



**Water Security in
Peri-Urban South Asia**

Adapting to Climate Change & Urbanization

**WATER SECURITY IN PERI-URBAN SOUTH ASIA
ADAPTING TO CLIMATE CHANGE AND URBANIZATION**

Scoping Study Report: Gurgaon

Dr. Vishal Narain

Working primarily on water security issues in Peri-Urban South Asia, across India, Bangladesh and Nepal, the project's main concerns are the rapidly changing peri-urban landscapes due to urbanisation and implications for water security in specific locations in the larger context of climate change. As an action research project, working across four locations in South Asia, it will serve as a basis for capacity-building at the grass roots level to address concerns of the poor, marginalised and other vulnerable communities to water security and seek to understand the dynamics of adaptation in the specific locations, for action and policy agenda at the regional level. It will build their capacities to cope with climate change induced water in-security.

The project is being coordinated by SaciWATERS, Hyderabad, India and executed in association with Bangladesh University of Engineering and Technology (BUET), Dhaka in Bangladesh and Nepal Engineering College (nec), Kathmandu in Nepal. This project is supported by Canada's International Development Research Centre (IDRC).

A scoping study was carried out for a period of six months from August 2010 – January 2011. It was an exploratory phase that investigated the key peri-urban and climate-change related issues in the research sites. The process of changing peri-urban landscape and its impact on water security and vulnerability was probed by literature review, field visits, discussions with various stakeholders, and use of other qualitative techniques. Specific sites were identified in Kathmandu (Nepal), Gurgaon, Hyderabad (India), and Khulna (Bangladesh) where the research would be carried out.

Four scoping study reports consolidate the outcome of this study. This is the Gurgaon Scoping Study Report.

Gurgaon Project

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1. Introduction

This is the report of the scoping study carried out for Gurgaon - one of the four study locations - under the IDRC funded project Water security in peri-urban South Asia: adapting to climate change and urbanization. This study was designed as an exploratory study in order to understand peri-urban water security in a context of climate change. It seeks to provide an understanding of the basic drivers of urbanization in Gurgaon, a synthesis of the current understanding of the implications of climate change/ variability for the district and present preliminary insights from exploratory field visits in terms of the implications of urbanization for water security of peri-urban residents.

The organization of this report is thus: section 2 provides a brief understanding of the problem statement; section 3 outlines the methodology chosen for the study. This is followed by the presentation of a literature review in section 4, looking at some recent peri-urban studies around Gurgaon and the NCR (National Capital region)¹ and description of the factors that have led to its growth. It also presents a brief summary of the current understanding of climate variability for the study region, based on the existing literature. Section 5 presents insights from field work. An effort is made to understand how urbanization processes shape the water security of peri-urban residents, as well as to identify some of the factors that shape the vulnerability of peri-urban residents to the impacts of an uncertain water supply. Section 6 presents a summary and conclusion, with some directions for the main research phase - into which this study is meant to be an input.

2. Description of research problem

Urbanization has been a defining characteristic of South Asia, and Gurgaon has been projected as one of the millennium cities typically produced by this process (Narain 2009a, b). Gurgaon has emerged as a major outsourcing hub of Northwest India and has seen a process of urban expansion sustained by a real estate boom. High rise residential buildings, glitzy malls and recreation centers are the visual landmark of the city.

However, this process has been sustained chiefly by acquiring the land and water resources of the peripheral villages. This poses important questions from a perspective of equity as well as ethics. How do these processes shape the water security of peri-urban residents? How are these effects further aggravated by the impacts of climate change and variability? Which groups are most vulnerable, and why? How do water users adapt to these changes? What can be the potential ways of intervening in order to address these challenges?

This project seeks to find answers to these questions, and the current scoping study seeks to set the stage for the main study by providing preliminary insights into the implications of urbanization and climate variability for peri-urban residents, the factors that shape their vulnerability to the impacts of these changes as well as assess their adaptation strategies. An attempt is made to understand the various forms in which peri-urban water issues manifest themselves and identify potential areas for intervention.

3. Methodology

The following activities were carried out as part of the scoping study:

- 1) A literature review to identify current strands of peri-urban research, especially as they relate to the NCR²
- 2) Collection of secondary sources of data to trace the growth of Gurgaon, the drivers of urbanization and their implications for water resources of the city, drawing on government sources, media reports and published articles in books and journals
- 3) Exploratory field visits to identify potential sites for research and the key issues for in-depth investigation and research in the main study
- 4) Interaction with different stakeholders to understand various perspectives around the issues
- 5) A stakeholders' meeting in village Sultanpur wherein the village sarpanch (headman), BDO (Block Development Officer) and village residents interacted on water

¹National Capital Territory of Delhi (NCT) or National Capital Region is the largest metropolis by area and the second-largest metropolis by population in India. It is the eighth largest metropolis in the world by population with more than 12.25 million inhabitants in the territory and with nearly 22.2 million residents in the National Capital Region urban area (which also includes NOIDA, Gurgaon, Greater NOIDA, Faridabad and Ghaziabad). The name Delhi is often also used to include some urban areas near the NCT, as well as to refer to New Delhi, the capital of India, which lies within the metropolis. The NCT is a federally administered union territory.

²This does not include however the conceptual literature on peri-urban issues, that has been covered earlier in a concept background paper prepared for the project and discussed at the inception meeting.

management issues in a wider context of development challenges

6) As a preliminary intervention, a visit of 24 mid-career civil servants to Sultanpur to sensitize them to peri-urban issues and providing peri-urban residents a forum to express their views (and frustrations!)

7) A preliminary presentation of the key findings and emerging issues at the regional office of the IDRC in New Delhi to share progress and elicit feedback³

Exploratory field visits were made to many villages in Gurgaon. The criteria for selecting these villages were various levels of their being peri-urban in terms of the extent of land use change - with consequent implications for occupational diversification, the varying distance from the city, the period since when land use change had occurred and the nature of governance structure (Panchayat vs. Gurgaon Municipal Corporation). A *snowball sampling*⁴ technique was used, wherein an understanding of issues in one village led to identification of other villages where similar or contrasting kinds of issues could be noticed.

Ghata and Wazirabad villages, for instance, have lost almost all of their agricultural lands to the modern residential areas of Gurgaon city; in fact, the settlement areas of these villages lie just across the road from some of Gurgaon's new residential areas. The land acquisition process in these villages has been on since the 1980s. On the other hand in such villages like Kheda Jhunjraula, Iqbalpur and Kaliawas, land acquisition is a relatively recent process. Lands have only recently been fenced for alternative land uses; changing land use is a new and emerging phenomenon, but one that needs to be closely watched and observed. Sultanpur, Sadhraana and Budheda are somewhere in between these two extremes with lands being sold off voluntarily or acquired for 'public purpose' at varying paces over the last three decades.

Wazirabad and Ghata are now under the jurisdiction of the Gurgaon Municipal Corporation and represent a category of villages that can be called 'rural enclaves' within the modern city, rather than 'peri-urban' - in a sense of the co-existence of urban and rural land uses,

institutions and activities as discussed and agreed in the conceptual discussions around the project.⁵ All other villages have functional Panchayats, and a wider co-existence of rural and urban activities, processes and institutions can be seen in them.

In each of these villages, semi-structured interviews were held to explore the major issues as related to changing water use and access, specifically in terms of the implications of the urbanization process for the same. Household as well as group interviews were held with small groups of people chosen at random. The objective was to assess the richness and potential relevance of research sites with a view to a better understanding of water security issues in a peri-urban context.

Key informant interviews were held with critical people such as village headmen, property dealers, real estate agents, youth leaders and women representatives. Meetings were held separately with groups of youth and women to assess their perspectives.

In the scoping study itself, some start has been made in terms of interventions. A visit was organized of 24 mid-career civil servants at MDI's School of Public Policy and Governance to Sultanpur village.

The objective of this meeting was two-fold; on the one hand, to sensitize mid-career civil servants to peri-urban



Fig.1 Village pradhan in Sultanpur talking to mid-career civil servants

³In addition, the project leader of the project participated in three workshops and conferences where peri-urban issues were discussed with a wide range of stakeholders. Details can be found on the project blog <http://peri-urbansouthasia.blogspot.com/>.

⁴A snowball sampling technique is one in which interviews with one person give leads to interviews with another.

