WATER RESOURCES IN PERU: A STRATEGIC VIEW

Julio M. Kuroiwa

Director, National Hydraulics Laboratory. National University of Engineering, Lima, Peru.

ABSTRACT

This paper summarizes the current situation of water resources availability in Peru. A brief description of Peru's spatial water resources distribution and population has been included. Water uses and future trends are quantitatively explained. Water related disasters are briefly described in this document. Recent government efforts to strengthen national, regional and local water authorities and users have also been commented. The implications of new water related laws are summarized. Finally, research efforts made by a few universities are presented as examples of works conducted in the water resources area.

Key words: Peru, water resources, water availability, environment, water issues, water management, research and development.

1. INTRODUCTION

Peru, with an area of 1 285 216 km^2 and a current population of 28 220 764 million inhabitants as of October 2007, is located on the center of the West Coast of South America. The presence of the Peruvian Current (locally known as Humboldt Current), the Andes range and the Amazon Jungle have created large climate diversity within the same country and a very uneven distribution of the water resources.

One hundred and six basins have been identified by the National Resources Institute of Peru (INRENA). Three macro drainage basins contain these major basins: the Pacific Basin, the Atlantic Basin and the Lake Titicaca Basin, which are shown in Figure 1.

The Pacific Basin is composed by hydrographic systems that are located on the Western Slope of the Andes. Most of the Rivers are short and very steep. Most of the rivers´ divides are located at over 5 000 m above the sea level and watercourses are less than 150 km long. The Atlantic Basin (or Amazon Basin) is composed by river systems that are located on the Eastern Slope of the Andes and convey water from the highlands to the Amazon River or a major tributary. The Lake Titicaca Basin is a closed system that includes other sub basins in Bolivia and ends in two lakes: Lake Poopó and Coipasa Salt Lake.

Although one may think of Peru as a country with abundant water resources, with an average 77 534 m^3/inhabitant/year, water resources are very unevenly distributed. The majority of the Peruvian population lives along the basins that convey water into the Pacific Ocean. Figure 2 shows the population density distribution. Darker shades show greater population density per region. The Peruvian Coast is a very arid area, ranging from hyper arid environments in the South and Central areas and semi arid areas in the North. The precipitation is virtually zero at sea level and near the divides the precipitation is less than 900 mm/year. Precipitation mostly occurs between mid November and mid April. Figure 3 shows a typical view of the Coast.

Table 1 shows that although annual water availability is only 37 363 millions of cubic meters which represents 1.8 % for the Pacific Basin, 70 % of the Peruvian population, 18 430 000 people, live in this area, which results in an availability of 2 027 m^3/person/year on the average. However, some populated centers have an average availability of less than 1000 m3/person/year. For instance, Lima is the second largest city in the world, following El Cairo, located in a desert area.

The Amazon basin, which also includes the highlands, has an annual water availability of 1 998 752 millions of cubic meters, which is 97.7 % of the water resources of the nation. With a population of only 6 852 000, the water index is 291 073 m^3/person/day. This is approximately 143 times the water availability of the Pacific basin.

The Lake Titicaca basin is part of a closed system formed by four major basins: Lake Titicaca (T), Desaguadero River (D), Lake Poopó (P), and Coipasa Salt Lake (S). These four basins form the TDPS system of which the main element, Lake Titicaca (8,400 km^3), is the largest in South America. (www.unesco.org/water/, 2009).

Table 1. Area, Water and Population Distribution in Peru. Source: INRENA (1995).

Basin	Area (1000 x km^2)	Population (Thousands)	% of Population	Water availability (annual MCM)	% of water availability	Water index (m^3/person/year)
Pacific	279.7	18430	70	37363	1.8	2027
Atlantic	958.5	6852	26	1998752	97.7	291073
Lake Titicaca	47.0	1047	4	10172	0.5	9715
Total	1285.2	26392	100	2046287	100.0	77534

The area of the Lake Titicaca basin within Peruvian borders is 47 000 km^2. The population in this area is 1 047 000, which is 4 % of the total. The annual volume of surface water is 10 172 000 m^3, 0.5 % of the total resources of Peru. The annual water availability is 9 715 m^3/person/year.

