International Journal of Applied Social Science
(An International Double Blind Peer Reviewed / Refereed Research Journal of Social Science)
Volume 10 (7 & 8), July & August (2023) : 468-481
Received : 17.06.2023; Revised : 02.07.2023; Accepted : 17.07.2023

RESEARCH ARTICLE
ISSN : 2394-1405
DOI: 10.36537/IJASS/10.7&8/468-481

Groundwater Depletion and Agriculture: A Study in Villages of Haryana

SHANTA RANI KERKETTA
Associate Professor (Economics)
Lady Irwin College, Delhi University, New Delhi (India)

ABSTRACT

Groundwater has become one of the important sources of water for meeting the requirements of various sectors in India in the last few decades. It plays a vital role in India's economic development and in ensuring its food security. Groundwater depletion is a problem that arises mainly due to pumping above the required level. The lowering of water levels caused by depletion has severe impacts on agriculture. Farmers are not getting enough groundwater for their crops. Therefore, the present study "Groundwater Depletion and Agriculture: A study in Villages of Haryana" was conducted to see the effects of ground water depletion on agriculture and also to see the knowledge level of the villagers about groundwater depletion and the ways adopted by them to solve this problem. The study revealed that most of the farmers are aware of groundwater resource and its depletion. Because of lack of groundwater, they are making changes in their cropping patterns. The amount of money spent on agriculture is increasing day by day.

Operational Definitions:
- Groundwater: Groundwater is water located beneath the ground surface in soilpore spaces and in the fractures of rock formations.
- Awareness level: It will include their knowledge and perception regarding the depletion of groundwater resources.
- Depletion: Loss of water from surface waterreservoirs or groundwateraquifers at a rate greater than that of recharge.
- Groundwater depletion: Groundwater depletion is the long-term water-level declines caused by sustained groundwater pumping.

Key Words : Groundwater depletion, Agriculture, Water

INTRODUCTION

Groundwater:

"Ground Water: Out of Sight, But Not Out of Mind."

Kevin McCray, Executive Director, NGWA

Groundwater is water that accumulates underground. It can exist in spaces between loose particles of dirt and rock, or in cracks and crevices in rocks. Different types of rocks and dirt can contain different amounts of water. The saturation zone is the portion of the soil and rock that is saturated with water, while the unsaturated zone is the portion of the soil and rock that is not saturated. The top of the saturated zone is called the water table. The diagram below illustrates these terms (Groundwater, SDWF, 2008).

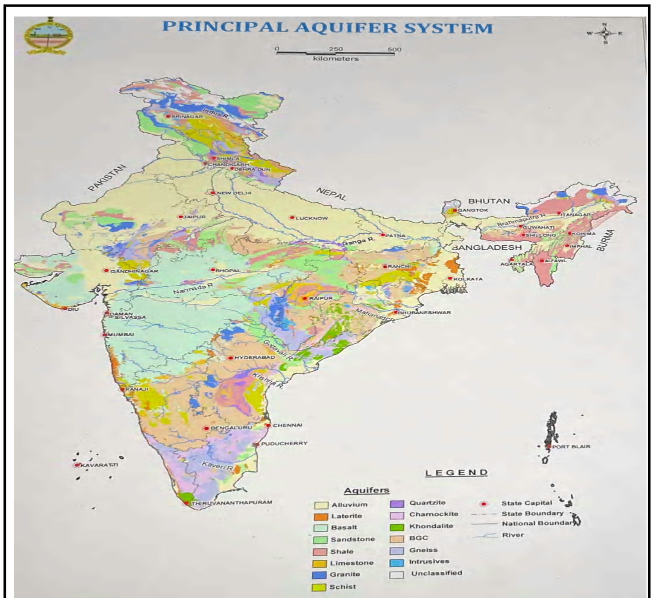
When it rains, the water infiltrates the soil and percolates downwards until it reaches the water table. Permeable surfaces, such as sand and gravel, allow up to 50 percent of precipitation to enter the soil. Rainwater can take years or even decades to reach the water table. Due to the immense volume of groundwater, once rainwater reaches the water table, it often remains there for an extremely long period of time. Some water that is currently stored in the ground may be rain that fell

How to cite this Article: Kerketta, Shanta Rani (2023). Groundwater Depletion and Agriculture: A Study in Villages of Haryana. *Internat. J. Appl. Soc. Sci.,* **10** (7&8) : 468-481.

hundreds or thousands of years ago (Groundwater, SDWF, 2008).

Aquifers are underground layers of permeable rock, gravel, sand or clay that water can be extracted from. In the above diagram, one can see that different types of rocks and soils that hold different levels of water, depending on the porous areas (or spaces). When the spaces are large enough to contain usable quantities of water, it is called an aquifer. Large particles, such as coarse sand and gravel, can hold more water than fine sand and clay, because the spaces between gravel particles are larger than the spaces between fine sand particles. So, we can say that gravel has a greater porosity, or ability to hold water, than clay (Groundwater, SDWF, 2008).

There are two types of aquifers; confined and unconfined. All aquifers sit on an impermeable layer of clay or bedrock. A confined aquifer has a layer of impermeable clay or bedrock above it, as well, and an unconfined aquifer does not. The below mentioned diagram illustrates the two types of aquifers, as well as the way in which the groundwater is connected to the surface. Artesian wells can be drilled into confined aquifers, because the great amount of pressure on the water (from the overlying ground) forces the water upwards. Unconfined aquifers can recharge nearby streams, during times of drought. Aquifers can range from a few hectares in area to thousands of square km (Dragoi, 2007) (Fig 1).



Major aquifers systems of India (2022)

Fig. 1 : Principal Aquifer System

Availability of Groundwater in India:

Availability of groundwater is widely variable across the length and breadth of the country. The great Himalayan ranges in the north act a rain shed divide ushering rainfall in the Indian plains, the most important source of ground-water recharge in the country. The consolidated rock formations of the Himalayas are not particularly conducive to groundwater. However, the Bhabars and Terais at the foothills of the lofty mountain chain act as a potential groundwater recharge zone for the aquifer systems down-hill. The deeper confined aquifers in these formations display flowing artesian conditions. The Indo-Gangetic alluvium occurring in the foredeeps of the Himalayas forms the most productive and extensive multi-aquifer system in India (CPCB, 2007).