⁵To an extent, these could be considered as representative of other villages as well in the city, such as Kanhai, Chakarapur and Sikanderpur, with almost all their agricultural land gone. The visual feel of these villages is still that of a 'village', but with no or little agricultural land - that is the basic characteristic of an agrarian society.

issues and second, to give peri-urban residents some voice and an opportunity to share their points of view with policy-makers. Some effort has also been made to catalyse the village Panchayat into action.⁶

An essential ingredient of the methodology was direct observation of activities. Much time was spent walking along the Gurgaon Water Supply Channel that brings water to the city of Gurgaon and cuts through three of the villages visited under the exploratory phase (Budheda, Kaliawas and Iqbalpur). This gave an opportunity to observe and explore first hand such issues as flooding of the adjoining fields after the rains and irrigation practices during the current (kharif) season. Observation of water collection activity helped identify other issues as the collection of water by men on their motor-cycles and scooters (noted particularly in Budheda) as well as the inconvenience caused in water collection on account of longer routes for water collection when lands were acquired for building a highway (as seen in Sultanpur).

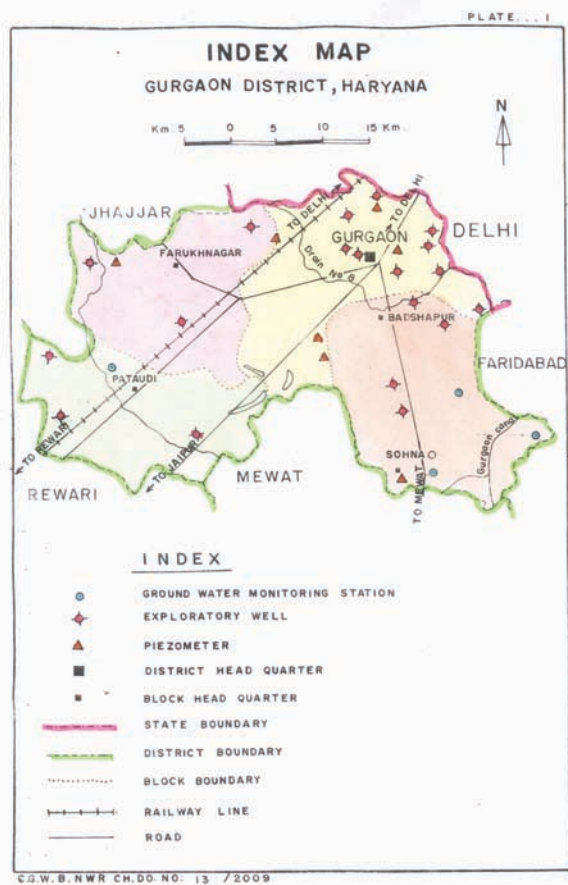


Fig.2 Map showing location of Gurgaon district

4. Literature review⁷

The Gurgaon district is situated in the south eastern part of the state of Haryana - one of India's major food baskets - occupying an area of 3852 sq.km. Towards the north, it is bordered by Delhi, in the east by the state of Uttar Pradesh, in the west by the Alwar district of the state of Rajasthan and in the south by the Mewat district of Haryana.

The drivers of growth in Gurgaon

The present city of Gurgaon can be considered to be the metropolitan area encompassing settlements around the original city, and expanding even further with the establishment of new neighborhoods and districts. A favorable tax policy by the Haryana government, improvement in city's infrastructure by Haryana Urban Development Authority and the need of a business center close to Indira Gandhi International Airport saw the emergence of Gurgaon as one of the most prominent outsourcing and off-shoring hubs in South Asia.

With the initiation of economic reforms in 1991, Gurgaon saw a massive expansion in its population and economy after the real estate major, DLF Group, started buying farmlands owned by the local people to start developing housing societies for the upper-middle class residents of Delhi. Further to this, the government removed bottlenecks to obtain permits and provided special incentives to Information Technology/IT Enabled Services⁸ (IT/ITES) and Business Process Outsourcing (BPO) sectors which attracted foreign investment. They were to receive preferential allotment of such resources and facilities like land and electricity. This made Gurgaon India's outsourcing hub in 1997 when GE Capital International Services (GECIS) was set up as the India-based business process services operations of GE Capital. Very soon, a plethora of BPO and Knowledge Process Outsourcing (KPO) firms such as Genpact, Evalueserve, Dell, Accenture, Hewitt Associates, Copal Partners and Convergys expanded their operations into the city. Apart from the above, a few IT and pharmaceutical firms set up base as well, though their distribution has tended to be

⁶ The village has a newly elected Sarpanch who is making some efforts to improve the village's access to water supply, but seemed somewhat unaware of his rights and obligations.

⁷ This section draws upon contributions by Sreoshi Singh and Pranay Ranjan.

⁸ The Information Technology-Enabled Services (ITES) industry provides services that are delivered over telecom or data network to a range of external business areas. Examples of such business process outsourcing (BPO) include customer service, web-content development, back office management and network consultancy etc.

skewed. At present, Gurgaon is the regional head-office of Alcatel-Lucent, Niksun, IBM, Opera Solutions and Bain & Company. Gurgaon is also the headquarters of two biggest automobile manufacturers in India -Hero Honda and Maruti Udyog.

In 2005, the Government of Haryana introduced the new industrial policy which gave further boost for increased and rapid urbanization; the key understanding and motive was to promote industrial growth, create wealth for the citizens and improve the quality of life. The professed goals of this policy were to generate employment and entrepreneurial opportunities across all sectors and facilitate dispersal of economic activities in the backward socio-economic regions of the state and ensure sustainable development through investment in key sectors.

Since the expansion of BPO/IT/ITES in Gurgaon, there has been a large influx of population largely from Delhi and surrounding states of Uttar Pradesh, Punjab and Rajasthan. The migration to Gurgaon city has led to rapid urbanisation and further growth of urban outgrowths in continuation of the municipal boundaries of the city, better known by the Census of India as the Gurgaon Urban Agglomeration (UA).

The total population of Gurgaon UA was 228820 in 2001, which was 62% of the total urban population of the district. A calculation of population growth reveals that from 1971 to 2001, growth has declined but a projected figure from 2001-2011 till 2021 shows that the growth rate is above 300% as shown in the table below followed by a graph representing the same.

The maximum increase of population has occurred in central Gurgaon town, which forms the industrial region,

contiguous to Delhi and therefore is the hub of the multinational corporations' expansion (Director of Census Operations 2004:36, 40, 51 cited in Singh, 2004). The NCR Planning Board as well as the Master Plans for urban areas and census for rural areas have projected the population of Gurgaon city till 2021 and found it to be above 3 million. Based on these figures, the growth rate of urban population from 1971-2021 has been shown in the figure below, pointing to massive increase in urban population from 2001 to 2010.

Likewise the level of urbanisation has increased from 3.35 percent in 1971 to 13.80 percent in 2001. A projected value shows that in 2011, the level of urbanization is

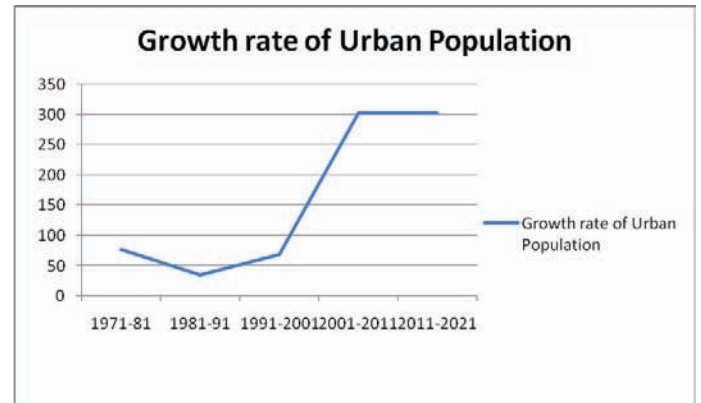


Fig.3 Graph showing growth rate of urban population
Source: Prepared from table-1

expected to be 52.53% which is likely to go upto 155 % approximately by 2021 indicating a very steep rise as shown in the graph below.

The migration data of Census 2001 indicates interstate migration as dominant nature of migration over the last 4-5 years, ie. 1995 onwards and the reason in most of the cases was for employment.

