Water Shortage in the Lower Deduru Oya Basin

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Abstract

Acute water shortage for agricultural, domestic, industrial and other activities is evident in the Lower Deduru Oya Basin (LDOB) due to changes in land use, abandonment of irrigation structures, extensive use of tubewells and lowering of groundwater levels. This situation has lead to a slowdown in the rate of agricultural development, weakening the socioeconomic activities and social milieu and also in controlling the improvement of living standards in the area.

In the early 1990s, farmers had agro-wells dug in their own farmlands. Subsequently, farmers obtained water from shallow tubewells and then shifted to deep tubewells due to the lowering of the groundwater levels following micro-morphology. Many farmers have reported that turbidity, pollution and salt water intrusion are the major issues in tubewells. In some instances, high salt concentration in tubewell water has made extracting water for irrigation a problem.

In order to evaluate the quality of water of the LDOB, the present study team examined the electrical conductivity, salinity and pH values of the water of 32 water samples from different locations. In some locations, for example, where the electrical conductivity is below 2000 and the salinity is also below 5.85, the water cannot be used for bathing and even for washing purposes. Laboratory analysis reveals that the salinity exists even in water samples obtained from tubewells that are 10-15m deep.

The Deduru Oya Basin and its surroundings receive heavy rains during the 1st inter monsoon and 2nd inter monsoon and northeast monsoon periods giving surplus water. The trend lines of the average annual rainfall of the Deduru Oya Basin indicate decreasing trends, and are insufficient to maintain mega irrigation works such as the proposed Deduru Oya Reservoir as well as proposed hydropower projects, which will be expected to be completed by 2010. Nevertheless, even after the completion of the Deduru Oya Reservoir by 2010, the Ridibendi Ela, Magalla Wewa and LDOB will face water shortage. Consequently, the problem will be arisen seriously than at present, and that is not a relevant response to the water shortage in the LDOB area.

Introduction

The Lower Deduru Oya Basin (LDOB) is a unique example that highlights the water shortage problem, and the way such a shortage obstructs and imposes negative impacts for socioeconomic development. During the recent past, supporters of politicians, law enforcement officers and other law-implementing government personnel disregarded and ignored the existing rules and regulations, to help their clients to expedite unscrupulous activities. The backing of the politicians and law-implementers have encouraged, especially among the sand miners, the removal of sand from the river bed and river banks, thus disturbing the natural cycle of interconnections between surface and groundwater levels. As a result, water deficits (shortage) even in short dry periods and water pollution have emerged as significant problems in the surrounding areas of the LDOB.

The acute water shortage for agricultural, domestic, industrial and other activities is evident in LDOB due to changes in land use, abandonment of irrigation structures, extensive use of tubewells, lowering of groundwater levels and water pollution. All these are linked to the insufficiency of water (water shortage) for the people, and this situation has been instrumental in slowing down the agricultural development, weakening of socioeconomic activities and social milieu and also in controlling the improvement of living standards in the area.

A properly designed management action plan is needed to minimize water shortage even during short dry periods and water pollution problems, which are caused by unwarranted land utilization practices. The development of a management action plan, for the LDOB in this particular case, requires a sound understanding of interactions between the physical characteristics (mainly topography, surface geology and climate) of the river basin and its human activities. The availability of detailed information pertaining to the above enables us to assess options such as allocating land for forest reservations, development of appropriate farming systems for certain areas, development of location-specific appropriate farming systems, increasing the groundwater table to the maximum possible levels etc. in terms of the relationship between physical and human resources.