Figure 1. Drainage Basins and Population Distribution. (Atlas Geográfico del Peru, 2007)

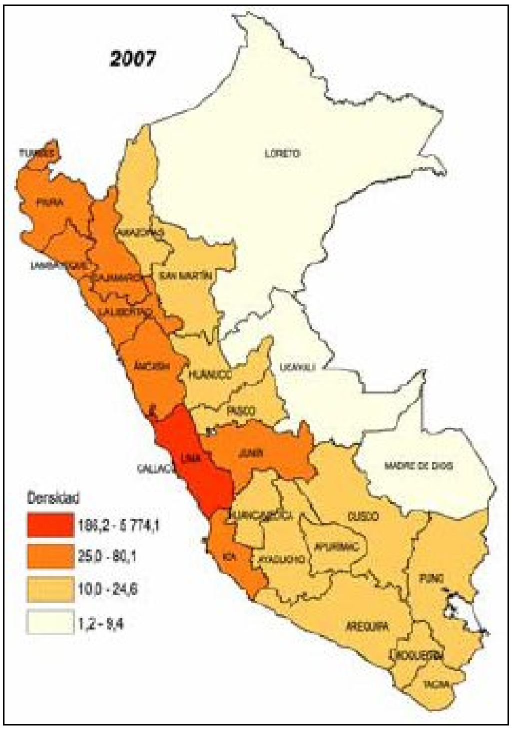


Figure 2. Population Density by Region. Notice that population density decreases towards the East where the Amazonian Regions are located. Source: Instituto Nacional de Estadística e Informática (2007)

Figure 3. Typical view of the Central and Southern Coast.

Figure 4. View of the Peruvian Sierra (Mountains). Mid altitudes. Source:

Figure 5. View of the Central Peruvian Sierra. Altitude is above 14 000 feet.

Figure 6. View of the Peru´s low jungle, a very humid area.

2. WATER USES IN PERU

The national water consumptive use is approximately 20 072 Millions of Cubic Meters (MMC) per year, of which 80 % is exploited in agricultural activities, 18 % is used in municipal and industrial activities and 2 % is used by the mining industry. However, water consumption is increasing in the latter economic activity. Non consumptive use (including power generation) is estimated at 11 139 MMC/year.

Agricultural activities

The potential area for reclamation is 6 411 000 Ha. However, only 1 729 000 Ha are being irrigated. In the Coastal region 1 080 000 Ha are irrigated, but only 836 000 Ha are actually being farmed for commercial purposes. The Peruvian Sierra (highlands) has 18 % of the area and the Jungle (Selva) has 5 % of the farmland. The main difficulties of developing agricultural activities in the highlands are the mountainous relief, water scarcity and the weather, particularly when the areas are over the 3 500 meters above sea level. The thin topsoil, which is easily eroded away when the soil has been altered by tilling, and the hot weather, are the main difficulties for the development of agricultural activities, particularly in the lowlands. Average irrigation efficiencies range between 35 to 40 %.

Municipal water and industrial activities

Municipal water and sewage service is provided by 45 service provider companies (SPC) that are licensed by SUNASS (National Superintendent of Sanitary Services, acronym in Spanish). They provide water in 114 of the 194 provinces Peru has. Provinces are sub divisions of the Regions. In Metropolitan Lima, 86.9 % has access to water services and 69.5 % has sewage connected to the wastewater system. The Peruvian Government is building a new water treatment plant in Lima upstream of the existing one and is also expanding the service to a number of communities. The goal is to provide full coverage by the year 2011, to partially comply with the Millennium Challenges. In towns where population is less than 2000, administrative boards partially cover the costs of water supply with a monthly contribution.

Industrial use

Most of the industrial activities are conducted in Lima and some major cities along the coastline of Peru. Water consumption in industrial activities is 1103 MMC/year in the Pacific Drainage Basin, 92 % of the total industrial use. Industrial use is 49 MMC/year in the Atlantic Drainage Basin, which represents 7 % of the total. The Lake Titicaca basin uses 3 MMC/Year, which is 1 % of the total. The main industrial activities that consume water are: the leather industry, textiles industry, production of beverages, food production, paper manufacturing and oil refineries.