Year	1971-81	1981-91	1991-2001	2001-'11	2011-'21
Growth rate of urban population	76.51	34.70	68.39	302.12	302.12

Table-1 Growth rate of urban population
Source: Calculated and compiled from data by Department of Town and Country Planning, Haryana

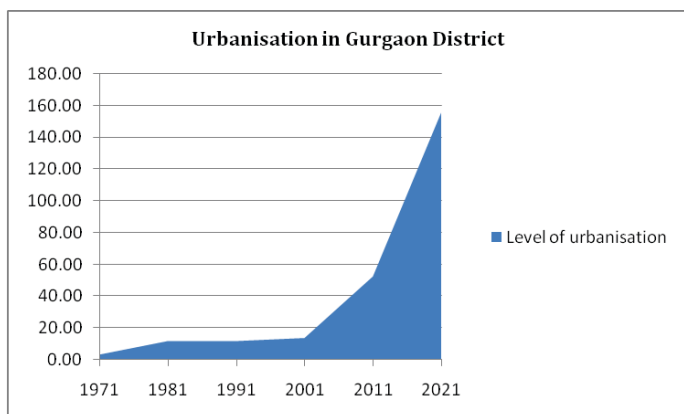


Fig.4 Graph showing level of urbanisation in Gurgaon
Source: Prepared from data by Department of Town and Country Planning, Haryana

A major impetus to the growth of Gurgaon has come from Real Estate that has emerged as an important industry in Gurgaon and construction of office complexes and malls has led to an influx of labor from poor and underdeveloped states like Bihar, Bengal and Orissa and across the border from Bangladesh. Real estate remains the third largest employer in the city after IT Services and the retail sector. There has been a substantial shift from the traditional means of livelihood like agriculture in terms of the occupational structure (Census of India, 2001).

Another major driver of land use change has been the initiative to set up SEZs (Special Economic Zones). In 2005, the Haryana Government decided to set up an SEZ through public-private partnership.⁹ In the official Masterplan 2021, a total of 4,570 hectares is allocated to Special Economic Zones.

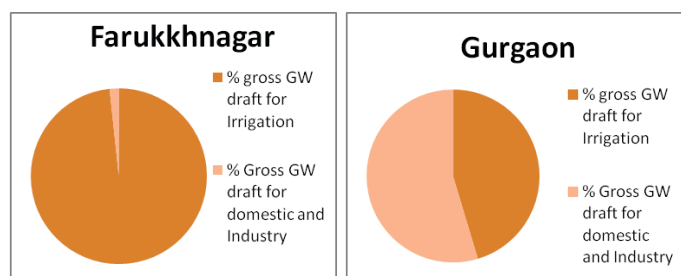
Though land acquisition has been a major driver of change in Gurgaon, it has been characterized by wide resentment (Narain, 2009a). In five villages of Khandsa, Narsingpur, Mohammedpur, Gadauli Khurd and Harsaru, villagers were opposed to the land acquisition by the government for Reliance Industries Limited (RIL) in contradiction to what was earlier promised to be a completely government set up SEZ; they chased away the police squad by pelting stones at them when they went to demolish houses and tube-wells (Gurgaon Workers News, Newsletter 2, April 2007). The farmers of Khandsa, Narsinghpur, Mohammedpur, Gadouli and Harsaru village took collective decision not to give 558 ha of land to Reliance

because the government had already taken land in 2003 in the name of industrialization (SANDRP, 2007).

Consequences of rapid urbanisation and peri-urban growth for landuse change and water security

A study by urban scholars (Chaudhry, Saroha and Yadav, 2008) indicates that the landuse pattern in Gurgaon has changed largely because of rapid urbanisation and expansion of the city into the peri-urban areas. Using remote sensing and GIS, they have shown how the expansion of Gurgaon and development of the new satellite town of Manesar has seen the total built-up area increasing from 26.58 sq kms in 1996-97 to 124.15 sq kms in 2001-02. Most of this expansion has taken place in areas which are scrublands, pastures, water bodies, land with high water table which is susceptible to water-logging and agricultural land.

Peri-urban areas of large cities are subject to being taken over by the expanding boundary and often grow upon lands where the natural water cycle once occurred, such as forests, meadows or wetlands. This can harm the recharging of the groundwater table, and can affect local water bodies. The natural water cycle is disrupted, and often, new pollutants such as pesticides can create problems for the ecology of an area. The pie graphs (prepared from data by Central Groundwater Board Report, 2007) below show the sector-wise percentage gross groundwater draft (in hectare per meter, ham) in the four blocks of Gurgaon district in 2004. Interestingly, Gurgaon block reveals the highest values in the domestic and industrial sector. Tubewells in the depth range of 45 to 90 m bgl (below ground level) have been installed by different agencies in the block.



⁹This SEZ was expected to be the largest in India and promised to provide 500,000 jobs. The main developer in this project- Reliance Industries Ltd. (RIL) - would hold 90 percent of the shares of the project. (Gurgaon Workers News - Newsletter 2, April 2007)

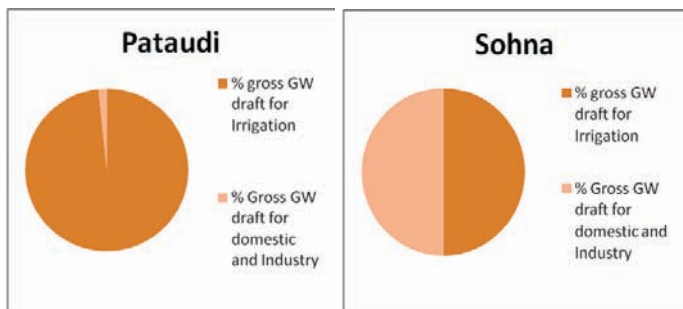


Fig.5 Sector-wise percentage gross ground water draft in four blocks of Gurgaon district

Source: Central Groundwater Board Report, 2007

Further, around Gurgaon city, there are eight golf courses. A hundred-acre golf course needs roughly 10 million litres of water a day, according to Force, an NGO working for water conservation. This water is enough to meet the requirements of 50,000 households. The eight golf courses (1200 acres) consume close to 120 million litres of water daily sourced from groundwater. This could be considered bad news for the water table in Gurgaon, which at present is 160 feet below ground level in certain areas. The water runs out at around 200 feet (Gill, 2010). Other recreational centres are also coming up which are encroaching forest areas as well, some of which have been designated as closed forests to be protected against any encroachment due to urbanisation (Chaudhary, Saroha and Yadav, 2008). Besides, lands have been acquired to build water treatment plants in peripheral villages to quench the thirst of the city; routes to water sources have been obstructed by construction of highways and water sources have been filled up for residential and other urban purposes (Narain 2009a, b).

TOI, Delhi edition, February 2, 2010, states that, "...scientists at the Central Ground Water Authority have been warning that Gurgaon's water table has been declining at a rate of about two meters (six feet) every year since 2006. Haryana draws 2.72 billion cubic meters of water whereas the annual availability is 2.64 bcm within NCR. It is predicted by the scientists that the city will have no water left by 2017" and this will also have serious implications for the residents of peri-urban Gurgaon, since their remaining water resources would also be under severe threat.

To cater to the increasing gap between demand and

supply, illegal ground water extraction is rampant. The above newspaper report noted that digging of bore wells was barred in Gurgaon in 2001. But, in the past three decades, 35,000 bore wells have come up, of which only 9,780 are registered. In May last year, Central Ground Water Authority (CGWA) had allowed more new bore wells to come up creating a flutter among local authorities in Gurgaon (ibid). Moreover, long powercuts during summer accentuate the problem and force residents to depend on tankers who charge Rs 600-700 per household for supplying about 3,000 to 4,000 litres of water. During summers, severe power cuts often urge residents to demand scheduled power cuts to alleviate their problems, but state-owned Dakshin Haryana Bijli Vitran Nigam (DHBVN) finds it extremely helpless because of a supply shortage of about 42 per cent (HT, Anonymous, 2010). A 70 kms long NCR water supply channel for carrying drinking water supply to Gurgaon, Manesar, Bahadurgarh, Sampla and Badli has been undergoing construction, at a cost of Rs 322 crore (Akansha, 2010). As we shall see below, this channel cuts through the peripheral villages, engulfing their land and water sources.

Besides, the policies for developing SEZs also have severe socio-economic and environmental impacts because bulk of the land acquired is fertile, agricultural land or in some cases forest land (Basu, 2007). To allure private investment, State Governments have often provided facilities like free or subsidised water supply (ibid), as a result of which there is inequality in water access for agriculture and domestic uses in the surrounding villages. Another serious impact is with regard to release of effluents from the SEZs, which pollute the groundwater as well as surface water sources that exist in the vicinity (Sanhati, 2009).

