses.

ation sites. Households were asked about the use of water for industrial purposes and electricity generation, but no such use was made of water by households directly.

Indigenous households make the greatest use of water bodies for disposing of wastes, with 22.3 percent and 14.4 percent responding that they dumped their wastes in rivers and streams, respectively (Table 6). Townspeople households generally make less use of water bodies for dumping, but 21.2 percent reported that they dump wastes into rivers. Little difference exists between the percentage of lowland versus montane valley households dumping wastes into water bodies.

A majority of households have some infrastructure, normally a latrine, for the disposal of human fecal waste (Table 7). Townspeople households had the largest proportion (96.2 percent) of such infrastructure, while colonist households had the smallest (73.8 percent). No difference was noted between geographic regions in the proportion of households with latrines. Where latrines exist, they lie an average of 58.3 meters from the households' source of water (Table 7). On average, indigenous households position their latrines furthest from water sources (74 m). Only minor differences were noted between geographic regions in the distance of latrines from water sources.

Use of Other Aquatic Resources

Rivers, lakes, and streams are used for more than water supply, transportation, recreation, and waste disposal. Between 78 percent and 89 percent of all households surveyed eat fish regularly (Table 8). Consumption is greatest in indigenous households; it is also slightly greater in

lowland households (87.2 percent) than in montane valley households (80.2 percent). Fishing is also a common activity in most households (Table 8). The percentage of indigenous households that fish (84.5 percent) is nearly equal to the percentage that eat fish (88.7 percent). The smallest proportion of households that fish are those of townspeople (47 percent) and those in montane valleys (55.6 percent). In line with other statistics in this section, indigenous households also consume the larger quantity of fish per week (4.8 kg/wk). Overall, the quantity of fish consumed in lowlands (3.4 kg/wk) is similar to that consumed in montane valleys (3.0 kg/wk), however, in the discussion it will be shown that the source of the fish is quite different. Rivers are the major source of fish caught by households of the regions, followed by streams (Table 8). The most common fish species consumed were boquichico (*Prochilodus cf nigricans*), lisa (*Schizodon fasciatum*), and zungaro (*Zungaro zungaro*), and 55.7 percent of indigenous households noted a decrease in the abundance of fish in recent years. Hook and line, followed by cast net and gill net, is the most common method of fishing (Table 9). Among indigenous households harpooning and use of barbasco (a natural poison) are also significant. Use of explosives was reported infrequently.

Households also acquire other resources from water bodies, including aquatic plants, crustaceans, and semi-aquatic animals that are hunted. Other animals and plants are collected in close proximity to water bodies, either because they are attracted there by the water, as in the case of animals, or because they grow in riparian habitats, as in the case of plants. Indigenous households make the greatest use of these resources, with 17.5 percent and

Table 6. Disposal of Wastes in Water Bodies

	<i>Indigenous</i>	<i>Colonist</i>	<i>Townspeople</i>	<i>Montane</i>	<i>Lowland</i>
Percent of households disposing of wastes into water bodies	38.1 (5.1)	31.1 (4.8)	27.3 (4.7)	30.0 (4.8)	33.5 (4.9)
River	22.3 (4.4)	18.8 (4.1)	21.2 (4.3)	20.9 (4.3)	20.7 (4.2)
Lake	0 (0.0)	0 (0.0)	0.8 (0.9)	0.0 (0.0)	0.6 (0.8)
Stream	14.4 (3.7)	13.1 (3.5)	6.8 (2.6)	11.7 (3.4)	10.4 (3.2)
Spring	0 (0.0)	0.8 (0.9)	0 (0.0)	0.0 (0.0)	0.6 (0.8)
Well	0 (0.0)	0 (0.0)	0 (0.0)	0.0 (0.0)	0.0 (0.0)
Other	25 (4.5)	20.5 (4.2)	25 (4.5)	24.6 (4.5)	25.6 (4.6)

Reported as percentages of total responses/margin of error in parentheses.

Table 7. Use of Systems to Evacuate Human Fecal Waste

	<i>Indigenous</i>	<i>Colonist</i>	<i>Townspeople</i>	<i>Montane</i>	<i>Lowland</i>
Yes - use some system	82.5 (4.0)	73.8 (4.6)	96.2 (2.0)	84.5 (3.8)	84.7 (3.8)
No - no system used	17.5 (4.0)	26.2 (4.6)	3.8 (2.0)	15.5 (3.8)	15. (93.8)
Dist. (m) of latrine from water source*	74	65.7	40.2	53.0	60.4

Reported as percentages of total responses/margin of error in parentheses.