Mining use

Peru is the top producer of silver in the world with 111.6 million ounces of mineral in 2006. It is also the third producer of zinc, contributing with 12 % of the total production worldwide and the fifth producer of gold, with 203,268 kg in year 2006. It is also among the top ten producers of plumb, tungsten, cadmium, bismuth, tellurium, molybdenum, and other metals. Currently, mining exports represent 45.9 % of the total sales overseas.

The use of water in the mining industry has been growing as the production worldwide increased and the demand for metals rose to unprecedented levels. The order of magnitude is 206.7 MCM/year of which 73 % are used in the Pacific Drainage Basin, 26 % are used in the Atlantic DB and 1 % in the Lake Titicaca DB.

Hydropower generation

Potential of hydropower generation is directly related to water resources availability and the topography of the area being considered for power development. In a particular project, persistence of discharge and difference of elevation between the forebay and the tailwater are components which allow one to calculate the gross power available. A study for evaluation of the potential for power generation in Peru was conducted in 1969 by the Association Lahmeyer – Salzgitter. It was sponsored by the former Federal Republic of Germany through the German Society of Technical Cooperation (GTZ, acronym in German), International Bank for Reconstruction and Development (IBRD) and the Peruvian Government. The evaluation considered potential power plants that could produce 20 MW or more. Sites in the lower Amazon Jungle were not considered, because of the lack of data, mainly topographic surveys and hydrological information, unfavorable geologic conditions and potential deleterious effects in the environment caused by the flooding of large areas. The theoretical power potential was estimated in 200 000 MW. This study was updated in 1979 by the Ministry of Energy and Mines (MEM, acronym in Spanish). In both cases, the reports mentioned that one of the main problems for the studies was the lack of data. Table 2 summarizes the number of power plants and their potential of power generation.

Table 2. Number of power plants and range of power generated in MW.

Power generated	Number of power plants
Less than 500 MW	1
Between 100 y 500 MW	9
Between 50 y 100 MW	4
Between 10 y 50 MW	10
Less than 10 MW	9

It is worth mentioning that Electroperu (the Government Owned Power Company) developed preliminary studies for hydropower generation of electricity, particularly in those sites in which the population heavily depended on thermal power. Sites in the Peru's Lower Jungle mostly use thermal power plants due to the lack of information on suitable locations and the absence of adequate connectivity in the area. For instance, the Napo – Mazán project consists of using water taken from the Mazán River, a tributary of the Amazon River, and divert it to a power plant. Power is generated taking advantage of the difference of elevation between the Mazán River and the Amazon River, which is approximately 6 m (19.7 ft). This project could provide electric power to Iquitos, the capital of the Loreto Region, and other cities in the Amazon area. There are a number of projects being developed. A number of companies have already applied for permits and it is expected that new power plants will be built in the short term.

Harald Federicksen (1996) pointed out that it is important not to waste time in coming up with real solutions for problems generated by the scarcity of water resources. There are four points that are key to understand the problems:

a) Scarce time to take preventive measures.
b) Limited measures that are currently available to mitigate the effects of water scarcity.

c) Competition for funds and resources allocations.

d) The minimum ability to handle droughts when they occur.

The last point is precisely the main problem related to power generation. Most of the hydropower plants in Peru are run-of-river. This means that water is taken directly from the river, with no significant storage capabilities, and is diverted to the power plant. This means that energy production in Peru is very vulnerable to droughts, although new thermal plants have been built in the last years due to the high demand for energy. Therefore, there is an immediate need to increase power generation.

2. ENVIRONMENTAL ISSUES AND WATER POLLUTION

Human activities have an impact on the surface and underground water resources. Agricultural activities, construction of infrastructure, industrial uses, mining, municipal water use and ranching have an impact on the environment.