Rural-urban water conflicts

As pressures on water increase and water has to be diverted from rural to urban purposes, there is evidence of emerging rural-urban water conflicts. In the third week of March 2008, farmers living near Gurgaon breached the Gurgaon canal, that is the major supplier of water to the city, forcing the residents of Gurgaon city to buy water

¹⁰This was reported in an article Private tankers take Gurgaon hostage in The Hindustan Times, March 25, 2008, Delhi Edition. p. 1.

from private sources (tankers) at prices as high as Rs.500-700 per 5,000 litres.¹⁰ About 400 water tankers had to be pressed into service to supply tubewell water to the people of Gurgaon on March 24, 2008. This could meet just about 30 percent of the total demand for water. The water crisis in Gurgaon - that necessitates these forms of rural-urban water flows could be seen as an outcome of the short-sightedness of the government in issuing licenses for malls and residential areas without taking cognizance of the water availability (Narain, 2009b).

Climatic variability

We now turn our attention to the issue of climatic variability in Gurgaon. As per a recent study by the Ministry of Environment and Forests (MoEF), a 3 to 7 per cent increase has been predicted in all India summer monsoon rainfall by 2030's with respect to the 1970's (Government of India, 2010). The publication also observes a gradual increasing trend in the frequency of hot days and a significant decreasing trend in frequency of cold days during the pre monsoon season over the period 1970-2005 (Government of India, 2010).

Looking back at the current year's summer monsoon rains, Delhi - Gurgaon's immediate neighbour - witnessed the wettest monsoon in the past 32 years with an aggregate rainfall of 949mm till 20 September 2010 (TOI, Anonymous, 2010a). However, Delhi was left behind in terms of summer monsoon rains, by the rainfall figures in Gurgaon of 1,064mm for the same month (TOI, Anonymous, 2010b).¹¹ It is also interesting to note that the Gurgaon district has average annual rainfall figures of 596mm (Government of India, 2007). Thus, rainfall in the current year certainly stands out from the general rainfall patterns over the past few decades.

A study points out that over the years, there has not been much variation in the annual average seasonal rainfall of Gurgaon (Singh, et. al., 2008). However, no specific trends could be observed in percent deviations over normal rainfalls. Although the Kharif rains showed wide variations, rains during Rabi showed increasing trend from

1970 to 1990 and a decreasing trend from 1990 to 2000. Most importantly, the study points out that occurrence of extreme climatic events in Gurgaon have increased in the last two decades (ibid).

The study also points out that the crop intensity has become low and the water table has been declining. The decrease in water table is attributed to the annual water deficit of 460 million cubic metres in the Gurgaon district (Singh, et. al., 2008). This has led to overexploitation of groundwater and thus sharp decline in the groundwater table.¹² The groundwater is extracted using pumps which run either with electricity or diesel. This in turn leads to an estimated 16-25 million metric tonnes of carbon emission (Shah, 2009). Also, with every meter decline in the pumping water level, the GHG emissions are understood to increase by 4.37% in Haryana (Shukla, et. al., 2003).

The findings of the study about declining groundwater and crop intensity are also supported by a very recent satellite study mapping agricultural yields from 1980 to 2006 (Bhattacharya, 2010). As per the study, overexploitation of groundwater coupled with rising temperatures could push agriculture to stagnation. The study finds remarkable slowdown in growth rates of Kharif and Rabi crops, especially during the period from 1996 to 2006.

It is important to note that the study points towards states in north India having the most pronounced slowdown in agricultural yield. As mentioned earlier, the slowdown has been attributed to the increasing pressure on groundwater and also rising temperatures in the Indian subcontinent (Bhattacharya, 2010). The factor of rising temperature is in line with the global climate change predictions as per which temperature would increase by 2 to 6°C (Misra, 2010). This increase in temperature is expected to reduce precipitation up to 16% leading to reduction in groundwater recharge by 50% (Misra, 2010). In case of this decrease in groundwater recharge, soil salinity is expected to increase by 20 to 25%, which in turn will cause reduction in agricultural growth by 10 to 15% (Misra, 2010).

¹¹Delhi also witnessed rainfall in the month of November, indicating early onset of winter monsoon which otherwise comes only after mid-December. The newspaper article mentioning this was appositely titled -Are these rains signals of a climate change? (TOI, Anonymous, 2010c).

¹²This observation is corroborated by interviews in the field, where decline in rainfall is cited as an important reason behind increased reliance on groundwater. See the following section of this report.

Another study points out that about 60% of the geographical area in Haryana faces soil degradation in the form of water logging, salinity and alkalinity (Singh, 2000). In the event of global predictions about climate change coming true, the state is bound to lose out more land currently suitable for agriculture. As pointed out in the publication released by MoEF, the frequency of hot days has increased during the period 1970-2005.

A study carried out in one of the villages of Gurgaon district indicates that there has been a shift of summer time to August-September and a relatively cooler period during October-November (Singh, et. al., 2008).¹³ This in turn indicates a gradual expansion of summer months up to September and thus will have a lot of implications for future agriculture in the village.

5. Major Findings and Analysis: Insights from the field

From a description of urbanization and climate variability trends at the macro level, we now move on to understand how these trends shape water security of peri-urban residents. In a peri-urban context, the first point that surfaced in the field is that water security, rather than water scarcity is the key issue. There is a challenge in dealing with excess water, as much as in dealing with a deficit, as well as in dealing with the uncertainty regarding which of these is likely to be true. Besides, changes underway in peri-urban areas-such as land acquisition processes to support the growing city create an uncertain and unpredictable environment that impacts water access. Further, to identify who the most vulnerable groups are, requires us to understand their location in power structures and village networks that allocate resources, goods and services.

Water security is the issue, and not just water scarcity

The first important issue that emerged from the field visits is that water security is the key issue, and not just water scarcity. That is, as noted above, the challenge is

not only in having to do with less water or adapting to water scarcity, but also in dealing with excess water.¹⁴ In fact, as some of the discussion on climate variability and rainfall in the preceding section shows, the current year was really not a good year to study the impacts of water scarcity in Gurgaon, as this was a year of well above average rainfall. We have seen this rainfall only after thirty years! was a sentiment often expressed in field interviews across villages. All the villages where field work was conducted saw a rise in the water table this year after the monsoon season.

Thus, as paradox would have it, this year, for many of the farmers, the main problem has been in terms of dealing with excess water that flooded their fields



Fig.6 Picture depicting flooded fields in Budheda

Tracts of agricultural land located in villages Budheda, Chandu and Kheda Jhunjraula, are on clayey soils in low lying areas - called in local parlance as *jheel*¹⁵. Many of the farmers interviewed said that their fields had got flooded and this had affected their harvest of paddy and pearl millet. Many of them had been unable to sow wheat this year, as the sowing season of wheat had passed while the fields were still flooded. Worst affected were those whose lands also passed by a sewerage canal - carrying wastewater from Gurgaon, wherein the sewerage water from the canals had overflowed into the fields.

¹⁴For the project, water security is referred to as an uncertainty in the supply of water.

¹⁵A discussion with villagers in Chandu suggested that about a fourth of the village's agricultural land remained submerged under water in the current cropping season. Many residents of this village had bought land in neighbouring Budheda - these tracts of land had been submerged.

Some families or clans can be more vulnerable

Usually, members of a family or clan have their tracts of land located adjacent to each other, which means that not only are certain individuals more vulnerable, but also certain clans or extended families. If for instance, a certain plot of land is acquired by the state, or becomes flooded on account of excess rains, it is likely to affect a whole clan or extended family that has its agricultural fields located along that tract. For instance, in Kheda Jhunjraula, one farmer interviewed said that he and his 4 brothers along with his 18 cousins-descended from his father and his four brothers - had about 90 acres of agricultural land located along a sewerage canal. The large bulk of their agricultural land was located here, and hence they were particularly vulnerable to the flooding of the fields after the rains in this tract of land. In the same village, on the other hand, a farmer had 10 acres of land, none of which lay either in a low-lying area over clayey soils, or along the sewerage canal. Thus, none of his fields were flooded.

The concept of vulnerability thus helps us understand the intersection of various stressors. As far as the effects of flooding of the fields is concerned, it seemed that the most vulnerable were those whose fields were on clayey soils - that could not absorb water; in low-lying areas - that allowed the water to flood; and along a sewerage canal - wherein the overflow of the water compounded the effects of the flooding; besides, most vulnerable were those who had most of their agricultural lands lying in such areas. These farmers and households would be the most vulnerable to the effects of flooding in times of high rainfall. That is, the most vulnerable would be those who have all these factors against them.

'Passing on' vulnerabilities

Another important issue that emerged is that people not only differ in their adaptive capacity and vulnerability, but also in their ability to pass on vulnerabilities to others. For instance, landlords can pass on their vulnerabilities to tenants, who have to pay an agreed amount when they take land on kann (contract).¹⁶ However, if the crop fails -

on account of less or excess water, or any other reason - the tenants suffer (see box below).