The middle part of the Deduru Oya Basin (MDOB) extends from Pallama to Kalatuwakele (Ibbagamuwa Divisional Secretary [DS] Area). Within this area, the number of diversion structures have been built across the Deduru Oya, for example, Ridibendi Ela anicut and Deduru Oya anicut at Batalagoda use the water mainly for irrigation purposes. Besides, small and medium size tanks gather water from streams connected to Kimbulwana Oya and Hakwatuna Oya. Likewise, people around the streams of Maguru Oya and Deduru Oya also use a considerable volume of water for their daily use. Although, this is an outstanding feature for controlling severe floods during the heavy rainy periods in the Lower Deduru Oya Basin, a severe drought when it hits, will endure in the same area for nearly 7 to 9 months creating an acute water shortage. Furthermore, this situation is likely to aggravate in the future after the construction of the proposed Deduru Oya Reservoir.

The population increase and enhanced economic activities in the recent past have seriously affected the topography, existing drainage system and land cover in the LDOB. Hence, a detailed analysis of the existing situation is a prerequisite for any integrated development effort. This paper will provide a basis for the development of a management action plan for the LDOB, which is a typical river basin system with all the characteristics required for a comprehensive study on water shortage. This paper is based on the study "Vulnerability of Land Use to Environmental Impacts: Evidence from the Lower Deduru Oya (river) Basin (LDOB), Sri Lanka", The main objective of the Research Project was to identify and document the topography, land use activities and land cover of the LDOB. More specifically, its other objectives can be divided into two, as, a) to analyze more particularly the physical processes and b) to analyze the links among topography, land use activities and environmental impacts. This paper attempts to reveal the reasons and consequences for the water shortage in the study area. This study can be used as a framework for developing environmental action plans for similar river basins in the country.

Methodology

A review of relevant literature and existing material pertaining to the environmental impacts that are caused by water shortage was conducted to gather evidence from the LDOB on a comparative footing. Water samples for laboratory analysis and deep-well locations were geo-referenced using a GPS device (SporTank MAGELLAN). Pre-testing of the questionnaire to collect socioeconomic data was done prior to the commencement of field work. Group discussions similar to Participatory Rapid Assessment (PRA) for the selected user groups such as Farmer Organizations (FOs), sand miners and transporters, small entrepreneurs, school teachers, senior citizens, Association of the Chilaw Tax Payers, public officers (government officers and police officers) were conducted with a focus to identify the water shortage problem in the study area.

An Overview of the Deduru Oya Basin

The LDOB lies within the intermediate climatic zone in the western part of Sri Lanka. It consists of lowland terrain (flat and flat to slightly undulating terrain) which extends from the river mouth (between Mahaduwa and Muttuwa) to Podidelpotha in Pallama DS Area (Figure 1). The area is located within the 91000E - 107000E and 265000N - 270000N National Grid System (1:50000 Chilaw Metric Map).

The whole Deduru Oya Basin is located in the Intermediate Agro-climatic Zone and its upper tributaries originate in the western part of the Central Highlands. This basin can be divided into two broad categories namely (a) Uplands, and (b) Lowlands. Within these two categories, six Geomorphic Surfaces (terrains) in the Deduru Oya Basin have been identified by Katupotha (1992) on the basis of absolute altitude, slope and other characteristics. The relationships of these phenomena are shown in Table 1. The drainage density and patterns as well as land use systems on each geomorphic surface depend on the geological structure, characteristics of each terrain, soil conditions and present climate.

Basic data of the Deduru Oya Basin are shown in Table 2. When compared, this basin with selected wet zone basins such as Kelani, Kalu and dry zone basins and Kubukkan Oya, Kirindi Oya, it represents that specific characteristics, mainly extended area of the basin, average amount of rainfalls and bifurcation ratio. They are accountable for the gross amount of contribution of rainfall to groundwater recharge and sub-surface run-off. Such a comparison is essential to understand water sufficiency and insufficiency in any area. Parameters such as the catchment area, gross contribution of rainfall to groundwater recharge, evapotranspiration, and sub-surface run-off losses, net groundwater recharge are also shown in the same table, while a categorization of streams by drainage orders is presented in Table 3.