Agricultural activities contribute to the pollution of watercourses. Use of pesticides and fertilizers on crops causes contamination of surface water and groundwater. During the rainy season, fertilizer and pesticide residues are washed away and mixed with runoff and diminish the water quality of streams they enter. For instance, contamination by agrochemicals has been reported in Lake Chinchaycocha, located in the Central Andes of Peru. Extraction of cattails also occurs because they are used as forage for livestock. Livestock contributes to the compaction of the wetlands surrounding the lake, destroying the habitat for native species. Mining activities also play a major role in the decrease of native fauna in this lake.

Aquifers are also vulnerable to excessive exploitation. They are depleted when the rate of demand is larger than the recharge rate. In coastal areas, depletion of the aquifer may also cause intrusion of salt, as it happens in La Yarada, in Tacna, near the Peru-Chile border.

Mining activities in Peru precede the times of the Spanish Conquest. Gold, silver and copper jewelry and other metal artifacts have been found in cultures that are even 3000 years old. Mining activities become increasingly intense during colonial and republican times. During the 19th and 20th centuries large investment were made in the exploitation of mine sites. At the beginning of the 20th century the investment was mainly private and foreign companies invested in Peru. CENTROMIN PERU was created when several mining sites were expropriated by the Peruvian Government during the 60´s.

Although the mining industry is heavily regulated nowadays, being the most important investors those who exploit mines in first world countries and follow their standards, passives from the past remain throughout the Peruvian territory and mitigation measures are needed to diminish pollution of watercourses. Unregulated mining activities have left untreated mine sites. Some tailings are exposed to the environment and are eroded away during the rainy season, rapidly diminishing the quality of water. Figure 7 shows an abandoned mine tailings on the right bank of Colorado River in the Northern Andes of Peru. Abandoned quarries, acid drainage are also issues which are gradually being solved in locations where investment is made by new investors which are obligated to assume the passives left by previous concessionaires.

Figure 7. Mine tailings on the left bank of Colorado River in Cajamarca, Northern Peruvian Andes.

Large scale municipal water treatment plants are practically non-existent in Peru. For instance, several collector sewages convey wastewater from Lima, the capital city, to the Pacific Ocean. Wastewater is mainly domestic and industrial. One of the first large treatment plants is about to be built in Callao, the coastal town next to Lima and will treat a fraction of wastewater produced in the capital city. The bid was already awarded this year to a Spanish construction company. Other wastewater plants will be built in the next several years by SEDAPAL, Lima's water company, according to their website (www.sedapal.com.pe, 2009).

According to Panamerican Health Organization (PAHO), 80% of the hospital bed occupation is caused by drinking contaminated water. Because of lack of culture of water, most cities and towns municipal services pour their sewage and solid wastes in water bodies and rivers.

This problem is specially critical in large cities like Lima with some 8 million inhabitants and Arequipa with about 1 million people which pollute the Rimac and Chili rivers respectively beyond permissible limits. Contamination reduces the volume of water of good quality and also substantially increases the cost of drinking water treatment. In medium sized cities and towns this problems is even more critical. To fulfill one of the 8 Objectives of the UN Millennium Declaration to reduce the infant mortality, it is necessary to lower the water contamination caused by the population, and agricultural and mining activities. It is a key issue to contribute to reduce poverty in the country.

3. WATER AND SOCIETY

Peru´s population is as diverse as its geography. There are three official languages in Peru. Spanish is Peru's official language, but also are Quechua and Aymara where they prevail. Thirty three indigenous languages (spoken mainly in the Amazon jungle) are also recognized as part of Peru's cultural heritage. Views on the use of water are as diverse as the Peruvian population. Scarcity of fresh water in the Coast and the Mountains and the increasing use of this resource have led to conflicts among users. Peru has created a system for defending its citizens´ rights against the abuse of the Government or large companies or institutions called People's Defensorship (Defensoría del Pueblo). (www.defensoria.gob.pe). This institution constantly reports conflicts that occur in Peru every month. Environmental issues are usually the main cause of conflicts (51 % as of May 2009). The majority of these conflicts are mostly related to water use.