When I reached Budheda, I started walking along the Gurgaon Water Supply channel that brings water to the Basai Water treatment plant for supplying it to the city of Gurgaon. The fields were flooded on account of the excess rains - this is a low lying area - and the overflow of wastewater from the sewerage canal coming from Gurgaon. The excess water seemed to have attracted painted storks and egrets that apparently searched for a feast in the flooded fields. Three ladies were walking by carrying what seemed to be loads of fodder on their heads. I started talking to them about the fields. One of them said that she had sown 2.5 acres of land - she had paid Rs. 10,000 as the amount for 2.5 acres of land; she had taken that tract of land on kann (contract). She had cultivated paddy but the harvest was reduced on account of the flooding. Whereas she would have reaped a harvest of 20 mann¹⁷ per acre, she would now get only about 5 mann. "You can see the paddy crop, but it will bear nothing, I tell you...", she said. She had earlier sown sponge gourd, which got spoilt and now she had sown paddy. The jowar crop had been completely damaged this year - she pointed out to what seemed to be like withered away twigs. She could not grow even fodder crops this year for the livestock. Her in-laws were harvesting some water chestnut in the distance. Some days ago, she said that she could not even walk in her fields as there was water till the shoulder level. "Some water overflows from the kutchha gundaah nullah (unlined sewerage channel), and from the pukka (lined) one, where farmers have installed pipes to irrigate the fields, the clay sheds off from the side of the pipes, causing the water to flow into the fields as well... hence this flood", she explained.

The second lady pointed out that she had already taken on contract 7 acres of land for 95 mann of harvest from Sukhdarshan Pandat - that land would not produce any paddy this year and she would be unable to sow wheat as the fields are unlikely to have dried up by the time when wheat needs to be sown. .

¹⁶These payments can be either in terms of cash or a certain measure of the produce.

¹⁷1 mann is equivalent to 40 kgs.

The third lady said that she had taken 3 acres of land on kann and the wheat harvest was almost ready when the lands were acquired for the NCR channel to supply water to the city. Her crop had to be destroyed... 'the owner got compensation for the land as well as the amount that I had paid him for tilling his land, but it was a loss to me, as the crop was almost ready'. It was a tremendous loss for her. When I asked them why they did not complain about the flooding of the fields and the need to pump out the excess water, they said, 'who will listen to us .. jisskee zameen hai, usko kuchh karma chahiye...(those who own the land should do something about this).'

Source: field notes diary, September 24, 2010

Likewise, when lands are acquired for urban or other purposes - a common phenomenon in peri-urban contexts - the land-owners gain doubly; they not only get the compensation for the land, but also the agreed amount from the tenants for the land that is given on kann. If, however, the tenant has sown some crop over the land, it is a loss to him when the land goes, as he gets nothing - neither the compensation, nor the value of the crop produced or about to be harvested (Box 1 above). This suggests that in order to understand vulnerability we need to understand the location of peri-urban residents in social and power structures and village networks that allocate goods, services and resources; tenants are definitely more vulnerable than land-owners.

It is also important to note that among land tenure arrangements - namely saajedaari (sharecropping) and kann (tenancy), it is the latter that is more common in peri-urban areas. This is because many peri-urban residents - large land-owners and cultivators - give their lands on kann as they migrate to the city, buy houses or set up shops there. Giving the lands on kann is a way through which they maintain their hold on rural assets. Thus, while these systems of land tenure facilitate the occupational diversification of the rural elite while allowing them to maintain their hold both on rural and urban assets, they also serve as a means through which

they can pass on their vulnerabilities to others.

When discussing the effects of flooding in the fields - a phenomenon widely noted this year in the kharif season when the scoping study was carried out, even as tenants are likely to be more vulnerable, they are unlikely to do something about the situation as they sense a lack of ownership of the fields (Box above).

Falling water tables

Though this year the rainfall did contribute to a rise in the water table, falling water tables over the past few decades were reported in all the villages chosen for study. In villages like Wazirabad and Ghata where almost all the agricultural land has been acquired for residential colonies and other urban purposes, the main reason cited was decline in rainfall, the concretization of urban spaces reducing the local recharge as well as the appropriation of groundwater by the new and upcoming residential colonies, many of whom have installed submersible pump-sets to meet their requirements of domestic consumption. In villages like Ghata and Wazirabad that have their residential areas- called in local parlance as the laldora - right across the road from where urban residential areas have been built over agricultural lands, the water table level has fallen very steeply.¹⁸ For Wazirabad, locals reported a fall in water table from about 70 feet in 1970 to 105 feet in 2010. In Ghata, the fall in water table level was reported from about 100-150 feet in 1980 to 250-400 feet in 2010. Local residents now extract water using high powered submersible pump-sets, unaffordable by smaller farmers and the poorer households.¹⁹ Thus, the appropriation of water for urban and residential areas makes the poor and smaller farmers more vulnerable as they are unable to bear the high costs of extraction with a fall in the water table.

In Sultanpur, Budheda, Chandu, Kheda Jhunjraula and Sadhraana, many farmers pointed out that less rainfall in the past years had meant a greater reliance on groundwater, which in turn, aggravated the stress on the resource. Tubewell numbers in these villages have multiplied in recent years on account of deficient rainfall

¹⁶The land acquisition process in these villages started about three decades ago in the early 1980s. Ghata lost lands to the development of residential sectors 55 and 56 while Wazirabad lost lands for sectors 51, 52, 53, 54, 56 and 57. Their johads - water bodies - were also filled up and acquired for the same purposes. There has been a reduction in recharge on account of the concretization of urban spaces as well as decline in the catchment area.

¹⁷Both these villages have now been brought under the jurisdiction of the Gurgaon Municipal Corporation. An important implication here is that while the village Panchayat has ceased operation in these villages, the GMC has not yet completely taken over, giving rise to some institutional lacuna. A major water infrastructure related problem that emerged in Ghata during the field interviews was that of stagnant water, that is, of water with no exit. The institutional lacuna made it difficult to assess whose responsibility that would be. Residents also complained about other implications of being under the jurisdiction of the municipal corporation, one of which being that they would have to now pay house taxes.

as well as the fragmentation of land-holdings and family size, causing each descending nuclear family unit from a joint family to have its own tubewell.

Rural-urban water flows

The rural-urban water flows take place in two forms; first, are the flows of water through canals and other infrastructure to water treatment plants to meet the domestic water requirements of urban residents. This takes place through the construction of canals that cut through the villages to transport water to the city. For these canals to be built, peri-urban residents lose land - as well as the water sources located on those lands. Among the villages visited in the scoping study, residents of Budheda, Kaliawas and Iqbalpur villages lost their lands for the construction of the Gurgaon Water Supply Channel.



Fig.8 These peri-urban residents have gradually lost all their lands to the city and now watch the last 50 acres go away

Interestingly, as noted in the preceding section, the NCR Channel is now being built to further augment the water supply of Gurgaon city. The NCR channel passes parallel to the Gurgaon Water Supply channel and there has been another round of land acquisition. Since the new canal will run parallel to the previous one, it is the same land-owners who had to part with their lands. Thus, vulnerability is not just about the interaction of multiple stressors, but also the repeated 'onslaught' of the same stressors on the same group of people.



Fig.7 The NCR channel being dug to augment Gurgaon's water supply cuts through Budheda village - the villagers lost their lands to its construction)

When the Gurgaon Water Supply channel was dug, many farmers in these villages had installed tubewells along the Channel in order to benefit from the local rise in water table. However, when lands were acquired for the NCR channel, these tubewells had to be removed. The same households were then affected. This once again demonstrates the element of water insecurity - and not just scarcity in peri-urban settings. The environment with regard to the availability of water is characterized by uncertainty and lack of surety of water supply.

This approach of expanding urban water supply by carrying water from the country side, cutting across villages, creates patterns of both water insecurity and vulnerability for peri-urban residents, and as noted above, some people are more vulnerable than others, depending upon where the lands are located and what strategic importance those lands may have.

The second form of rural-urban water flows are the more 'informal' ones, characterized by the flows of water in tankers from the village to the city. These flows are noticed, for instance, in Wazirabad, where water earlier used for irrigation is now used in nurseries that cater to the requirements of the urban residential areas, or to provide water for construction and other urban activities. The purchase of water from water tankers in

¹⁶These payments can be either in terms of cash or a certain measure of the produce.