The water shortage or deficit of the LDOB is controlled by the middle part of the Deduru Oya Basin (MDOB) and the upper reaches. The MDOB is more significant than the upper Deduru Oya Basin (UDOB), because the water flow of the main river is diverted to large irrigation reservoirs situated away from the river course. Examples are Magalla Wewa, and Batalagoda Wewa. In addition, the Hakwatuna Oya Reservoir located on a major tributary, catches an extensive volume of water. This pattern will be expanded after the construction of the proposed Deduru Oya New Reservoir. The MDOB area appears as mainly undulating terrain extending 30 m – 150 m AMSL, which is significant as a water storage area.

Figure 1. Study area, the Lower Deduru Oya Basin (from Deudru Oya mouth to Podidelpota).

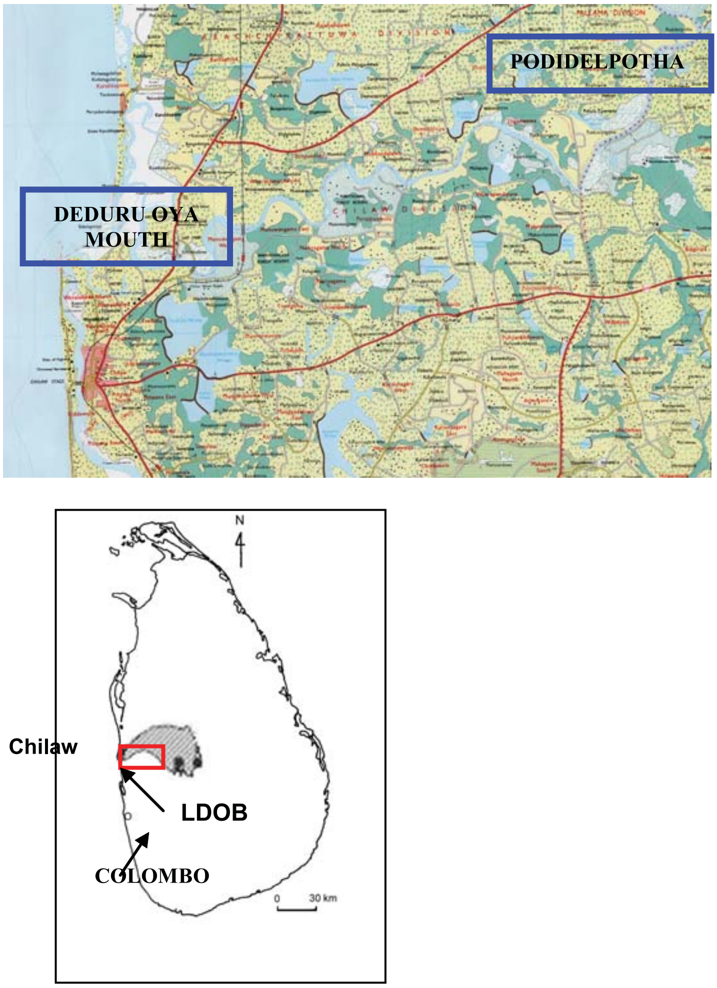


Table 1. Characteristics of terrains in the Deduru Oya Basin.

Class (Terrain)	Absolute altitudes (meters)	Landforms	Vegetation	Soil
Almost flat (A I)	< 30	Sand spit, barrier beach, beach ridges, brackish-water marshes, swamps, peat bogs, meanders, point bars, ox-bow lake	Creeping vegetation mangroves, grasslands riverine forest	Unconsolidated sand, silt and clay; peaty clay.
Flat to slightly undulating (A II)	< 30	Low hills and rises; natural level, flood plain, marshes	Riverine forest, dry evergreen forest, swamp vegetation	Red or yellow with brown earths; alluvial soil, bog soil