The tubewells tapping granular horizons in this belt have recorded a yield up to 75 litres per second (lps). Potential aquifers down to more than 600 m deep have been explored in this region. Semi-consolidated formations with moderate groundwater yield occur in narrow valleys or structurally faulted basins in the belts fringing the peninsular region adjacent to the Ganga plain, Narmada and Tapi valleys, coastal belt and in parts of Rajasthan, Gujarat and also parts of the northeastern region. Open wells in these sedimentary formations have yield in the range 1–5 LPs. Basalt lava flows of the Deccan Traps in Central India in Maharashtra, Madhya Pradesh and Gujarat has usually poor to moderate potential. Dug wells and dug-cum-bore wells are the most common groundwater structures generally yielding between 1 and 20 lps. Peninsular India is mostly characterized with consolidated formations like granites–gneisses and other igneous and metamorphic rock assemblages (Chatterjee and Jha, 2006). Groundwater in these formations occurs in weathered and fractured zones. Open wells generally record a yield between 1 and 9 lps and bore wells tapping deeper fracture zones have occasionally recorded high yields, up to 30 lps. The occurrence of groundwater in these terrains is, however, site-specific unlike alluvial areas. The coastal areas having thick alluvium deposits form the prospective aquifer systems. Deep tube wells tapping multi-aquifers in these tracts have yield potential up to 60 lps. Ground- water development in these coastal areas is, however, associated with the risk of sea-water intrusion (Chatterjee and Jha, 2006).

Total Annual Ground Water Recharge in the country

(2022) has been assessed as 437.60 billion cubic meters (bcm). Ground water resources are replenished through rainfall and other sources like return flow from irrigation, canal seepage, recharge from water bodies, water conservation structures etc. The main source of annual ground water recharge is rainfall, which contributes nearly 61 % of the Total Annual Ground Water Recharge. The Total Annual Extractable Ground Water Resource of the country has been assessed as 398 bcm, after keeping a provision for natural discharge. The Annual Ground Water Extraction of the country (2022) is 239 bcm, the largest user being irrigation sector. The Stage of ground water extraction for the entire country, which is the percentage of ground water extraction with respect to Annual Extractable Ground Water Recharge, has been computed as 60 %. The extraction pattern of ground water is not uniform across the country, resulting in ground water stressed conditions in some parts of the country while in some other areas; ground water extraction has been sub- optimal. Out of the total 7089 assessment units (Blocks/ Districts/ Mandals/ Talukas/Firkas) in the country, 1006 units (14%) have been categorized as 'Over-Exploited', 260 units (4%) have been categorized as 'Critical', 885 units (12%) have been categorized as 'Semi-Critical' and 4780 units (67%) have been categorized as 'Safe'. Apart from this, there are 158 assessment units (2%), which have been categorized as 'Saline' as major part of the ground water in phreatic aquifers is brackish or saline. Similarly out of 24.71 lakh sq km recharge worthy area of the country, 4.31 lakh sq km (17 %) are under 'Over-Exploited', 0.77 lakh sq km (3%) are under 'Critical', 3.03 lakh sq km (12%) are under 'Semi-Critical', 16.19 lakh sq km (66%) are under 'Safe' and 0.4 lakh sq km (2%) are under 'Saline' category assessment units. Out of 398.08 bcm of Total Annual Extractable Resources of the country, 46.05 bcm (12 %) are under 'Over-Exploited', 13.02 bcm (3 %) are under 'Critical', 47 bcm (12%) are under' Semi-Critical', 291.88 bcm (73%) are under 'Safe' category assessment units.

Over-exploitation of ground water resources could be due to various region-specific reasons. Assessment units located in the north-western part of the country (particularly in the states of Punjab, Haryana, Delhi and Uttar Pradesh) have plenty of replenishable ground water resources but because of the over extraction beyond the annual ground water recharge, many of these units have become Over-exploited. Over-exploited units are also common in the western part of the country, particularly in Rajasthan and Gujarat where the prevailing arid climate results in low recharge of ground water and hence stress on these sources. In peninsular India, over-exploited units are wide spread in the states of Karnataka, Tamil Nadu and parts of Andhra Pradesh and Telangana which could be attributed mainly to the low storage and transmission capacities of aquifers of the hard rock terrains, which results in reduced availability of the resource.

The total Annual Ground Water Recharge for the entire country, as in 2022 has increased by 1.29 bcm as compared to the last assessment (2020). The total Annual Extractable Ground water Resources has also increased by 0.56 bcm. The Annual Ground Water Extraction for irrigation, domestic and Industrial uses has also decreased by 5.76 bcm during this period. These variations are attributed mainly to refinement of parameters, refinement in well census data and changing ground water regime.

It is also pertinent to add that as it is advisable to restrict the ground water extraction as far as possible to annual replenishable resources, the categorization also reflects the relation between the annual replenishment and ground water extraction. An area with low groundwater potential may not be considered for ground water extraction and may remain safe and an area with good ground water potential may be heavily used for ground water extraction and may become over exploited over a period of time. Thus, water augmentation efforts can be successful in such areas, where the groundwater potential is high and there is scope for augmentation. (Dynamic Ground Water Resources Assessment of India – 2022)

Sources of Groundwater:

There are three types of groundwater sources namely shallow groundwater, deep groundwater and springs.

Shallow Groundwater:

That can be reached by means of hand dug wells in areas where rainwater has been trapped in the underground such as in valleys, downstream of earth dams and near swamps, seasonal water courses, rivers and lakes (Multiso and Thomas, 2000).

Deep groundwater:

Deep groundwater is rainwater that has percolated deep into the underground during centuries or thousands of years (Multiso and Thomas, 2000).

Springs:

When ground water comes to the surface and flows freely under natural pressure, it is called a "spring". Springs may be of two types- shallow springs and deep springs. Shallow springs dry up quickly during summer months, whereas deep springs do not show seasonal fluctuations in the flow of water. In some geographic areas, springs constitute an important source of water. Springs are simpler to exploit, as no pumping is needed to bring the water to the surface. Springs are exposed to contamination (Struckmeier, 2005).

Techniques/Methods of Extraction of Groundwater:

Shallow wells

When the groundwater lies within a few metres of the surface, exploitation is possible with shallow wells which are mostly dug by hand. These wells normally have a diameter of 1 metre or more and are dug below the groundwater table. Water is pumped from these wells, often using human or animal power but, increasingly, with small diesel-powered pumps.

The amount of water that can be abstracted from shallow wells is limited, and, as a result, the areas which are irrigated from these water sources will also be limited (Brouwer *et al.*, 1992).