¹⁷1 *mann* is equivalent to 40 kgs.

times of a shortfall in supply was reported to be a local adaptation strategy in Budheda, Chandu and Kheda Jhunjraula villages. In Kheda Jhunjraula, a local water supplier brings water from Farookhnagar to sell to locals – the price is about Rs 3 to 4 per pot (about 10-12 litres).²⁰ In Sultanpur village, on the other hand, located right across the road, water users need not resort to buying of water through tankers as they are able to obtain water on the strength of social relationships from their acquaintances that have hand-pumps located above 'fresh' water.

In Chandu, the village Panchayat pays the tanker operator to provide water to the village in times of shortfall.²¹ In Budheda, a private property dealer owns two water tankers that he uses to provide water to the residents when local supply is in shortfall. The purchase of water from water tankers can be seen as an important adaptation strategy and merits further investigation.

Urban- rural water flows: source of both opportunity and vulnerability

Urban- rural water flows basically take the form of urban sewerage flowing into the villages. In Budheda, for instance, sewerage based irrigation is quite organized – farmers take permission from the Irrigation Department to install pipes along the canal to irrigate, and pay the Irrigation Department a nominal sum on an annual basis. Sewerage is a cheap source of irrigation- as it does away with the need for application of chemical fertilizers and costly pumping. However, it is known to have adverse health impacts for producers and consumers of the crops. Besides, as seen above, during the rains, it overflows and floods the fields.

From this perspective, sewerage irrigation should be seen as a key factor shaping peri-urban water (in) security; on the one hand, it allows farmers to overcome the constraints faced by the absence of sources of irrigation – in Gurgaon there are no irrigation canals, so farmers depend on rainfall both for rainfed agriculture as well as for recharging the aquifers²² – on the other hand, its excess is counter-productive. A very interesting aspect that emerged in Budheda, is that with the tubewells gone after

the land acquisition for the NCR channel, irrigators were forced to rely on sewerage, and this again highlights the complex interplay of factors that shapes water security in peri-urban contexts.

Pre-emption of water by urban elite

It is important to understand that it is not just the physical flows of water from rural to urban areas that are an important aspect of the rural-urban water nexus, but also the use of rural water (and land) resources by urban elite within the rural geographical boundaries. This came out very conspicuously in the case of Sadhraana village, where much agricultural land has been sold to farm-houses. These farm-houses belong to the urban elite and extract water using 15 hp submersible pump-sets that the locals can not afford. The owners of farm-houses have acquired lands overlying fresh groundwater; when their lands are located over saline groundwater, they have bought small parcels of land over the fresh groundwater, install submersible pump-sets there, and transport water to their farm-houses using underground pipes over a distance of 2-3 kms. Once again, the small and marginal farmers lose out, as they are unable to afford the high costs of extraction. In general, this reinforces the point made above, that water use in peri-urban contexts is appropriated by actors other than the local residents, with implications for the water security especially of the poor, small and marginal farmers. The usual understanding of groundwater depletion in Indian groundwater management literature is in terms of its pre-emption by the rural elite; in peri-urban contexts, the phenomenon is quite different. The resource is appropriated by outsiders or used for purposes other than 'rural', raising questions both of ethics and equity.

Gender relations

Several observations emerged in the field from a gender perspective. While the tasks of collecting water are determined through a gender-based division of labour, changes underway in peri-urban areas can impact gender relations in several ways. In Budheda, as immediate sources of water have got dried up, male members of the

²⁰In this village, this water is mainly used for drinking. Though there is piped water supply, it is erratic and the quality of water is not considered fit for drinking. The piped water supply is used for other domestic needs such as washing utensils or scrubbing the floor. The local groundwater is saline, and therefore drinking water is transported from Farookhnagar by the water tanker operator and sold. It seems that this is a daily phenomenon and water purchases are widespread.

²¹A water tanker of about 3000 litres capacity costs Rs. 600 (USD 13 approx).

²²In fact, in Budheda the only farmers who grow paddy are those who have access to sewerage water.

household increasingly fetch buckets of water on their motor-cycles or scooters. Sultanpur is a Rajput village wherein the tasks of water collection are done by men rather than by women. The acquisition of lands for the Kundli-Manesar Palwal Expressway means that the routes to water collection get disturbed - the village is underlain by saline groundwater; however, residents obtain fresh water from across the railway line. With the construction of the highway, the route of water collection has got disturbed and a longer distance must be walked to collect it.

In Sadhraana, the lowering of the local water table on account of the increase in extraction from farm-houses and other competing uses means that women walk longer distances to collect water. At the same time, immediate or proximate sources of water belonging to relatives and acquaintances are longer available to many as the lands on which they were located have been acquired (see discussion below on erosion of social capital); once again, vulnerability is about the interaction of different stressors.

Adaptation strategies: appreciating the social and agro-ecological context

A wide mix of adaptation strategies are noticed across the villages. The most common include buying water from tankers and obtaining water from acquaintances. Technological responses include change in water extraction technologies from animal and manually operated pulleys to tubewells and submersibles, as noticed most conspicuously in Sadhraana village. The use of sprinklers is also common, as noticed especially in Sadhraana and Sultanpur. Three reasons were given for the adoption of sprinklers, namely, that the terrain is undulating; the soils are clayey, that prevent flooding; as water gets scarce there is a need to use it more carefully and apply it closer to crops and fourth and most interesting, peri-urban areas are areas of intense occupational diversification, that creates a demand for less labour intensive technologies for irrigation. In other words, one needs to look at the social, institutional and agro-ecological context



Fig.9 Sprinklers are an important adaptive strategy in Sultanpur and Saadhrana villages

The demise of social capital

Social capital plays an important role in shaping the adaptation strategies of peri-urban residents to situations of water scarcity. In times of need, it is common indeed for residents of these villages to take water from their friends, relatives or acquaintances without having to pay for it. This observation came out practically across all the villages chosen for study. The terms used in local parlance to denote this are 'bhai-bandi', 'bhai-chaara', 'uth-baith' and 'hookah-pani'.

The role of social capital is well understood in the context of adaptation to the impacts of climate change in general. However, what is of interest is that on account of a number of factors, social capital is constantly eroded in peri-urban areas. When we started talking to elderly peri-urban residents in Sultanpur - about what changes they had experienced in their lives in recent years, the starting point of their observations was 'hamaara bhaichara khatam ho raha hai', (our social capital is being eroded). A number of reasons can be ascribed to this; namely, the erosion of CPRs that often provide a social glue, increasing occupational diversification and migration to the city, as well as a general influence of urban norms and practices on the rural ethos.

In Sadhraana village, one of the landless households interviewed used to take water from the tubewell of a relative. However, the latter sold off his land to a farm-house and the household no longer had access to it. The acquisition of common grazing lands - as seen both in Budheda and Sadhraana - erodes the social glue that binds resource users together. While social relations play a role in adaptation to water scarcity, they may no longer be available as a resource in peri-urban areas, either because of the loss of social glue that binds people together, or because the physical assets of those who provide the resource are no longer available.

Location of households

It seems that location is an important factor influencing the vulnerability of households, whether it be the location

of the house or of the agricultural fields. As noted above, the location of agricultural fields - low lying or at an elevation is an important factor shaping their vulnerability, for instance, to flooding. Similar holds when it comes to location of households - whether at an elevation or low lying in terms of their access to organized sources of drinking water. Households in Chandu, Sultanpur and Kheda Jhunjraula lying at an elevation do not receive piped water supply simply because of the inability to pump water to that elevation.

The four villages selected for study: rationale and key issues

The table below presents the key features and peri-urban issues across the villages.