*Reported as average of total responses.

Table 8. Consumption of Fish and Other Aquatic Flora and Fauna

<i>Fish</i>	<i>Indigenous</i>	<i>Colonist</i>	<i>Townpeople</i>	<i>Montane</i>	<i>Lowland</i>
Percent of households that eat fish	88.7 (3.3)	85.2 (3.7)	78 (4.3)	80.2 (4.2)	87.2 (3.5)
Percent of households that fish	84.5 (3.8)	65.6 (5.0)	47 (5.2)	55.6 (5.2)	73.2 (4.6)
Kg fish per week consumed *	4.8	2.8	2.7	3.0	3.4
River	68 (4.9)	55.7 (5.2)	40.9 (5.1)	48.6 (5.2)	59.1 (5.1)
Lake	8.2 (2.9)	2.5 (1.6)	3 (1.8)	1.1 (1.1)	8.0 (2.8)
Stream	38.1 (5.1)	18 (4.0)	5.3 (2.3)	11.2 (3.3)	27.4 (4.7)
Flora and Fauna					
River	10.3 (3.2)	8.2 (2.9)	3 (1.8)	4.3 (2.1)	9.8 (3.1)
Lake	6.2 (2.5)	2.5 (1.6)	0 (0.0)	1.1 (1.1)	4.3 (2.1)
Stream	17.5 (4.0)	7.4 (2.7)	2.3 (1.6)	4.2 (2.1)	12.8 (3.5)

Reported as percentages of total responses/margin of error in parentheses.

*Reported as average of total responses/standard deviation in parentheses.

Table 9. Fishing Techniques

	<i>Indigenous</i>	<i>Colonist</i>	<i>Townpeople</i>	<i>Montane</i>	<i>Lowland</i>
Harpoon	16.5 (3.9)	2.5 (1.6)	0.8 (0.9)	3.2 (1.8)	8.5 (2.9)
Gill net	38.1 (5.1)	25.4 (4.6)	19.7 (4.2)	12.3 (3.4)	43.3 (5.2)
Cast net	49.5 (5.2)	34.4 (5.0)	15.9 (3.8)	41.5 (5.2)	20.1 (4.2)
Bow and arrow	24.7 (4.5)	0.8 (0.9)	0.8 (0.9)	2.7 (1.7)	12.8 (3.5)
Hook and line	75.3 (4.5)	56.6 (5.2)	38.6 (5.1)	46.0 (5.2)	65.3 (5.0)
Explosives	7.2 (2.7)	4.9 (2.3)	5.3 (2.3)	5.9 (2.5)	5.5 (2.4)
Barbasco	16.5 (3.9)	1.6 (1.3)	0.8 (0.9)	4.8 (2.2)	6.1 (2.5)
Other poison	8.2 (2.9)	0.8 (0.9)	0 (0.0)	1.1 (1.1)	4.3 (2.1)
Closing off stream	3.1 (1.8)	1.6 (1.3)	0 (0.0)	1.6 (1.3)	1.2 (1.1)
Other	5.1 (2.3)	1.6 (1.3)	0.8 (0.9)	2.7 (1.7)	1.8 (1.4)

Reported as percentages of total responses/margin of error in parentheses.

10.3 percent responding that they collect flora and fauna from streams and rivers, respectively. Lowland households make more use of these resources than montane valley households (Table 8).

Discussion

Inhabitants of the Pachitea watershed live in intimate contact with their water resources and exert direct control over water management and protection. As data gathered in this study have shown quantitatively, a majority of households take their water directly from primary sources (springs, streams, and rivers), transport it manually to their homes, and make use of it after only the simplest form of treatment (boiling). These same sources of water provide fish and an assortment of other aquatic and riparian resources. Rivers and streams are also the depositories of waste for a significant proportion of the population. Personal and/or product transportation for a significant proportion of the inhabitants is via river, and many inhabitants swim and seek relief from the heat of the day in rivers and streams.

These multiple and direct contacts between people and water resources hold several implications for protect-

ing water quality, especially water quality linked to organic wastes. In many instances, the source of a household's water for domestic use is also a depository for its solid and liquid organic wastes. Even those households that carefully dispose of their wastes away from water sources are vulnerable to contamination introduced by less responsible upstream neighbors or by animals using the same water sources. Households located downstream of population centers are especially at risk, as towns with sewer systems deposit their untreated wastes directly into nearby rivers.