Submersible bores:

When the groundwater level is very deep, constructing a hand-dug well becomes impossible. Deep wells must be drilled into the ground. Generally, submersible pumps/bores are installed below the groundwater table to lift water to the surface. They may be driven by an electric motor or a diesel-powered engine on the surface with a long vertical shaft, or by a submerged electric motor inside a waterproof casing (Brouwer *et al*., 1992). With the inception of Solar power, now-a days the farmers are also using submersible bores pump to extract water. Infact the Government is laying much emphasis towards the usage of solar power for extracting water from the ground.

Infiltration Galleries:

An infiltration gallery is a horizontal drain made from open jointed or perforated pipes, or a block drain, which is laid below the water table and collects groundwater. Infiltrations galleries need soils at are permeable to allow sufficient water to be collected. The gallery should be surrounded with a gravel pack to improve flow towards it and to filter any large particles that might block the perforations (WHO, 2009).

Radial collector wells:

Where groundwater supplies are needed, it is often cost-effective to consider the use of a radial collector well. Collector wells can be used in almost any geologic setting where the subsurface materials are unconsolidated, consisting of sand and/or gravel deposits. A radial collector well can be used to develop water supplies from both freshwater and seawater sources (WHO, 2009).

Tube well:

A tube well is a type of water well in which a long 100–200 mm (5 to 8 inch) wide stainless steel tube or pipe is bored into the underground aquifer. The lower end is fitted with a strainer, and an electric pump at the top lifts water for irrigation. The required depth of the well depends on the depth of the water table (Stapleton, 1983).

Hand pump:

Hand pumps are manually operated pumps; they use human power and mechanical advantage to move fluids or air from one place to another. They are widely used in every country in the world for a variety of industrial, marine, irrigation and leisure activities. There are many different types of hand pump available, mainly operating on a piston, diaphragm or rotary vane principle with a check valve on the entry and exit ports to the chamber operating in opposing directions. Most hand pumps have plungers or reciprocating pistons, and are positive displacement (Water Aid, 2010).

Effects of Groundwater Depletion:

Pumping groundwater at a faster rate than it can be recharged can have some negative effects of the environment and the people who make use of the water:

Lowering of the water table:

The most severe consequence of excessive groundwater pumping is that the water table, below which the ground is saturated with water, can be lowered. For water to be withdrawn from the ground, water must be pumped from a well that reaches below the water table.

If groundwater levels decline too far, then the well owner might have to deepen the well, dig a new well, or, at least, attempt to lower the pump. Also, as water levels decline, the rate of water the well can yield may decline (PDEP, 2006).

Increased costs for the user:

As the depth of water increases, the water must be lifted higher to reach the land surface. If pumps are used to lift the water (as opposed to artesian wells), more energy is required to use the pump. Using the well can become expensive (Zhu, 2008).

Reduction of water in streams and lakes:

There is link between the water in lakes, rivers and groundwater. Mostly the water flowing in rivers come from seepage of groundwater into the streambed. Groundwater contributes to streams in most physiographic and climatic settings. The proportion of stream water that comes from groundwater inflow varies according to a region's geography, geology, and climate (PDEP, 2006).

Groundwater pumping can alter how water moves between an aquifer and a stream, lake, or wetland by either intercepting groundwater flow that discharges into the surface-water body under natural conditions, or by increasing the rate of water movement from the surface-water body into an aquifer. A related effect of groundwater pumping is the lowering of groundwater levels below the depth that streamside or wetland vegetation needs to survive. The overall effect is a loss of riparian vegetation and wildlife habitat (Scanlon, 2002).

Land subsidence:

The basic cause of land subsidence is a loss of support below ground. In other words, sometimes when water is taken out of the soil the soil collapses, compacts, and drops. This depends on a number of factors, such as the type of soil and rock below the surface. Land subsidence is most often caused by human activities, mainly from the removal of subsurface water (PDEP, 2006).

Deterioration of water quality:

One water-quality threat to fresh groundwater supplies is contamination from saltwater intrusion. All of the water in the ground is not fresh water; much of the very deep groundwater and water below oceans is saline. In fact, an estimated 3.1 million cubic miles (12.9 cubic kilometers) of saline groundwater exists compared to about 2.6 million cubic miles (10.5 million cubic kilometers) of fresh groundwater (Gleick, 1996). Under natural conditions the boundary between the freshwater and saltwater tends to be relatively stable, but pumping can cause saltwater to migrate inland and upward, resulting in saltwater contamination of the water supply (PDEP, 2006).

Artificial Recharge Techniques

A wide spectrum of techniques is in vogue to recharge ground water reservoir. Similar to the variations in hydrogeological framework, the artificial recharge techniques too vary widely. The artificial recharge techniques can be broadly categorized as follows:-

a) **Direct surface techniques**
- Flooding
- Basins or percolation tanks
- Stream augmentation
- Ditch and furrow system
- Over irrigation

b) **Direct sub surface techniques**
- Injection wells or recharge wells
- Recharge pits and shafts
- Dug well recharge
- Bore hole flooding
- Natural openings, cavity fillings.

c)**Combination surface–sub-surface techniques**
- Basin or percolation tanks with pit shaft or wells.

d) **Indirect Techniques**
- Induced recharge from surface water source.
- Aquifer modification.

Effects of Groundwater Depletion on Agriculture:

Over pumping of groundwater for domestic and industrial activities in rural areas are leading towards the problem of groundwater depletion which in turn is leading to various agricultural problems (Cross, 2007). There are two types of effects of groundwater depletion on agriculture.

a) Due to poor quality of groundwater

b) Due to non- availability of groundwater

People are polluting groundwater by performing various industrial activities. The water which gets released from industrial activities goes into ground and pollutes the groundwater. This polluted groundwater, when used in agriculture, can harm the crops. Many times crops get damaged and do not grow properly. And if they grow, then, it can harm to human health due to various chemicals/harmful substances into it. Poor quality of groundwater used in agriculture can also make the land infertile and barren (Krishna, 2009).

When sufficient amount of groundwater is not available, it is not possible to grow crops. Sometimes, due to poor availability of groundwater, crops get damaged. As farmers cannot grow their crops, they are shifting towards other occupation, which is leading to the decrease in agricultural productivity (WGO, 2006).

In the absence of water, sometimes, farmers make changes in their types of crops grown (crop diversification). In that situation, they need to shift from one type of crop (which requires more water) to another (which requires less water). It changes their entire growing pattern and forces them to cultivate those crops which cannot be eaten and also are not commercially profitable to them (Kalf, 2005).