Village	Major driver of land-use change	Main peri-urban water issues	Jurisdictional status
Wazirabad	Residential areas for the modern city	Falling water tables from competing pressures and reduced groundwater recharge from lessening of catchment area and concretization of urban spaces, rural-urban water flows through tankers	Gurgaon Municipal Corporation
Ghata	Residential areas for the modern city	Falling water tables from competing pressures and reduced groundwater recharge from lessening of catchment area and concretization of urban spaces; stagnant waters on account of absence of water exit	Gurgaon Municipal Corporation
Budheda	Dental hospital and college, water treatment plant for the city, Gurgaon water supply channel, NCR channel	Urban- rural water flows in the form of sewerage irrigation, loss of land to quench urban thirst	Village Panchayat
Sadhraana	Sultanpur National Park, Farm-houses	Falling water tables and competing pressures from farm-houses	Village Panchayat
Sultanpur	Sultanpur National Park, Farm-houses, Reliance SEZ, KMP Highway	Falling water table levels because of growing competition for water, diversion of routes for water collection on account of highway construction	Village Panchayat

Village	Major driver of land-use change	Main peri-urban water issues	Jurisdictional status
Chandu	Water treatment plant	Sewerage irrigation, loss of land to quench urban thirst	Village Panchayat
Gadholi Khurd	Residential area, SEZs	Fall in water table on account of growing competition for water	Village Panchayat
Khedki Majra	Residential area	Recipient of urban sewerage	Village Panchayat
Kheda Jhunjraula	Reliance SEZ - recent process	Still to be observed (what happens to water sources when lands are acquired and the study of existing vulnerabilities)	Village Panchayat
Iqbalpur	SEZ, NCR Channel, GWS channel	Loss of land to quench urban thirst	Village Panchayat
Kaliawas	SEZ, NCR Channel, GWS channel	Loss of land to quench urban thirst	Village Panchayat
Gual Pahadi	TERI campus, residential areas, farm-houses, Aravalli biodiversity Park	Falling water tables due to competing pressures	Gurgaon Municipal Corporation

Based on the above findings and analysis, for the main research phase, four villages have been selected, namely, Budheda, Sadhraana, Sultanpur and Kheda Junjraula. These villages provide perhaps the most potentially rich sites to study water security, vulnerability and adaptation. As noted earlier in the paper, villages like Ghata and Wazirabad, though interesting in terms of the magnitude of changes witnessed, may not make good potential research sites for the simple reason that they are better perhaps understood as rural enclaves rather than peri-urban. There is virtually no agricultural land left and that leaves out a very interesting and important water use for study, namely that of irrigation.

Budheda has been selected because it provides a good illustration of how the ecological foot-print of urbanization is borne by peri-urban areas. Budheda has lost land twice - for the Gurgaon Water Supply Channel and the NCR channel- to provide water to the growing city, and also lost some grazing lands for the same. At the same time, it receives the waste of the city - in the form of the

city's sewerage that is used for irrigation. This gives an opportunity to study two types of rural-urban water nexus, one in terms of the ecological foot-print of the city and how it spills over into the village and second, an opportunity to study urban-rural water flows. Besides, this village could be considered representative of the kinds of changes witnessed also in neighbouring Iqbalpur and Kaliawas - that have similar patterns of land use change. In this village, the following aspects merit study:

- 1) The implications of the land acquisition process for the NCR channel and GWS channel for the water security of the peri-urban residents
- 2) Identification of differential vulnerabilities as well as the ability of water users to pass on their vulnerabilities to others as noted above and how this is shaped by social relations as well as the location of people in village networks and power structures
- 3) The dynamics of sewage based irrigation in terms of its relative role in irrigation and changing pattern of dependence vis a vis groundwater

4) The study of the interface of water users with artifacts - namely, pipes and outlets, through which they access sewage water, and the

5) Potential of mobilizing the irrigation department to address problems associated with flooding and drainage

Sadhraana is interesting as it presents a very unique form of urban rural water nexus, namely the appropriation of water by the urban elite through farm-houses. Once again, this gives us an opportunity to study a specific type of rural -urban nexus that could be considered representative of peri-urban water dynamics widely seen not just in Gurgaon but in different parts of the country. In this village, we will focus on

1)The gradual process of land use change in the village starting from the 1960s onwards through the 1980s

2)The mechanisms through which farm-house owners have acquired land and water resources in the village

3)The implications of this process for the peri-urban residents

4)Assessment of differential vulnerabilities and the factors shaping the same

Sultanpur provides a good example of how different pressures over a period of time have impacted land use changes. Starting with the Sultanpur National Park in the 1960s, the major driver of land use change now has been the Reliance SEZ. In this village, we will

1) Document the process of land use change historically since the 1960s, and identify the major drivers of change

2) Study the interface of peri-urban residents with the Sultanpur National Park and competition for water sources

3) Assess differential vulnerabilities especially among those who live in the main village and those in the settlement called Dhaanis

Finally, what distinguishes village Kheda Jhunjraula from other villages is that this is really a peri-urban village in the making. The land acquisition process is relatively recent; lands have only recently been ear-marked and there is an opportunity to examine what happens to water sources in the process. Besides, it gives us an opportunity

to study the role and effect of constraints other than urbanization and climate change - such as saline groundwater and low lying areas - whose effects climate change and urbanization will aggravate further.

6. Summary and conclusion: leading to the main research phase

Several key issues emerge from the above understanding. First, there is a wide variety of ways in which urbanization and climate variability shape the water security of peri-urban residents. The uncertainty associated with water supply caused by climatic variability is further aggravated by the processes of urbanization. The issue is not only that of water scarcity, but also of excess. Further, water insecurity is experienced differently by different groups of people depending upon social relations as well as their location in village networks and power structures that allocate resources, goods and services. Adaptation responses also vary and are shaped by a mix of technological and institutional factors. An important issue - and this needs to be seen as a general message of the overall project and not just for Gurgaon - is that there is a need to break away from the dichotomy in rural and urban water supply and better appreciate the linkages and flows of water across rural and urban areas.

An interesting aspect that a surface from this analysis specific to Gurgaon, is that location cannot alone define peri-urban or the nature and extent of rural-urban flows and linkages. The four villages are located about the same distance from the city - and almost adjacent to each other - but they experience very different forms in which urbanization influences water access of peri-urban residents.

In the main research, it is proposed to investigate these issues at further length using a mix of ethnographic and participatory approaches. In-depth household interviews will be undertaken to understand elements of risk, exposure and coping capacity as well as the livelihoods portfolio across urban and rural assets, patterns and role of remittances and how different members of the household (men/women) experience vulnerability, as also

to understand their location in village networks that allocate goods, services and resources. In understanding gender, the key is to break away from household as a unit of analysis informing conventional, structured interviews. Women will be interviewed separately and time budget exercises shall be carried out to understand the time and effort involved in water collection, how it has or it has not changed over time.

Focus group meetings shall be undertaken to examine how different groups experience water insecurity differently and to identify the vulnerable groups. Key informant interviews will be carried out to understand land transactions, forms of influence used to acquire land as well as how the Insecurity of land tenure shapes water insecurity. As in the exploratory study, direct observation shall be carried out. Observation of irrigation and water collection activities will be done in order to understand actual access to water, conflicts and their resolution and the user interface with technology. Semi-structured interviews with Panchayat members and municipal officers shall be undertaken to understand their perspectives, identify institutional lacunae and possible interventions. A range of PRA exercises shall be undertaken to understand livelihoods (seasonality analyses), patterns of poverty and access (wealth-ranking), climate variability and changes in water supply (trend lines), major impacts of development interventions on the villages (time line), Institutional relationships and gaps (venn diagram), and changes in resource use and profile (village transects, resource maps).

While we have done a preliminary assessment of the implications of climate change for the Gurgaon district, it is proposed in the main study to do something like an ethnography of climate change to understand how people experience a changing climate, how they perceive its implications for their livelihoods, and then to superimpose these changes with the changes brought on by urbanization, in terms of its implications for water availability and access. In terms of intervention, it is important to note that the villages chosen for study are underlain by what locals call khara paani or saline

groundwater; hence, augmenting local water supply can not be the basis for intervention. Instead, interventions will have to evolve around providing a forum for interaction between peri-urban residents and urban or government authorities, sensitization of policy-makers to peri-urban concerns and issues and mobilization of the community to ask for change and providing support to them in the same.

References and Bibliography

Bhattacharya, A., 2010. Green revolution over, agriculture yields staring at dead end? The Times of India, [online] 26 November. Available at:

<<http://timesofindia.indiatimes.com/home/environment/developmental-issues/Green-revolution-over-agri-yields-staring-at-dead-end/articleshow/6991376.cms>> [Accessed 26 November 2010].

Department of Town and Country Planning. Demographic Profile and Settlement Pattern in Chapter 4 of Preparation of Sub Regional Plan for Haryana Sub-Region of NCR-2021: Interim Report -II. [online] Available at:

<<http://tcpharyana.gov.in/ncrpb/4.chapter4.pdf>> [Accessed 26 November 2010].

Government of India, Ministry of Environment and Forests (MoEF), 2010. Climate change and India: A 4x4 assessment - A sectoral and regional analysis for 2010s. INCCA Report 2. [pdf] Available at:

<<http://www.indiaenvironmentportal.org.in/files/fin-rpt-incca.pdf>> [Accessed 26 November 2010].

Government of India, Ministry of Water Resources, Central ground water board, 2007. Groundwater information booklet Gurgaon district, Haryana. [pdf] Available at: <http://cgwb.gov.in/District_Profile/Haryana/Gurgaon%20Broucher.pdf> [Accessed 28 November 2010].