In the absence of any wastewater treatment infrastructure, water users in the Pachitea must rely on dilution to lower contaminant concentrations and on natural processes to assimilate organic wastes. Health data from the region and a small set of water quality analyses suggest, however, that the capacity of these processes to effectively maintain water quality is being surpassed. Aparicio (1999) reported that greater than 50 percent of households interviewed complained of health problems linked to water. Likewise, hospitals operated in the towns of Puerto Inca and Oxapampa recorded a total of 8,125 cases of illness related to water between January and October 1998 (Aparicio, 1999). Acute diarrhea was the most commonly

reported illness (4,172 cases) along with “other” helminthic infections (intestinal worms – 3,578 cases), but 62 cases of viral hepatitis and 18 cases of cholera were also reported. The threat of waterborne pathogens is indicated in certain water samples from this same time period collected by the Environmental Unit of the Pichis-Palcazu Special Project (administered through the Ministry of the President). In their monitoring report published in April 1999, the unit reported positive detections of fecal coliform bacteria in six of 14 samples collected, although concentrations never exceeded 9 MPN/100ml (PEPP, 1999). Total coliform bacteria were detected in all samples, with concentrations ranging from 4 to 240 MPN/100ml. Even higher concentrations of coliform bacteria reported in other parts of the Peruvian Amazon suggest that the problem of organic wastes is more or less ubiquitous (Gómez, 1994).

The strong dependence of the local people on fish consumption makes their health even more vulnerable to diminishing water quality, as productive fisheries rely on clean water. Based on data collected in this study, indigenous people consume approximately 120 g of fish per day per person. For colonists and townspeople, the per capita consumption rates are approximately 71 and 79 g/day, respectively. Our values for indigenous consumption of fish compare well with the 122 g/day per person reported for the Shiringamazu Community of the Palcazu Valley (Bayley, 1981) and the 175 g/day per person reported for the Campas Community of the Pichis Valley (Gaviria, 1980). When indigenous, colonist, and townspeople consumption rates are taken together, however, they are less than the estimated 136 g/day/person calculated for fish consumption among mixed people of the nearby Ucayali river valley in a 1966 survey (Pierret and Dourojeanni, 1967). In that survey, fish were found to constitute 62 percent, by weight, of the animal protein consumed by those interviewed. If we assume that total daily consumption of meat (222 g/day/person) is similar between the two populations interviewed, then fish still constitute between 32 percent and 54 percent of animal protein consumed by local people in the Pachitea, with the remainder coming from wild animals, chickens, pigs, and, to a lesser extent, cattle.

Productive fisheries also rely on intact fish habitat, and thus human health is also linked to habitat preservation. To date there has been little perturbation of the river system’s natural structure and flooding patterns. No major engineering structures such as dams, dikes, or diversion canals have been constructed along the main rivers of the Pachitea basin, and none are immediately planned to our knowledge. However, several species of fish eaten by local people actually migrate annually into the basin in what the natives have traditionally called the *mijano*. These species include the boquichico (*Prochilodus cf nigricans*) and catfish like the zungaro (*Zungaro zungaro*) that make use of the extensive floodplains of the Ucayali river. These floodplains are under severe pressure from colonists who

clear away the floodplain forest to make way for seasonal crops (Salo and Kalliola, 1993). Thus, the destruction of fish habitat outside of the Pachitea is likely impacting the quality of fisheries in the basin. There are also occasional commercial fishing vessels from Pucallpa that ply the lower reaches of the Pachitea and extract large quantities of fish for markets elsewhere. In past decades, dynamite was used as a popular form of fishing that proved especially destructive to aquatic communities. In fact, Bayley (1981) reported that dynamite was the most common method of fishing used in the Palcazu valley at the beginning of the 1980s. Our results suggest that dynamite is still used, but at a reduced intensity. By far the most popular methods of fishing were hook and line, cast nets, and gill nets.

Water Use among Indigenous vs. Colonist Households

Some of the most interesting and informative results of our survey come from comparing water use patterns between indigenous and non-indigenous households. In several respects, indigenous households are in more intimate contact with the region’s water and thus more vulnerable to the ill effects of poor water management. Indigenous households registered, on average, lower per capita water consumption (12.5 l/day) than colonists (15.8 l/day), but they gathered a larger proportion of their water manually and drank it untreated more often. Indigenous households eat fish and other aquatic flora and fauna in larger quantities and make nearly equal use of rivers and streams for recreation. Indigenous households also make greater use of rivers as a transportation media.