In the jungle and lower jungle conflicts arise from the opposition of various native ethnic groups who have witnessed the imbalances caused by intense uncontrolled human activities. However, there are places that have been taken by informal miners whose activities are not controlled by the Government. The invaders face no opposition from the natives who accept the monetary benefits of gold exploitation. Damages to the environment are very severe because miners use mercury during the extraction process (El Comercio, April 24, 2009). In Madre de Dios region, gold miners have already deforested 150 000 Ha of primary forests and surrounding wetlands have also been affected. Minister of the Environment Antonio Brack called damages caused by informal gold miners in SE Peru as “monstrous”. Seven ministries will evaluate damage caused by the miners this year.

There are places in Peru where underground and surface waters naturally carry heavy metals. One of these locations is located in the Peru – Chile border highlands. The population, which lives in small rural communities, used to be exposed to water with high Arsenics content. Technological solutions have been proposed by Rodriguez (2007), using technology that can be easily applied by the inhabitants of this area.

4. EXTREMES: FLOODS AND DROUGHTS IN PERU - REDUCING THE RISK OF DISASTER OF CLIMATIC ORIGIN.

The IPCC working groups I to III have predicted in their reports of 2007 that the average world temperature will have an increment from 1.5 to 4ºC during the 21st century (IPCC, 2007). Therefore, it is expected that climatic disaster as El Niño will be more severe and frequent in the next decades. El Niño 1982-83 caused severe flooding in the country northwestern coast and drought in the high plateau of the Titicaca Lake basin which is located, over 12000 feet high. These two negative effects caused material loses of 6.2% of the country GNP of 1983.

To reduce the losses in urban areas in Peru was initiated the Sustainable Cities Program in 1998 focused on its first attribute: the cities safety. The best argument to convince the chief of the El Niño Reconstruction Committee (CEREN) at the same time, Peru prime minister was that the flooding maps El Niño 1997-98 were practically carbon copy of those of El Niño 1982-83 of main cities affected by both El Niño as Tumbes, Piura Talara, Paita, etc.

In addition to the functions of the National Water Authority of Peru (ANA) that is to have an efficient water use in the country, including disaster reduction, Peru's National Center for Strategic Planning (IEPLAN) has nominated a specialist on El Niño Southern Oscillation (ENSO) to reduce its future negative impact.

In addition, negative trends in precipitation patterns have been observed in Chile and part of the Western Coast of South America. Southern Peru may be affected by diminished water availability. Positive trends in precipitation have been observed in the Amazonian region, which may lead to more frequent flooding in riverside areas.

The Andean glaciers are disappearing due to an increase in air temperature at high altitudes and diminishing trend in precipitations. Figure 8 (Morales-Arnao, 1982 – 1997 – 2005) shows glacier Yanamarey evolution in the course of 23 years. The same phenomenon has been observed in all Peruvian glaciers. Therefore, water reserves in form of ice and snow are diminishing at a fast rate and may adversely affect water availability in the near future.

Figure 8. Vanishing glacier Yanamarey between 1982 and 2005. (Morales Arnao, 1982, 1997 and 2005).

5. INSTITUTIONAL FRAMEWORK

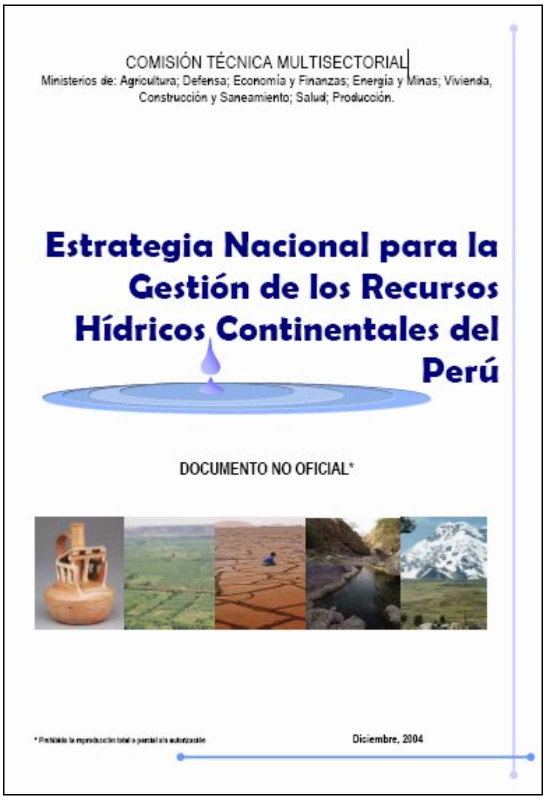
The importance politicians, entrepreneurs and the society at large gave to Peru's natural resources is reflected in Peru's national coat of arms (or Great Shield) which shows a Vicuña, a Quinoa tree and a cornucopia, which represent the Animal, Vegetal and Mineral Kingdom, respectively. This reflects the importance natural resources have in Peru's economic life. In fact, Peru has been a supplier of raw materials to industrialized countries for about 200 years.