Significance of the study:

In India people are mostly dependent on groundwater for their existence. It is more in rural areas as they do not have access to enough municipal water supplies. As a result, they are pumping more and more groundwater which is leading to the situation of groundwater depletion. This groundwater depletion has various effects on agriculture. Moreover, most of the farmers are not aware of the problem of this groundwater depletion. Presently, it is an emerging issue which needs to be taken care of. If this situation will remain like this for few more years, then the groundwater scenario will become worse and there will be no groundwater at all.

At present we need to focus more on the groundwater. Farmers need to make aware to combat with this situation. And for this, first we need to understand the problems that they are facing due to groundwater depletion in terms of money that they are spending for getting groundwater, poor quality of crops, damages to crops and so on. Apart from this, we also need to understand their knowledge regarding groundwater.

Objective :

– To study the effects of depletion of groundwater resources on agriculture.

Review of Literature :

The rate of global groundwater depletion has been on the rise, warning of a potential disaster for an increasingly globalized agricultural system Marc Bierkens (Bierkens *et al.,* 2010)

In an upcoming issue of Geophysical Research Letters, a journal of the American Geophysical Union, Professor Marc Bierkens of Utrecht University in the Netherlands and his colleagues find that not only is global groundwater extraction outstripping its natural recharge rate, this disparity has been increasing.

Groundwater represents about 30 percent of the available fresh water on the planet, with surface water accounting for only one percent. The rest of the potable, agriculture friendly supply is locked up in glaciers or the polar ice caps. This means that any reduction in the availability of groundwater supplies could have profound effects for a growing human population.

Using a database of global groundwater availability and estimates of groundwater usage and recharge rates, Bierkens and his team have been able to model both where, and how quickly, groundwater stores are being depleted. They find that the rate at which global groundwater stocks are being used has more than doubled between 1960 and 2000, increasing the amount lost from 126 to 283 cubic kilometers (30 to 68 cubic miles) of water per year. Because the total amount of groundwater in the world is unknown, it's hard to say how fast the global supply would vanish at this rate. But, if water was siphoned as rapidly from the Great Lakes, they would go bone-dry in around 80 years.

"The rate of depletion increased almost linearly from the 1960s to the early 1990s," says Bierkens, of Utrecht's Physical Geography Department. "But then you see a sharp increase which is related to the increase of upcoming economies and population numbers; mainly in India and China."

It is not just that there are more thirsty and hungry people catalyzing groundwater depletion, using the water for drinking water, irrigation and industry. It's also, says Bierkens, that as a population grows, "people start to live in locations where there is less precipitation. If you want to feed those people, you need to find water somewhere else."

In another study, Paolo D'Odorico of the University of Virginia in Charlottesville and his colleagues model a world which is increasingly dependent on a globalized water supply (D'Odorico *et al.,* 2010).

D'Odorico says that we are moving towards a system of trading what is called 'virtual water'. He is referring to a network where food is produced in a region that has water for irrigation, and then sold to feed inhabitants of other regions. The study by him and colleagues at the Politecnico di Torino, in Turin, Italy, finds that as we become ever more efficient at producing food in areas with a plentiful water supply and shipping to regions lacking sufficient water to feed a hungry population, we reduce our ability to cope with shocks to the network, like droughts or crop failure.

"The exchange of virtual water allows the system to sustain a larger population and to make an apparently more efficient use of the existing resources, with less water resources in water-rich regions remaining unutilized," the researchers report in their paper.

When taken together, Bierkens' and D'Odorico's works erect warning signs that we may be living on another kind of virtual water. "You're living on loaned money, in this case loaned water," says Bierkens. "It's a water debt you build up because these aquifers are not being recharged, but it allows you to raise your standard of living. I don't want to insult you, but it sounds a bit like how some people in the U.S. and Europe live when it comes to money."

Indeed, Bierkens' model shows the highest rates of depletion in some of the world's major agricultural centers, including California's central valley, northwest India, northeastern China, northeast Pakistan, and the Midwest United States. These are thirsty regions with high levels of production. But, above merely supplying nearby populations, they are all exporters of agricultural products.

According to the United States Department of Agriculture, the U.S. agriculture trade turned a net profit of nearly $27 billion in 2009. The European Union's commission on Agriculture and Rural Development says India had a surplus of $4 billion, mostly from exports of rice and soybeans. China, while remaining an overall importer of agricultural products, is still a major exporter of corn – corn which is predominantly grown in the slowly dehydrating northeast. And so, the regions currently using up their essentially non-renewable stores of groundwater the fastest are also helping to feed people in other parts of the world.

The end result is a burgeoning population whose existence depends on virtual water.

"If you let the population grow by extending the irrigated areas using groundwater that is not being recharged, then you will run into a wall at a certain point in time, and you will have hunger and social unrest to go with it," says Bierkens. "That is something that you can see coming for miles."

While such grim consequences of groundwater depletion would hit hardest locally, says D'Odorico, "if groundwater depletion affects one of the major producers of food in the global market, the impacts of that depletion would be felt worldwide."

Groundwater levels in Punjab, Rajasthan, Haryana and Delhi are falling dramatically- by one foot a year- a trend that could lead to "extensive socio-economic stresses" for the region's 114 million residents, says a scientific paper based on the U.S. National Aeronautics and Space Administration's satellite imagery (The Hindu, August 14, 2009)

A staggering 109 cubic km of groundwater has been lost in just six years (2002-08) - a figure twice the capacity of India's largest surface reservoir Upper Wainganga and "much more" than the government's estimation, says the paper published in the latest issue of international journal Nature.

The depletion is caused entirely by human activity such as irrigation, and not natural climatic variability, concludes the study co-authored by Matthew Rodell, a hydrologist with NASA. Groundwater is being pumped out faster than it is being replenished.

The finding is based on images from NASA's Gravity Recovery and Climate Experiment (GRACE), a pair of satellites that sense changes in Earth's gravity field and associated mass distribution, including water masses stored above or below the Earth's surface.

Between August 2002 and October 2008, the region lost 109 cubic km of groundwater, almost triple the capacity of the largest man-made reservoir in the U.S., Lake Mead. If measures are not taken to ensure sustainable groundwater use, consequences may include collapse of agricultural output and severe shortages of potable water, said Professor Rodell.

Depletion is likely to continue until effective measures are taken to curb groundwater demand which could propel severe shortages of potable water, reduced agricultural productivity, conflict and suffering, the research paper added. Rajasthan, Punjab, Haryana and Delhi are semi-arid or arid. The region has benefited from the Green Revolution "fuelled largely by increased production of groundwater for irrigation."