Misra, A.K., 2011. Impact of Urbanization on the Hydrology of Ganga Basin (India). *Water Resources Management*, 25(2) pp. 705-719.

Narain, V., 2009a. Growing city, shrinking hinterland: land acquisition, transition and conflict in peri-urban Gurgaon, India. *Environment & Urbanization*, 21(2), pp. 501-512.

Narain, V., 2009b. Gone land, gone water: crossing fluid boundaries in peri-urban Gurgaon and Faridabad, India. *South Asian Water Studies* 1(2).

Rajamani, L., 2009. India and Climate Change: What India Wants, Needs, and Needs to Do. *India Review*, 8 (3), pp. 340-374.

Shah, T., 2009. Climate change and groundwater: India's opportunities for mitigation and adaptation. *Environment Research Letters*, 4 (3), pp.1-13.

Shukla, P.R. Nair, R. Kapshe, M. Garg, A. Balasubramaniam, S. Menon, D. & Sharma, K.K., 2003. Development and climate: an assessment for India. Unpublished Report Submitted to UCCEE, Denmark, Ahmedabad: Indian Institute of Management. [pdf].

Available at:

<<http://www.developmentfirst.org/india/report/fullreport.pdf>> [Accessed 25 November 2010].

Singh, M. Kalra, N. Chakraborty, D. Kamble, K. Barman, D. Saha, S. Mittal, R.B. & Pandey, S., 2008. Biophysical and socioeconomic characterization of a water-stressed area and simulating agri-production estimates and land use planning under normal and extreme climatic events: a case study. *Environmental Monitoring and Assessment*, 142, pp. 97-108.

Singh Amrita, 2004. 'The conversion of Gurgaon farmland into real estate assets throughout the 1990s - A look at legal adjustments'. An excerpt from *Deliberate Democracy and Electoral Fallacy: The Logic of Coexistence / A Comparative Study of Two Globalizing Cities in India*. [online] Available at:

<<http://sanhati.com/articles/1695/>> [Accessed 27 November 2010].

Singh, R.B., 2000. Environmental consequences of agricultural development: a case study from the Green Revolution state of Haryana, India. *Agriculture, Ecosystems and Environment*, 82, pp. 97-103.

TOI, Anonymous., 2010a. Delhi witnesses wettest monsoon in 32 years. The Times of India, [internet] 20 September. Available at:

<<http://timesofindia.indiatimes.com/city/delhi/Delhi-witnesses-wettest-monsoon-in-32-years/articleshow/6588127.cms>> [Accessed 27 November 2010].

TOI, Anonymous., 2010b. Rain springs green hope for Gurgaon. The Times of India, [internet] 23 September. Available at:

<http://timesofindia.indiatimes.com/articleshow/6609739.cms?prtpage=1>[Accessed 27 November 2010].

TOI, Anonymous., 2010c. Are these rains signals of a climate change? The Times of India, [internet] 18 November. Available at:

<<http://timesofindia.indiatimes.com/city/hyderabad/Arrethese-rains-signals-of-a-climate-change/articleshow/6944894.cms>> [Accessed 26 November 2010].

Audirac Ivonne, 2005. Information Technology and Urban Form: Challenges to SmartGrowth, International Regional Science Review, 28(2), pp.119-145.

Castells, Manuel, 1996. Megacities and the end of urban civilization (The past is too small to inhabit), New Perspectives Quarterly, 13(3), pp. 12-15.

Basu, Pranab Kanti, 2007. Political Economy of Land Grab. Economic and Political Weekly, April 7, Perspectives, pp. 1281-1287.

Chaudhry, G.P., Saroha B.S. and Yadav M., 2008. Human Induced Land Use/ Land Cover Changes in Northern Part of Gurgaon District, Haryana, India: Natural Resources Census Concept, Journal of Human Ecology, 23(3), pp. 243-252.

Florida, Richard. 2000. Competing in the age of talent: Environment, amenities and the new economy. Report prepared for the R. K. Mellon Foundation, Heinz Endowments, and Sustainable Pittsburgh. January 2000. Heinz School of Public Policy and Management, Carnegie Mellon University, Pittsburgh, PA. [online] Available at: <<http://www.heinz.cmu.edu/swic/florida3.pdf>> [Accessed 26 November 2010]

Gappert, G. 1985. Urban Issues In An Advanced Industrial Society, Chapter 27 In: John F Brotchie, Peter Hall & Peter W. Newton (ed.) The Spatial Impact of Technological Change.

Graham, Stephen, and Simon Marvin. 2000. Urban planning and the technological future of cities. In Cities in the telecommunication age, James O. Wheeler, Yuko Aoyama, and Barney Warf, eds. New York: Routledge.

Hall, Peter. 1997. Modeling the post-industrial city. Futures 29 (4/5), 311-22.

Kotkin, J., & DeVol, R.C., 2001. Knowledge-Value Cities in the Digital Age. (Santa Monica, Milken Institute).

Kumar, Pushpam 'An Assessment of Economic Drivers of Land Use Change in Urban Delhi (SANEI's SIXTH ROUND OF FUNDED PROJECT). [online] Available at:

<http://www.saneinetwork.net/pdf/SANEI_VI/SANEI-VI%20Project%204%20AN%20ASSESSMENT%20OF%20ECONOMIC%20DRIVERS%20OF.pdf> [Accessed 26 November 2010]

Mishra, 2009: <http://www.livemint.com/2009/11/25001047/Controversy-over-changes-in-SE.html>.CGW, 2007. Gurgaon District. Ministry of Water Resources, New Delhi. [online]

Available at: <http://cgwb.gov.in/District_Profile/Haryana/Gurgaon%20Broucher.pdf>

Mitchell, William J. 2000. E-topia. Cambridge, MA: MIT Press.

Naisbitt, J. 1982. Megatrends: Ten new directions transforming our lives. New York: Warner.

Newton, P.W. & O'Connor, K., 1985. The Location of High Technology Industry: An Australian Perspective, Chapter 19 In: John F Brotchie, Peter Hall & Peter W. Newton edited, The Spatial Impact of Technological Change.

Sanhati, 2009. 'A Citizens Report Card on Special Economic Zones.' [online] Available at: <<http://sanhati.com/wp-content/uploads/2010/11/five-years-of-sez-act.pdf>>

Sassen Saskia, 2002. Towards A Sociology of Information Technology., Current Sociology, 50(3), pp. 363-373.

SANDRP, 2007. SEZ Threat to water and food Security. [online] Available at:
<http://www.sandrp.org/threat_water_food_security_April2007.pdf>

Soja, Edward W., 2000. Post Metropolis: Critical Studies of Cities and Regions. Blackwell Publishing, UK.

Storper, Michael, and Allen Scott. 1992. Pathways to industrialisation and regional development. London and New York: Routledge.

Anonymous, 2008. Anti Reliance SEZ Panchayat meet in Gurgaon [online] 14 July Available at:
<<http://www.merineews.com/article/anti-reliance-sez-panchayat-meet-in-gurgaon/137563.shtml>>

California water and Landuse Partnership, [online] Available at:
<<http://www.coastal.ca.gov/nps/watercyclefacts.pdf>>

Gill, Vineet, 2010. Should Gurgaon stop playing golf?. Times of India, Gurgaon edition [online] 18 September. Available at:
<<http://timesofindia.indiatimes.com/city/gurgaon/Should-Gurgaon-stop-playing-golf/articleshow/6575723.cms#ixzz14DYQpmgi> [Accessed on November 10, 2010]

Simi., Apr 26, 2010. 'Munak Canal Finally Get Share but Only for Games: Haryana' [online] Available at:
<<http://www.gurgaonscoop.com/water>>

HT, Anonymous, 2010. Power-Hungry Gurgaon Now Thirsty For Water, Hindustan Times [online] 18 April. Available at:
<<http://www.hindustantimes.com/Power-hungry-Gurgaon-now-thirsty-for-water/Article1-532677.aspx>>

Akansha, 2010 'Haryana to Construct 500 New Lined Water Courses', [online] 1 April Available at:
<<http://www.gurgaonscoop.com/section/water/2>>

Sukanya, S., 2010. Gurgaon water table declining at alarming rate. The Times of India, [internet] 2 February. Available at:

<<http://timesofindia.indiatimes.com/city/delhi/Gurgaon-water-table-declining-at-alarming-rate/articleshow/5525647.cms>> [Accessed 13 November 2010].

Gurgaon Workers News - Newsletter 2007, [online] 2 April, Available at:
<<http://libcom.org/library/not-yet-special-enough-special-economic-zones-part-1>>