Undulating (B)	30-150	Hills and rises, low rock knobs, valley bottoms	Dry evergreen forest, swamp vegetation	Reddish-brown earths; Non-calcic brown soils and low humid glay soils; red-yellow podzolic soils; strongly mottled sub-soils and low humid glay soils
Rolling and hilly (C)	150-460	Hills and ridges, rock knobs and erosional remnants, valley bottoms.	Dry evergreen to semi-evergreen	Reddish-brown earths and immature brown loams, red-yellow podzolic soils
Dissected rolling and hilly (D)	460-915	Dissected hills and ridges, deep slopes, moderately deep valleys, erosional remnants, rock-lands and lithosols.	Semi-evergreen forest	Immature brown loams,erosional remnants with shallow soils
Steeply dissected rolling and hilly (E)	Over 915	Steeply dissected hills and ridges, steep slopes, deep valleys, rock-lands and lithosols	Semi-evergreen forest	Reddish-brown latazolic soils; erosional remnants with shallow soils

Source: Katupotha 1992

Table 2. Basic data of the Deduru Oya Basin.

Attribute	Value
Catchment area (sq. km)	2,616.32
Perimeter (km)	306
Axial length (km)	86
Basin width (km)	308
Form factor	0.36
Circulatory ratio	0.36
Elongation ratio	0.68
Stream frequency	0.57
Average rainfall in the Deduru Oya Basin (mm)	1,728
Gross amount of rainfall of the basin (MCM)	4,522
Evapotranspiration and sub-surface runoff losses (Cu. Mt.)	3,648.41
Net groundwater recharge CM	5,472.33
Discharge to the sea (MCM)	1,608
Discharge density	0.747
Bifurcation ratio	4.23
Discharge to the sea (percentage of rainfall amount)	36 %
Average net groundwater recharge for catchment per km CM	13.77

Source: Arumugam 1969; Irrigation Department 1974; Piyasiri, 2007

Table 3. Drainage orders of the Deduru Oya Basin.

Stream Order	Number of Streams	
	Strahler[b]	Horton[a]
1 st order	701	1,146
2 nd order	172	294
3 rd order	38	55
4 th order	8	12
5 th order	2	3
6 th order	1	1

Notes: [a]Based on Horton (National Atlas of Sri Lanka),
[b]Based on Strahler (Drainage Orders by Katupotha [personal observation])

Identify the Long-term Climatic Conditions and Trends

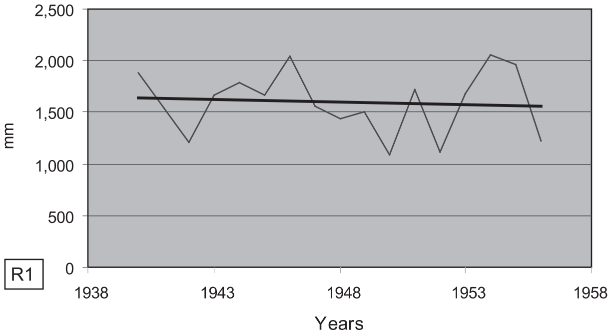
The global average of near surface air temperature over land, and sea surface has increased since 1861. Over the twentieth century this increase has been 0.6° ± 0.2° C. This value is about 0.15°C larger than the estimate by the Second Assessment Report (SAR) for the period up to 1994. These numbers take into account various adjustments, including urban heat and island effects. The records show a great deal of variability. For example, most of the warming occurred during the twentieth century, during two periods, from 1910 to 1945 and from 1976 to 2000. Globally, it is very likely that the 1990s were the warmest decade and 1998 was the warmest year in the instrumental record, since 1861.

The trend lines of the average annual rainfall of the Deduru Oya Basin indicate decreasing trends in the two periods at Ridibendi Ela Rainfall Station (Figure 2 - R1, R2 and R3). Figure 2 (R2) shows a high decreasing trend. At the Batalagoda Rainfall Station (RS), the rainfall has been decreasing at a lower rate than at Ridibendi Ela RS.