METHODOLOGY

The present study of the title "Groundwater

Depletion and Agriculture: A study in Villages of Haryana" have been carried out to give an insight into the impact of groundwater depletion on agriculture. It also explores the awareness and knowledge of the people regarding groundwater resources. Also, it studies the ways adopted by them to overcome this problem.

In order to facilitate the discussion of the various aspects in the systematic manner, the study has been divided in the following sections:

Locale of the study:

The present study was conducted in villages of 4 major towns Sohna, Pataudi, Firozpur Jhirka and Punhana of Gurgaon and Mewat districts of Haryana. Over the last few years, due to over extraction of groundwater, the groundwater resources are getting depleted in these areas because of which people are facing a lot of problems in their agriculture (Fig. 2 and 3).

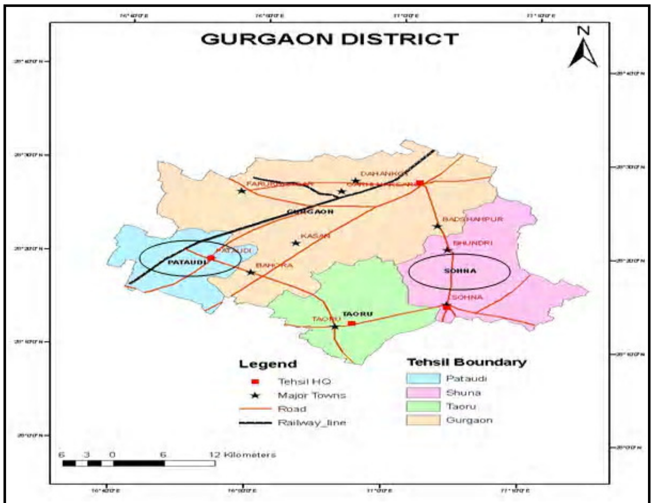


Fig. 2 : Gurgaon district

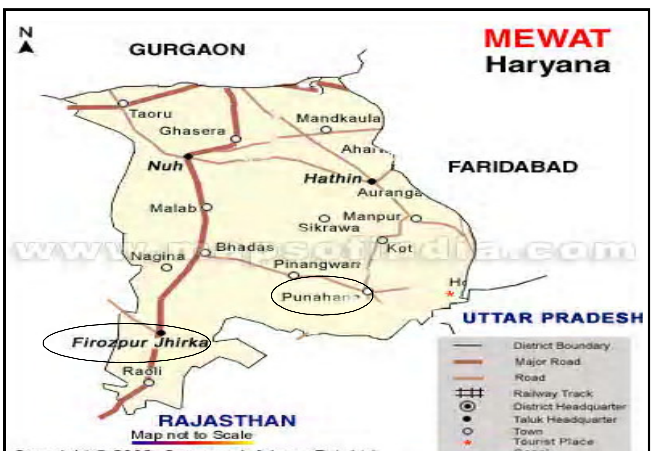


Fig. 3 : Mewat Haryana

The locales of these areas were selected because it was very convenient for the researcher to visit those areas, as travelling there is not a problem as they are well connected by roads.

Sample :

Sample Characteristics:

The sample selected were farmers living in villages of 4 towns (Sohna, Pataudi, Punhana and Firozpur Jhirka) of Gurgaon and Mewat Districts of Haryana who are facing problems due to depleted ground water resources.

As comparison needs to be done, the farmers who are living in that area for more than 10-15 years were selected.

Sample Size:

In order to make an in-depth study as well as to have a wider coverage of the concerned interest area, the sample size of 120 was chosen from villages of 4 major towns of the Gurgaon and Mewat District, Haryana.

The sample consisted of people whose main occupation is agriculture. These people mainly constitute the farmers. They were chosen mainly to know the problems arising due to groundwater depletion and how much they are aware regarding groundwater resources.

Sample Selection :

Various districts of Haryana were identified and 2 districts were selected randomly to conduct the study. Then villages of two major towns of each district were selected. From each town the sample size of 30 was selected which made the total sample size of 120. The purpose behind data collection was explained to them and they were assured of the pursuit to be purely an academic exercise maintaining confidentiality of any information received from them.

Sampling Technique:

Purposive random sampling was used for the study. We have taken randomly those persons who are farmers by occupation and living in that area for more than 10 years.

Study Technique:

Tools for Data Collection:

For the purpose of data collection Questionnairescum-interview schedule were used.

The questionnaire provides with information on the effects of depletion of groundwater resources on agriculture, their awareness about the depletion of groundwater resources and the ways they are adopting to overcome this problem.

The questionnaire was divided into four sections: the first section consisted of questions regarding their profile. This included some basic questions regarding their gender, marital status and educational qualification. Second section consisted of the questions about their knowledge about depletion of groundwater resources. Third section consisted of the questions of effects of depletion of groundwater resources on agriculture. Lastly, the fourth section consisted of the questions about the ways adopted by them to solve the problem of depleted groundwater resources.

Data Collection:

The researcher collected the data through the questionnaire- cum- interview techniques. The interview schedule was designed in such way that those who preferred to fill it up themselves had the option to do so.

FIELD STUDY

As stated early, the study sample consisted of a total number of 120 respondents, from four towns named as Sohna, Pataudi, Punhana and Firozpur Jhirka of Gurgaon and Mewat district of Haryana.

Field study shows that most of the respondents (39.17%) have 1-10 acres of land. There are very less farmers who have more than 30 or 40 acres of land. 25.83% farmers have 11-20 acres of land. Due to decrease in agricultural activities, people are selling their land to others and are working as paid workers.

People have knowledge about groundwater resources as they are getting water from these resources for their agriculture. But they do not have any scientific knowledge regarding these groundwater resources and their responses were from real life experience only. They are using groundwater for irrigation in their fields as they are not getting enough surface water and also no other means of water is available to them.

Most of them are using groundwater for domestic purposes also like for drinking, taking bath, washing clothes etc. There is shortage of municipal water in these areas and this is the main cause of using groundwater. Some said that groundwater level has gone so down that the groundwater which they are getting is pure (because of various layers of earth, water is getting filtered) and therefore, they are using it for drinking purpose also. They said "panijitnijyadagehrai se nikalajatahaiutna hi jyadasafhotahai." The respondents are also using it for their animals.