Peru is a Unitarian country. Its constitution establishes that natural resources, renewable or not, are property of the State and its exploitation is given in concession to the private sector, provided that previously established conditions are fulfilled (Peru's Constitution, 1993). A large portion of Peru's income is based on the exploitation of its natural resources, particularly mining activities, large scale fishing, and others. Agricultural and food industry is becoming increasingly important as well. The lack of planning and control of economic activities has led to environmental disasters that have caused the contamination of soil and water of a number of basins. Air pollution also occurs as a consequence of transportation of contaminants. Damages caused by the environment led to the creation of the Ministry of the Environment in 2008.

INRENA (National Resources Institute)

Prior to the creation of the national water authority, ANA, INRENA, the National Resources Institute of Peru, was in charge of conducting the necessary actions to make use of the renewable natural resources and guard the conservation of the management of the rural environment and wild biodiversity. This institute was part of the Ministry of Agriculture and had a Superintendent of Water Resources who used to be in charge of planning water allocations and coordinate with users along with the ministry of Agriculture. Hydrologic research was also conducted by INRENA to estimate the availability of water resources on a per basin basis. Several INRENA officers championed the publication of a non-official document called "National Strategy for Peru´s Continental Water Resources Management" in which they included views from 7 ministries which are: Agriculture; Defense; Economy and Finance; Mines and Energy; Housing, Construction, Water Supply and Sewerage; Health and Production. See Figure 6.

In recent years, the growth of water use because of population growth, new economic activities that require water, increase of polluted waters, and increase of conflicts among users has led to the Government and the society and large to demand the creation of a National Water Authority that dealt with water issues from a comprehensive point of view. This new institution was created in March 2008 by Legislative Decree 997. The National Water Resources System was created shortly thereafter.


COMISIÓN TÉCNICA MULTISECTORIAL
Ministerios de: Agricultura; Defensa; Economía y Finanzas; Energía y Minas; Vivienda, Construcción y Saneamiento; Salud; Producción.

Estrategia Nacional para la Gestión de los Recursos Hídricos Continentales del Perú

DOCUMENTO NO OFICIAL*

Diciembre, 2004

Figure 9. Unofficial document (Anonymous, 2004). National Strategy for Peru´s Continental Water Resources Management.

ANA (National Water Authority)

The recently created National Water Authority (ANA, acronym in Spanish) is the government institution in charge of conducting the necessary actions to secure the sustainable use of water by all sectors on a per basin basis within the integrated natural resources management framework. Strategic alliances are established with regional and local authorities, and the social and economic actors involved in water issues.

Its main functions are to produce the policies and the national water resources strategy, manage and formalize water rights, promote the fair distribution of water, and to facilitate the solutions of conflicts among users. ANA (2009) recently published the book “Política y Estrategia Nacional de Recursos Hídricos del Perú” which provides insight in a general analysis of the current situation and proposes courses of action to solve the problems generated from the uneven distribution of water resources, its scarcity and multiple uses. This document was largely based on Anonymous (2004) which was promoted by INRENA officers. See Figure 9.