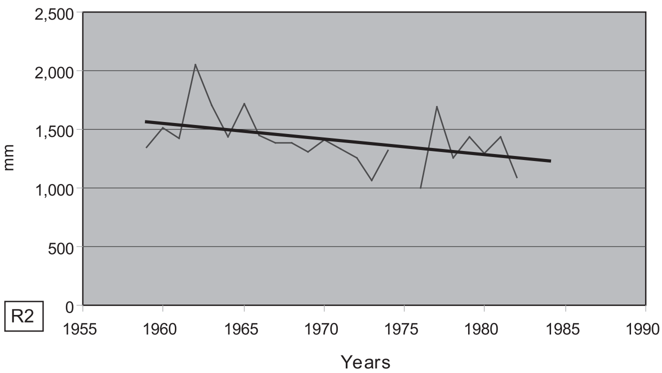
However, the trend lines of rainfall at Nikaweratiya and Kurunegala show an almost equal distribution (Figure 2 R4 and Figure 3 R5). The trend lines at Maradawila Estate, about 1.5 km away from the Deduru Oya (left bank) shows that the average annual rainfall has been decreasing, but with fluctuations (Figure 3 R7). Twenty-year records of this station revealed that 1991, 2001 and 2003 were minimum rainfall years. Although the Ratabalagara Estate represented an increasing trend line, the years such as 1991/1992, 2001 and 2003 reported minimum rainfalls (Figure 3 R7). This estate is located on the same river bank and is about 10 km away from Deduru Oya. When compared with rainfall data (years) at Maradawila Estate and Ratabalagara Estate with Batalagoda, Kurunegala, Chilaw and Nikaweratiya RSs, these have more data (years) to examine long-term trends.

The annual average temperature (AAT) at the Kurunegala Meteorlogical Station (MS) shows an increasing trend between 1870 and 1990. Puttalam and Katunayaka MSs are located to the north and south of the Deduru Oya estuary, respectively. The trend line at Puttalam MS reveals that the AAT is increasing as rapidly as in the Kurunegala MS. At the Puttalam MS, higher temperatures were recorded around 1869, 1881, 1906, and 1914, 1945 – 1950 and 1980 – 1990. These periods are coinciding with the high temperature values at Kurunegala

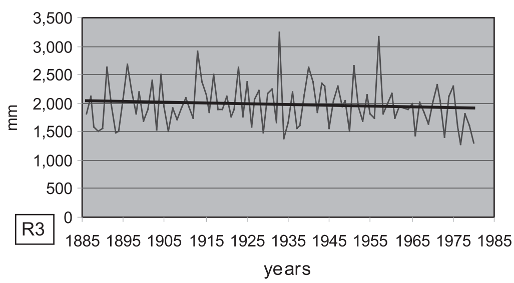
Figure 2. Decreasing trends of rainfall at selected stations of the MDOB.



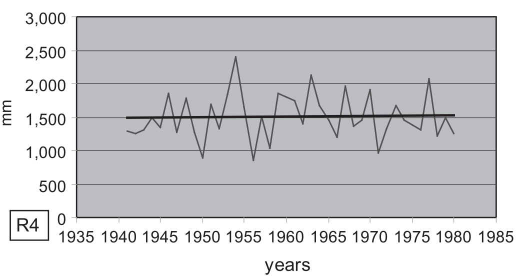
Average Annual Rainfall and Trends at Ridibendi Ela