In spite of the fact that they all are engaged in agriculture and facing water problems, respondents said that they don't know anything about depletion of groundwater resources. They have knowledge about the sources from which they are getting water and the problems faced due to scarcity of water, but they are still unaware of water depletion problem.

They believe that less/no rainfall is the main reason for groundwater depletion. They replied that in the absence of rain, the earth is getting dry and there is lack of groundwater.

Some of the old respondents replied that the rainwater which falls on the surface of the earth is evaporating and hence, not going into ground. Thus, this rainwater is getting wasted. Also, most of the rainwater is going into "nallahs" and cannot be used.

The respondents says that rainwater can become a major source of water but in the absence of rainwater harvesting systems and their lack of knowledge regarding this, they cannot make full use of the rainwater.

The field data reveals that more than half of the respondents do not have the knowledge about artificial recharge of ground water resources. When respondents were asked about artificial recharge of ground water resources, they replied that they are not aware of these kinds of techniques/methods. Moreover, they say that they are not given any information/training about groundwater and related issues earlier.

Due to depleting groundwater levels, farmers are facing lots of problems in their agriculture. They are not getting sufficient groundwater and hence, their crops are getting damaged, they are changing their cropping pattern and some are shifting towards other occupations. They need to invest more on groundwater resources to get them, which is a very big problem for them because they do not have that much money to spend. This section indicates the actual problems faced by them because of groundwater depletion.

When respondents were asked about the groundwater resources from which they are getting water, majority of them said that they are using submersible bores for pumping groundwater. They said that the level of groundwater has gone down so much that it is very difficult to pump groundwater from hand pumps and this is the main reason for using these submersible bores because it is very easy to pump water from these.

The submersible pump can boost the water pressure well above atmospheric and thereby push the water to the surface despite the great height and weight of the water column. Multiple stage submersible pumps are arranged in series so that the discharge from the first stage becomes the intake for the next stage with each successive stage adding its pressure to the previous one. Surface suction pumps are really only practical for water that's a few feet below the surface; after that, deep pressure pumps are a much better idea. The respondents say that they are using tube wells also for pumping groundwater and some are also using boring to extract groundwater. Very few respondents are using hand pumps. The reason for using hand pumps in some areas is the average groundwater level.

Apart from all these, they are not using any other means for getting groundwater.

Results showed that majority of the respondents dig the ground on monthly basis to get water. Due to poor supply of municipality water, they use groundwater in their almost each and every activity and hence, they need to dig the ground very frequently.

The data reveals that due to over- pumping of groundwater, the groundwater is getting depleted and people need to dig the ground deeper. The respondents say that now they are digging 101-150 feet below the ground to get the water but earlier it used to be only 1-50 feet. They said, at that time more groundwater was available and we did not have to dig the ground more deep.

35% respondents replied that at present they are digging 151-200 feet and 10.83% respondents said that they are digging above 250 feet which is very difficult and requires lot of energy, time and money to put into it. Some respondents also said that earlier they were digging around 51-100 feet to get groundwater but it was not as difficult as now. Some respondents told us that it goes down by 10 feet in a year which is a very big number.

All the respondents said that we dig deep at a time but insert the pipe down according to our requirement level. And as the groundwater level goes down, we push the pipe deeper and deeper. We do this, so as to avoid digging ground again and again, as it require a lot of man power and money.

The field data revealed that most of the respondents (94.17%) were growing wheat, 80% of the respondents were growing onion and peas. Apart from this, they were growing other crops also which include cucumber, wheat, chilies, Ladies finger and many more.

Their trend of growing crops clearly indicates that they are growing those crops which require less or medium water. Data revealed that there are various problems which they are facing due to depleted groundwater resources. 90% of the respondents replied that they are not getting sufficient water for their crops and hence, they are getting damaged.

Some respondents also said that due to lack of water they are not able to produce sufficient amount of crops. They say that now agricultural production is decreasing.

The data also revealed that more than half of the respondents are paying between Rs. 5,00- 1,500 for manures/fertilizers. Earlier also they were paying almost the same amount. So, there is no such big difference in the prices of manures/fertilizers

Earlier more than half of the respondents were spending around Rs. 20,000 for extracting groundwater (which includes the cost of motors, pipes, labour and other equipment). But now they are paying more for getting groundwater for their fields.

All the respondents say that they are using water only as much as required so that they do not have to pump more groundwater and hence, avoiding the depletion of groundwater resources. From them, many people also say that they use water conservation techniques like rain water harvesting. They replied that they do not have any technical knowledge so are just saving the rain water in their tanks.

All the respondents say that they are not recycling water as they are not aware of those techniques and are not performing any other activities to save groundwater. Some people also said that before monsoon, they make canals in their field and at the monsoon time, rainwater collects in it and goes directly into the fields.

Summary and Conclusion:

Ground water is an essential and vital component of our life support system. The ground water resources are being utilized for drinking, irrigation and industrial purposes. However, due to rapid growth of population, urbanization, industrialization and agriculture activities, ground water resources are under stress. There is growing concern on the deterioration of ground water quality due to anthropogenic activities. When water tables decline continuously, sustainability of irrigation practice is in doubt. Such is the case with large tracts of agricultural land in north-west India. Way out of the problem is in restriction of irrigation water requirement to annual availability of water resources whether from surface water supplies or rainfall over cropped area or seepage from canals. Steps involved in budgeting water are diversification of some area from high to low water demanding crops, correcting the growing period, improving irrigation efficiency through discouraging luxurious use of water, fine-tuning irrigation, watersupply according to soil properties and minimizing transmission and delivery losses. More importantly is the message and continuous reiteration of the fact that ground water is depleting and that it is high time that we need to conserve and save water for future generation. The Government should come out with legal framework to conserve the ground water to ensure that the ground water is consciously trickled down for future generation or else it is not far that parts of State like the one under study becomes Cape Town.

Policy Recommendations:

Due to development in Haryana, people are pumping more and more groundwater which is depleting the level of groundwater in that area. If this situation will remain same, then in next few years, there would be no groundwater at all. It can lead to various worst conditions like drought. So, it needs to be prevented as soon as possible. There are many ways by which we can conserve and recycle the groundwater:

- Use surface water and ground water wisely.
- Enhance public awareness and knowledge of groundwater
- Encourage artificial recharge of groundwater.
- Make full use of rain water.
- Reuse and recycle water.
- Take appropriate measure to avoid pollution
- Make your children aware about judicious use of water.