While these use patterns seem to expose them more directly to the harmful effects of poor water quality, indigenous people appear to better discriminate between water sources and waste disposal areas than do rural colonists (Tables 2 and 6). Whereas rivers were a source of water for human consumption among 30 percent colonist households, indigenous households took larger percentages of their water for human consumption from streams and springs. Conversely, indigenous households deposited larger percentages of their waste in rivers, downstream of their water sources. Indigenous households also, on average, located their latrines slightly further from water sources. It is tempting to attribute these seemingly more intelligent use patterns to traditional knowledge among the indigenous communities, and this may in fact be true. Perhaps counter-intuitively, however, indigenous households make more use of methods of fishing such as explosives and poisons (including the natural poison, barbasco) (Table 9), which kill indiscriminately and are widely held to be unsustainable.

Water Use in Mountain Valleys vs. Lowlands

There are also distinct patterns in water use between households located in the mountainous portions of the western basin and the eastern lowlands. A much larger proportion of mountain valley households have water piped

into them, and only 35 percent of households reported collecting their water manually. This compares to 94 percent of lowland households. Despite the convenience of water being piped into their homes, inhabitants of the mountain valleys use less water per capita (12 l/day) than do lowland inhabitants (17 l/day). A larger proportion of mountain valley households also report treating their water prior to consumption. The relative abundance of piped water may be attributed to the longer history of colonization in the mountain valleys and more economically successful communities. The mountain valleys are also better served by roads, and thus the use of rivers for the transportation of people and products is substantially less. The use of rivers for recreation, however, is actually higher.

An especially interesting observation is that while fewer mountain valley households reported fishing, the consumption of fish (both percent of households consuming and quantity consumed) is comparable between mountain valley and lowland households. As in the lowlands, commercial fishing is nearly non-existent in the mountain valleys, so the difference between what is caught and what is consumed must be made up for by importation of fish from outside the basin. According to data presented by Aparicio (1999), fish imported to the Huancabamba valley are marine species that come mainly from the capital city of Lima.

Management Implications

The many uses described in this paper demonstrate that the relationships between local people of the central Peruvian Amazon and their water resources, especially surface water, are direct and in many ways more intimate than in more developed or less humid areas. Water at its source (river, stream, spring) provides for household needs, carries away wastes, waters animals, provides food, transports people and products, and serves recreational needs. The importance of water at its source cannot be overstated, as this fundamental issue markedly distinguishes the humid Amazon portion of Peru from the less humid cordillera and arid coast and has profound implications for water management.

Households and communities of the basin are linked by the flow of streams and rivers. This is mainly an upstream-downstream linkage, but downstream inhabitants may also significantly affect the aquatic resources of upstream inhabitants by altering the annual upstream migration of fish. In the absence of dams, reservoirs, irrigation canals, and other significant water supply infrastructure, little government control is exerted over water resources in the Pachitea basin. Water resources management is thus left mainly to communities and individual households. In light of basinwide linkages of communities and households via river and stream flow, management efforts should be closely coordinated on a basinwide scale. To date, however, there is little or no coordinated activity among the basin communities or inhabitants to manage water and aquatic resources.

Protection of surface water quality must be the main focus of water management efforts in the basin, as this is most likely to be the limiting characteristic of water for both human consumption and fish productivity. Already between 74 percent and 96 percent of households report that they use some system to evacuate fecal wastes. These include both latrines and, in towns, simple sewer systems. Properly designed and placed, latrines will effectively protect water bodies from contamination, but sewer systems of the basin generally discharge directly into water bodies. Towns should evaluate the option of discharging their wastes into natural or artificial wetlands for treatment prior to discharge to the river system. When considering natural wetlands, however, care must be taken to evaluate benefits against losses in species habitat. Proper land management in uplands is also crucial, as mismanagement leads to increased erosion and further deterioration of water quality.

Across the basin, households should take care to construct adequate latrines, and they should also be especially diligent about boiling or otherwise treating water prior to consumption. Moreover, they should strive to conserve those parts of the natural aquatic system that provide water purification services (McClain, in press). Expensive water purification systems are unlikely to be constructed in the Pachitea for many years and the basin's inhabitants must rely on natural services provided by riparian forests, wetlands, and hyporheic zones. The conservation of riparian buffer strips is a common recommendation in development activities in the Peruvian Amazon (INADE-APODESA, 1990) and it is required by law, but still many landholders cut them.