Average Annual Rainfall and Trends at Ridibendi Ela



Average Annual Rainfall and Trends at Batalagoda

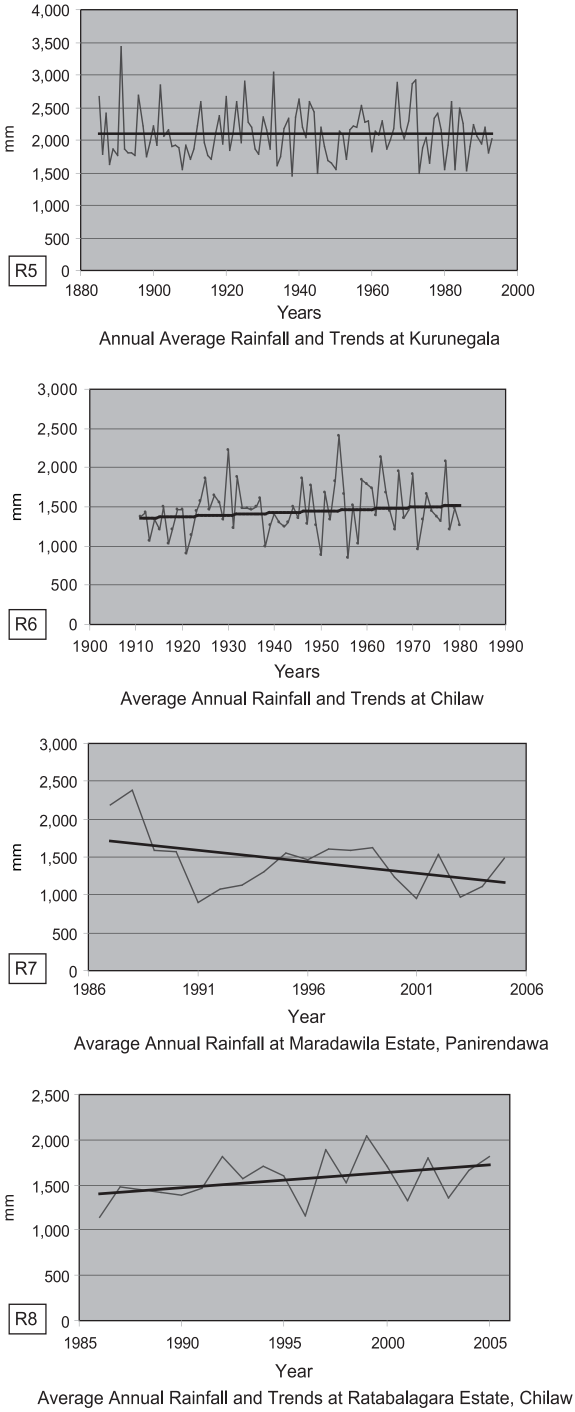


Average Annual Rainfall and Trends at Nikaweratiya

MS and also with global warming periods. The low rate of increase at Puttalam MS is related to its location, close to the Puttalam Lagoon and the sea. The Katunayaka MS is also located close to the Negombo Lagoon and the sea. The second episode of global warming (1976 – 2000) is reflected in the Katunayaka MS data. The trend line indicates that the AAT has risen at a higher rate than at the Puttalam MS.

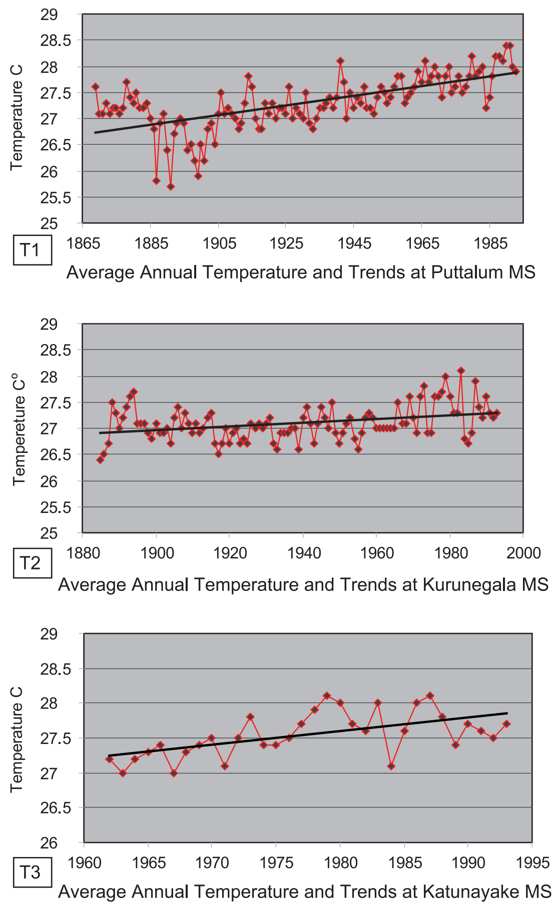
It is noteworthy that the fluctuations of AAR and AAT within the Deduru Oya Basin can be correlated with the changes of the land use pattern in the area. Man-made causes such as urban development, resettlement schemes, and deforestation in and around the basin,