The following recommendations are suggested to improve this condition:

1) Recommendations regarding Data Management
- Strengthen appropriate organizations and frameworks for monitoring the quantity and quality of groundwater on a regular basis.
- Prepare database to compile, store and retrieve vital data on groundwater properties and variables necessary to detect significant changes in groundwater level.

2) Recommendations regarding Investigation/ Implementation
- Perform detailed and precise studies using modern tools to generate relevant and accurate data, which shall ultimately result in a more accurate assessment of groundwater resources.
- Encourage and implement artificial recharge, conservation, water-saving irrigation, conjunctive use of surface water and groundwater, fresh and brackish water treatment and reuse of wastewater, and land use planning and land zoning as per the availability of water and taking appropriate measures to avoid pollution.

3) Recommendations regarding Awareness generation
- Enhance public awareness and knowledge of groundwater.
- Enhance capacity building of groundwater centers/institutes and create work environments for better communication, co-ordination, and collaboration among water managers, planners, decision-makers, scientists, water users, etc.
- Develop a state of knowledge and capability that will enable the countries to design future water resource management plans by themselves addressing economic efficiency, gender equity, social justice and environmental awareness in order to facilitate achievement of the water management objectives through broad public participation.

4) Recommendations regarding Policies
- Establish legal and regulatory framework regarding development and use of groundwater.
- Revise policies on subsidized power in the agricultural sector. Suitable cost and charging systems of electricity is to be decided to ensure recovery of operation and management and capital cost and avoid misuse/overuse of power.
- Encourage and involve community organizations to prescribe irrigation charges and to become

responsible for collection and imposition of penalties for nonpayment.

– In the case of industrial effluent disposal, follow the principle of "polluter pays".

REFERENCES

Bhatnagar, S. (2007). Agricultural Law (1st ed.). Delhi: Mittal. Retrieved from http://books.google.co.in/books?id=CCRMUHXJjXYC&printsec=frontcover&dq=agricultural+laws&hl=en&ei=KaeiTevXDZDKrAf S8tX7Ag &sa=X &oi=book_result&ct=result&resnum=4&ved=0CEMQ 6AEwAw#v=onepage&q=agricultural%20laws &f=false

Brouwer, C., Hoevenaars, J. P. M., Hatcho, N. and Heibloem, M. (1992). Scheme Irrigation Water Needs and Supply. ILRI, Wageningen, The Netherlands. Retrieved from http://www.fao.org/docrep/u5835e/u5835e00.htm#Contents

Central Ground Water Board. (2006). Dynamic ground water resources of India (as on March 2004), New Delhi. Retrieved from http://www.scribd.com/doc/17375055/Groundwater-India.

Chatterjee, R. and Jha, B. M. (2006). Methods for estimation of replenishable ground water resources adopted in India. In Paper presented at the International Conference on Ground Water for Sustainable Development. New Delhi. Retreived from http://www.scribd.com/doc/17375055/Groundwater-India

Chauhan, D. R. *et al.* (2007). Comprehensive District Agriculture Plan (C-Dap) for Rashtriya Krishi Vikas Yojana of XIth Five Year Plan, District Mewat, Haryana.

Chopra, R. and Bishawanath, G. (2000). 'Sustainable Development Framework for India: The Case of Water Resources (Mimeo)', Institute of Economic Growth, Delhi.

Clothier, B. (2008). Wise use of water and nutrients in agriculture. *SciTopics*. Retrieved April 7, 2011, from http://www.scitopics.com/Wise_use_of_water_and_nutrients_in_agriculture.html

CPCB (2007). Status of groundwater quality in India- part 1. New Delhi: MoEF. Retrieved Feb 2007, from http://www.cpcb.nic.in/upload/NewItems/NewItem_47_foreword.pdf

Cross, K. and Bergkamp, G. (2007). Groundwater and Ecosystem Services: towards their sustainable use. International Symposium on Groundwater Sustainability. Retrieved from http://aguas.igme.es/igme/isgwas/Ponencias%20ISGWAS/13-Bergkamp.pdf

Das, S. (2006). Groundwater overexploitation and importance of water management in India– Vision 2025. In Tenth IGC Foundation Lecture. The Indian Geological Congress, Roorkee.

D'Odorico, P., Laio, F. and Ridolfi, L. (2010). Does globalization of water reduce societal resilience to drought? *Geophysical Research Letters,* **37**: 10.1029/2010GL043167

Dragoi, J. I. and Popa, R. (2007). Vulnerability assessment of a shallow acquifer situated in Danube's Plain (Oltenia-region, Romania) using different overlay and index methods. In A. J. Witkowsi, A. Kowalczyk, and J. Vrba (Eds.). Groundwater vulnerability assessment and mapping (pp. 73-86).

Gandhi, B. V. J. and Kumar, A. (2009). 'Glimpses of a Forgotten Land: Socioeconomic Distribution of Mewat District', *Research Bulletin no 2*, IRRAD Publications.

Gandhi, B. V. J., Sharma, L. and Maheshwari, P. (2009). 'Escaping Poverty in Rural Mewat – Case Studies from an Integrated Approach', *Research Bulletin no 1*. IRRAD Publications.

Gleick, P. H. (1996). Water resources. In S. H. Schneider (Ed.). Encyclopedia of Climate and Weather. Oxford University Press, New York, vol. **2**, pp.817-823

Groundwater (2008). Safe Drinking Water Foundation, Canada. Retreived from http://www.safewater.org/PDFS/resourcesknowthefacts/Groundwater.pdf

Ground Water Estimation Committee, Ground Water Estimation Methodology–1997, Ministry of Water Resources, Govt of India, 1997.

Gupta, S. (2007). Groundwater Information Booklet, Mewat District, Haryana. CGWB, MoWR, Govt. of India. Retrieved from http://cgwb.gov.in/District_Profile/Haryana/Mewat.pdf

Kalf, F. R. P. and Woolley, D. R. (2005). Applicability and methodology of determining sustainable yield in groundwater systems. *Hydrogeol. J.,* **13** : 295–312.

Kamal, S. (2009). Use of water for agriculture in Pakistan: experiences and challenges. University of Nebraska, Lincoln.