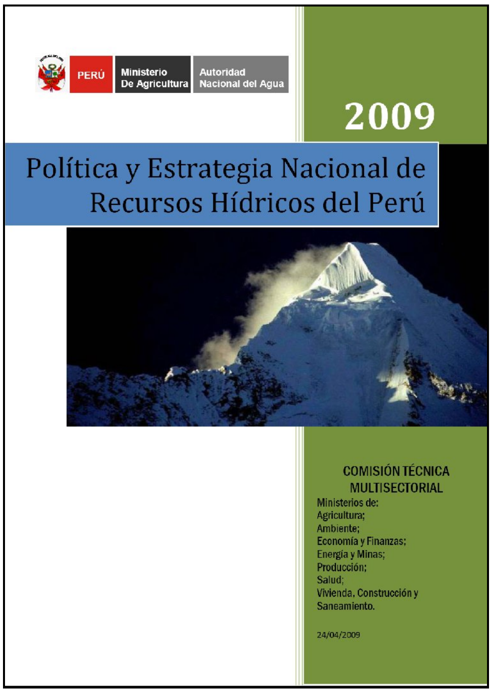


Figure 10. Document published recently by ANA (2009). This publication is based on Anonymous (2004).

National Water Resources System

The National Water Resources System (NWRS) was created by Legislative Decree 1081 in September 2008. Its main goal is ensure that all sectors of the government: national, regional and local, who have any kind of authority on water issues and users who can be individuals, associations or companies work in a coordinated manner to make sure water resources are used in a sustainable and effective way considering the criteria of quantity and quality of water and opportunity of the interventions. The following institutions, agencies and private participants are part of the NWRS:

1) ANA: National Water Authority
2) Ministry of the Environment
3) Ministry of Agriculture
4) Ministry of Housing, Construction and Sanitation.
5) Ministry of Health
6) Ministry of Production
7) Ministry of Energy and Mines
8) Public agencies that are related to water management at regional and local levels.
9) Basins´ councils
10) Public and private water operators
11) Water users´ boards

Peru's Water Resources Law (Law 29338 – March 2009)

Peru's new water resources law has been published in March 2009. This new law establishes that ANA is the top technical and normative authority to deal with water issues in Peru. The National Court of Resolution of Water Controversies is part of ANA and its mandates are final and can only be appealed by judicial means. Basin Councils are also established. They participate in the planning and coordination of water uses. They may cover one or two regions, in which case each region will provide the necessary members to insure that all sectors of society are fairly represented by this authority.

Users´ boards are also regulated. They operate, manage and maintain water distribution infrastructure, decide on water distribution amongst its members and also charge for the use of water.

Farmers´ communities and Tribal Communities rights are also recognized in this law. Water may be used according to their traditions. These organizations have the same rights and obligations than the users´ boards.

Priorities in water use are clearly defined. The top priority is primary use, which is direct consumption by human beings. Population use is the second priority. This is consumption in a network of domestic users. Productive use comes third. This use is linked to economic activities.

6. RECENT EFFORTS IN WATER RESOURCES RESEARCH IN PERU

The Hydraulic Resources - University Research Consortium (HR-URC) of Peru is composed by eight universities qualified by CONCYTEC, the National Council of Science, Technology and Innovation of Peru, a government agency that promotes scientific and technological research in Peru. These universities are: Universidad Nacional de Ingeniería (UNI), Universidad Nacional Agraria – La Molina (UNALM), Universidad Peruana Cayetano Heredia (UPCH), Pontificia Universidad Católica del Perú (PUCP), Universidad Nacional Mayor de San Marcos (UNMSM), Universidad Nacional de Trujillo (UNT), Universidad Nacional San Agustín de Arequipa (UNSAA) and Universidad Nacional San Antonio Abad del Cuzco (UNSAAC). They were ranked and qualified mainly based on research production.

HR-URC has organized three meetings so that the universities that are members of HR-URC could present their present and future research projects. In addition, other organizations such as regional (state) and national agencies participated and presented their expertise as well as the issues they deal with on a daily basis.

CONCYTEC has acted as a facilitator to produce Pro Hidro, the National Plan for Research on Science, Technology, and Innovation in Water Resources. Members of Pro Hidro are university instructors and researchers, public and private water resources managers, regional (state), local and national government officers.