Figure 3. Trends of rainfall at selected stations of the MDOB and LDOB.



have been responsible for the vulnerability of land use. The two global warming periods that have been identified from 1910 to 1945 and from 1976 to 2000 are reflected in these data of the rainfall stations of the Deudru Oya LDOB and MDOB and Puttalam, Kurunegala and Katunayaka Meteorological Stations (Figure 4 – T1, T2 and T3).

Figure 4. Trends of temperature at selected stations of the MDOB and LDOB: NagasawT1T2.



Source: Nagasawa et al.1995

It is very difficult to find continuous rainfall and temperature data relating to the Deduru Oya Basin. However, the limited data that is available provide sufficient clues to identify sequential drought and flood periods. Likewise, these data reflect the results of deforestation, encroachment of forest reservations, chena cultivation etc. The lapse of time, increase of population by settlement rather than by natural growth, improper land use practices, legal and illegal forest felling in forest reservations and other forests were instrumental in reducing surface water storages and groundwater levels.

Water Shortage

Recent changes in land use activities and land cover, which took place during the last few decades, are easily observable, while inadequate water for agriculture and domestic use account for a large part of this change. Forest felling in the bank reservations and surrounding areas, sand and clay mining and encroachment of forest lands have been instrumental in fluctuating the water level and in eroding the banks of the Deduru Oya. These activities have been responsible for widening and deepening the river in the study area. As a result, annual frequency and intensity of floods decreased, and the continuous flow of the stream has been hampered.