Krishna, M. (2009). Long Term Consequences of Groundwater Pumping in Australia: A Review of ImpactS Around The Globe. *J. Applied Sciences Environmental Sanitation*. **4** (2) Retrieved Aug. 31, 2009, from http://www.trisanita.org/asespaper2009/ases18v4n2y2009.pdf

Liswaniso, P. (2007). Role of Water in the Socio-Economic Development, its Importance and Links. Retrieved July 15, 2007 from http://aydpels.blogspot.com/2007/07/role-of-water-in-socio-economic.html

Liu, J., Fu, J., Lei, X., Liu, H., Macer, D., Qiao, Q., Sun, A., Tachiyama, K. and Zheng, Y. (2009). Water Ethics and Resource Management. UNESCC. Retrieved Apr. 23, 2009, from http://www.docstoc.com/docs/68288971/Water-Ethics-and-Water-Resource-Management

Molden, D. (2007). Water for food, Water for life: A Comprehensive Assessment of Water Management in Agriculture. London: Earthscan, and Colombo: International water management institute.

MOWR (2002). National Water Policy, Ministry of Water Resources, Government of India.

MS Nucleus (2001). Water: Teacher Guide. Retrieved from http://www.msnucleus.org/membership/html/jh/earth/water/jhwater.pdf

Mutiso, G. and Thomas, D. (2000). Where there is no water. SASOL, Kenya. Retrieved from http://www.infonet-biovision.org/default/ct/282/soilConservation

National Bank for Agriculture and Rural Development. (2006). Review of methodologies for estimation of ground water resources of India. Technical Services Department, NABARD, Mumbai, 2006.

Pandey, S. (2007). Groundwater Information Booklet, Gurgaon District, Haryana. Central Groundwater Board, MoWR, Govt. of India.

PDEP. (2006). Managing your On- lot Drinking- Water (OLDS) System for Homeowners. Retrieved from http://www.yorkccd.org/wordpress/wp-content/uploads/2009/08/051101-This-OLDS-House-Wells-FINAL.pdf

Purohit, R.R. and Chatterjee, R. (2009). Estimation of Replenishable Groundwater Resources of India and their Status of Utilization. Vol. **96**, No. 12. Retreived June 25, 2009, from http://www.docstoc.com/docs/53945750/Estimation-of-replenishable-groundwater-resources-of-India-and

Rajagopalan, S. P., Sharma, S. K. and Tankhiwale, N. R. (1998). Detailed guidelines for implementing the ground water estimation methodology – 1997. Central Ground Water Board, Ministry of Water Resources, Govt. of India.

SANDRP. (2004). 'Dams Rivers and People '*SANDRP*, Vol. **2**, Issues 7-8.

Scanlon, B. R., Healy, R.W. and Cook, P.G. (2002). Choosing appropriate techniques for quantifying groundwater recharge. *Hydrogeol. J.*, **10** : 18–39.

Sharma, D. (2010). Critical issues on groundwater in India. New Delhi: Teri Publications. Retrieved July 13, 2010, from http://www.iges.or.jp/jp/news/event/isap2010/pdf/day2/Sharma.pdf

Sharma, L. (2008). 'Saline Ground Water Pockets in Mewat: Prevalence, Challenges and Solutions' in *the Reader on water and Health* (forthcoming). New Delhi: Sage publications.

Sharma, L.M. (2008). 'Containing Contamination through Integrated Water Management: Experiences from Ghagas', Institute of Rural Research and Development, p.15

Sharma, L., Satyawada, A. and Chowdhury, A. (2008). 'Saline Ground Water Pockets in Mewat: Prevalence, Challenges and Solutions, *Working Paper no 2*. Rural Research Center Publications: Institute of Rural Research and Development. P.35

Singh, K. (2010). Groundwater development and management in India: Critical Issues. Retrieved Sept 7, 2010 from http://www.worldwaterweek.org/documents/WWW_PDF/2010/tuesday/K16-17/GWD_india_singh.pdf

Stapleton, C. K. (1983). "Tubewells and their Construction" . Waterlines Vol. **2** No. 1. IT Publications. Retrieved July 1983, from http://www.wateraid.org/uk/what_we_do/sustainable_technologies/technology_notes/243.asp

Struckmeier, W., Rubin, Y. and Jones, A. A. J. (2005). Groundwater- reservoir for a thirsty planet. Retrieved Dec. 2005, from http://www.yearofplanetearth.org/content/downloads/Groundwater.pdf

Tanwar, B.S. and Kruseman, G. P. (1985). 'Saline Ground Water Management in Haryana State, India,' *Hydrogeology in the Service of Man, Memoirs of the 18th Congress of theInternational Association of Hydrogeologists*, Cambridge, 24-30.

TERI (2007). Groundwater. Retrieved http://edugreen.teri.res.in/explore/water/ground.htm

Van der Velde, M., Green, S.R., Vanclooster, M. and Clothier, B.E. (2007). Sustainable development in small island developing states: agricultural intensification, economic development and freshwater resources management on the coral atoll of Tongatapu. *Ecological Economics,* **61** : 456-468

Water Aid, India (2010). Hand pumps. Retrieved Nov. 1, 2010, from http://www.wateraid.org/international/what_we_do/sustainable_technologies/technology_notes/2061.asp

Water policy briefing, IWMI (2000). The socio-ecology of groundwater in India. Vol-4. Retrieved from http://www.iwmi.cgiar.org/publications/Water_Policy_Briefs/PDF/wpb04.pdf

WBCSD (2009). Water Facts and Trends. Retrieved March 12, 2009, from http://www.wbcsd.org/DocRoot/lD1tMGiLZ7NL9mBOL2aQ/WaterFactsAndTrends-Update.pdf

W.G.O (2006). Groundwater for life and livelihoods- the framework for sustainable use. Theme II- Session FT 2.26 Retrieved March 18, 2006, from http://www.iah.org/downloads/occpub/IAH_WWF_briefing.pdf

WHO (2009). Fact Sheet on Environmental Sanitation. Water Sanitation and Health. Retrieved from http://www.who.int/water_sanitation_health/emergencies/envsanfactsheets/en/index1.html

Wolff, A. (2007). Water: A Drash for Sukkos. Retrieved from http://www.canfeinesharim.org/uploads/12437Water Drash.pdf

Yoshihide Wada, Ludovicus P. H. van Beek, Cheryl M. van Kempen, Josef W. T. M. Reckman, Slavek Vasak and Marc F. P. Bierkens (2010). A worldwide view of groundwater depletion *Geophysical Research Letters* : 10.1029/2010GL044571

Zhu, T., Ringler, C. and Cai, X. (2008). Energy Price and Groundwater Extraction for Agriculture: Exploring the EnergyWaterFood Nexus at the Global and Basin Levels. Retrieved from http://www.infoandina.org/system/files/recursos/Energyprice_GW.pdf

****