Comprehensive and effective water management in the basin will require a Master Plan for aquatic resources protection and management that integrates finer-scale plans of local communities (native, peasant and colonist), producers associations, municipal governments, conservation areas, and other water-related plans. These plans should be developed through a participatory methodology that actively involves local people, as it is in their hands that the ultimate power for implementation lies.

Conclusions

The results presented in this paper have illuminated the relationship between people and water resources in a region of the humid tropics for which virtually no quantitative data previously existed. Inhabitants of the Pachitea basin live in intimate contact with their aquatic resources, and their health and dietary security are closely linked to the quality of the basin's waters and vitality of its fisheries. We have drawn the following conclusions from our analysis.

- Surface water is by far the predominant source of water for inhabitants of the basin, irregardless of social group

(indigenous, colonist, townspeople) or geographical location (mountain valley, lowland). Colonists tend to take their water most often from rivers, while indigenous people take more water from streams and springs.

- Water consumption varies from 12.5 to 17.0 l/day per person, with the greatest difference between mountain valley households, which use the lower value and lowland households, which use the upper value.
- Households in towns and mountain valleys are most often served by public water supply and piped water, but a majority of households also reported collecting water manually from water sources. Greater than 90 percent of lowland households reported collecting their water manually, with the highest single social group percentage being registered by indigenous households.
- Between 70 percent and 87 percent of all households reported that they treat their water prior to consuming it, with boiling ranking as the most common form of treatment (70 to 83 percent). Indigenous households reported consuming untreated water more often (30 percent), but it is likely that individuals from all social groups consume untreated water on occasion when in the countryside away from their homes.
- Between 27 percent and 38 percent of households reported dumping wastes into water bodies, but between 74 percent and 96 percent also reported that they have some form of system to dispose of human fecal waste. In some cases, particularly in towns, this system may discharge wastes into water bodies.
- Irrigation is virtually non-existent in the basin and cultivators from all social groups and geographic areas rely almost exclusively on direct rainfall to water their crops.
- Domestic animals also rely on surface water and very often drink from the same sources as their owners. Colonist households most frequently reported that their animals drink from streams up gradient of human water sources.
- Rivers are the most important aquatic avenue for the transportation of people and products in the basin, and they also serve as the main site of water-related recreation for between 54 percent and 66 percent of households.
- Fish are an important form of animal protein for between 78 percent and 89 percent of households in the basin. Indigenous households consume the greatest quantity of fish (120 g/day/person) and also catch fish more often (84 percent of households). Most fish are caught in rivers, but fishing in streams is also important. Indigenous households also make the most use of other aquatic and riparian resources such as medicinal plants.
- Water use patterns in the Pachitea basin are distinct from those in the higher Andean Cordillera and along the Peruvian coast. The most important difference is the lack of irrigation in the Pachitea and the greater

importance of rivers and streams as sources of fish, as avenues for transporting people and products, and as recreational sites. These differences have strong ramifications for management and make the model of water management developed in the more populated arid regions of Peru inappropriate for the humid Amazon region.

- Water management efforts in the Pachitea basin should focus on the protection of water quality in rivers and streams to preserve human health and maintain fisheries. In the absence of engineering controls, water quality protection will be best accomplished by careful disposal of wastes away from water bodies and preservation of natural water purification features such as riparian forests and wetlands.
- Regional coordination of management activities is essential given the close linkage of upstream and downstream water users. We recommend that a basinwide Master Plan that empowers end-users and integrates more detailed plans developed at community and association levels.

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About the Authors

Michael E. McClain is an Assistant Professor in the Department of Environmental Studies at Florida International University, Miami, Florida, USA. He specializes in the hydrology and water quality of large tropical rivers, with special emphasis on the Amazon. He is the General Coordinator of the Andean Amazon Rivers Analysis and Management (AARAM) project. Email: mcclainm@fiu.edu.

Carlos A. Llerena is a professor in the Department of Forest Management at the Universidad Nacional Agraria La Molina, Lima, Peru. He specializes in watershed management and forest hydrology in the Andean Amazon region and is the Peruvian Coordinator of the Andean Amazon Rivers Analysis and Management (AARAM) project. Email: callerena@lamolina.edu.pe.

Luis Miguel Aparicio Alcazar is a Forestry Engineer who specializes in forestry management and the conservation of natural resources. He is currently with the Fundación peruana para la Conservación de la Naturaleza in Lima, Peru. Email: lmaparicio@yahoo.com.

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