Six main research areas have been identified by members of Pro Hidro as follows:

a) Water availability.

b) Water resources integrated management.

c) Water supply and wastewater.

d) Water quality.

e) Risk management

Research areas have also been divided in lines of research and finally, research projects were proposed. One of the main difficulties consists of the lack of reliable hydrologic and meteorological data. Some examples of research produced by Peruvian scholars follow.

Research on water availability

The main objective of this are is to evaluate present and future water resources availability on a basin by basin basis. Several research projects are being conducted in this area.

The National Agrarian University at La Molina (UNALM) is currently studying water resources availability in the Peruvian Andes, particularly in the White Range where global warming has caused retreat of the snow covered areas. They are also studying rainfall-runoff relations in the Amazon Jungle of Peru. Both projects are supported by French universities.

The National University of Engineering (UNI) is studying rainfall-runoff relations in several natural settings in Peru. Peru's area and weather diversity makes it necessary to study water resources in different geographical conditions.

There is a lack of real time records of precipitation and discharge in Peru. Therefore, techniques have to be developed from basins that have better information than others. Two research projects have been recently concluded by UNI graduate students. In the first one, a Master's thesis has shown that it is possible to predict mean daily discharges based on daily precipitations in a basin with very limited data by using conceptual models such as the Tank and NAM models.

The Major National University San Marcos (UNMSM) is conducting research on groundwater resources near marine areas. The objective is to study potential solutions for avoiding intrusion of saline water in coastal wells.

Research on water quality

The purpose of this research area is to improve the capacity of monitoring, contamination reduction and preservation of water quality.

A team led by Dr. Guy Carvajal has been working on the reduction of contamination levels of Arsenic, Cadmium and Lead from polluted water by filtering water through sand. The method consists of using a mix of magnesium, sand and marine spores. Marine spores are used to oxidize magnesium, which creates a barrier that traps heavy metals. Results clearly show that after two hours of filtering, concentration of heavy metals decreases below OMS permissible limits. Dr. Guy Carvajal is a micro biologist specialized in Genetics who works as a professor at the school of Environmental Engineering of the National University of Engineering.

Dr. Juan Rodriguez, from the school of Science of UNI, has developed a method to remove arsenic from water. Surface and subsurface water is prone to contamination from the soil whose arsenic content is high in rural areas in Southern Peru (near the Peru – Chile border). Water is poured into a plastic bottle containing water and an iron wire. This is exposed to sunlight after lime drops were added to water. This induces settling of arsenic. Arsenic is removed from the bottom of the container afterwards and disposed of properly.

7. CONCLUSIONS AND RECOMMENDATIONS

1) Peru has a very uneven distribution of water resources and population. People had a strong tendency to populate the coast, which is a very dry area. Water availability per capita is one of the lowest in the world.
2) Most of consumptive water use is agricultural, followed by municipal and industrial activities, and mining. This latter activity is gradually increasing its water consumption.
3) Contamination of water bodies and streams is an issue that needs to be solved. Passives left from past human activities and current unregulated economic activities are harming water resources in Peru.
4) Water related extreme events affect the life and economy of Peru. On one hand El Niño Southern Oscillation causes flooding in the Northern Coast of Peru and on the other hand, may cause severe droughts in other regions.
5) Glaciers are rapidly disappearing from the Peruvian Andes. This may significantly affect water resources availability in the near future.

6) Water related laws and regulations have been rapidly changing during the last two years. The Ministry of Environment and the National Water Authority were created in 2008. The Water Resources Law and the National Water Resources System were created this year.
7) The new water resources law confers full power to ANA to deal with water issues on a national scale. It also provides a framework in which national, regional and local authorities and users can use water in a sustainable, effective and efficient way. Functions and limitations of users´ boards are established. Traditional and ancestral uses by farmers´ communities and minority ethnic groups are recognized as well.
8) Research efforts are made in Peru in the water resources area. Most of the work is concentrated in a few large universities. Main research areas are water availability and water quality. The main difficulty for conducting research on water availability is the lack of reliable data.

8. ACKNOWLEDGEMENTS

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Professor Julio Kuroiwa Sr. provided ideas for this paper and partially reviewed this contribution to the meeting.

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