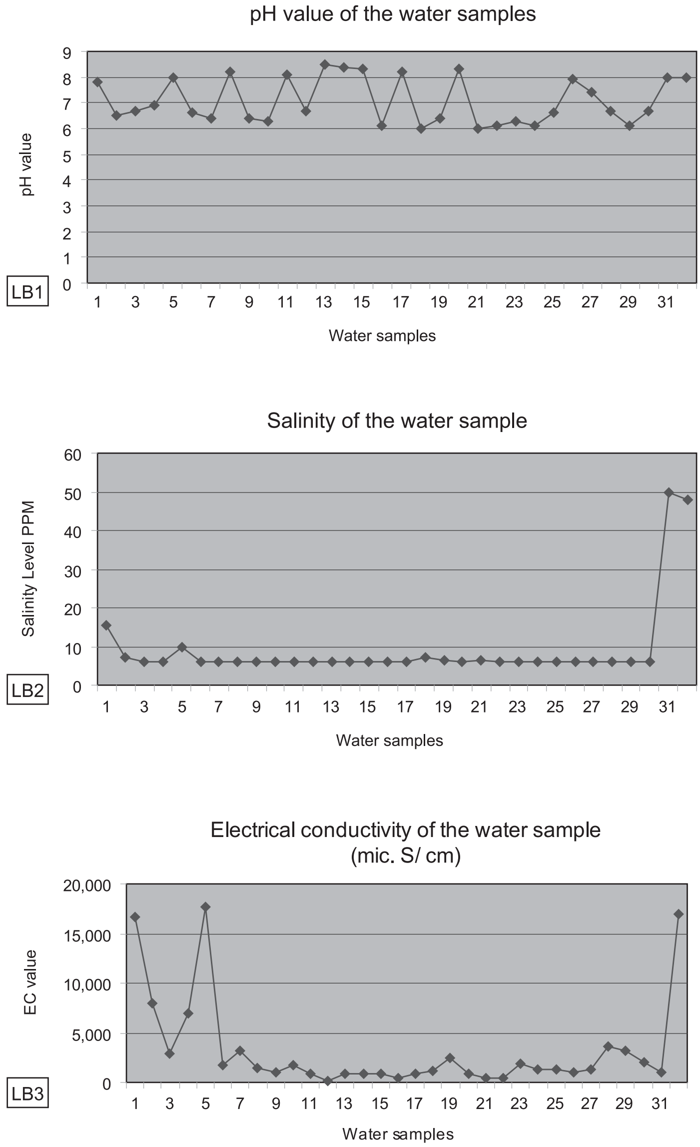
The traditional water source for surface irrigation was water collected in depressions (locally known as *ebas*). Once *ebas* have no water, farmers used to dig open ponds (agro-wells, named as *Gala Linda*) within their farmlands to provide water for cultivation. Using these open ponds, farmers cultivated coconuts, paddy as well as leafy vegetables. The open water ponds dried up gradually due to the reduction in the volume of water flow in the Deduru Oya, and lowering the water table because of excessive sand mining in the river bed and at the banks. Consequently, farmers who faced water scarcities for their cultivations were compelled to use tubewells. At the beginning these wells were 8-12 meters deep. Hundreds of tubewells are found in the four DS Areas in the LBOB. Water is pumped from these tubewells for the cultivation of coconut, paddy and leafy vegetables, as well as for animal husbandry and domestic uses.

During recent years banana and leafy vegetables have become the predominant crops in the study area. There is no longer any paddy cultivation, and coconut lands have been reduced to the minimum due to gradual lowering of the water table. The response of the farmers to this situation is manifested by the construction of tubewells, which sometimes are as deep as 20 – 30 meters or more from the surface level. Suspended and dissolved impurities present in the water of these tubewells make it unsuitable for many purposes, mainly for growing crops and using for drinking purposes. This is an acute problem experienced in many locations close to the Deduru Oya.

One of the major contributory factors for this is the extraction of water without any limitation from both public and private tubewells for agriculture as well as for domestic uses. Simultaneously, the water level of the river also shows a sharp drop owing to the deepening of the river bed by sand mining. This has resulted in further environmental problems. Lateral seepage of water from the ground into the river and the flow of tidal water upstream have been more significant among them. The inflow of tidal water flow is of such an extent as to cause salt water intrusions into the tubewells. This inflow is at its maximum during the pronounced dry periods occurring in February to March and July to mid-September.

Once water supplies are classified, water quality standards may be set up for different purposes such as drinking, other domestic uses and cultivation. To evaluate the water quality of the LDOB, the present study examined 31 water samples from different locations. The result of these water samples are shown in Figure 5. The SLS (SLS Drinking Water Standards 614; 1983 Part 1) drinking water standards show that the pH value should range between the preferred values of 7.0 to 8.5. But the maximum pH values of WHO range from 6.5 – 9.2 and SLS values range from 6.5 – 9.0. According to SLS, Electrical Conductivity Value (ECV) for drinking water should be 750. But the maximum value is represented to be at 3,500. The laboratory test data show that ECV in Sample Nos. 12, 16, 21 and 22 are below the preferred values and Samples 1, 2, 4 and 5 exceed the maximum values.

Figure 5. Water quality of the surveyed area from different locations.



Salinity is the saltiness or dissolved salt content of a body of water. It measure as 35 g dissolved salt / kg sea water = 35 ppt = 35 o/oo = 3.5 % = 35,000 ppm (The Engineering Tool Box 2005). The salinity of different waters is as follows:

drinking water - 100 ppm

restriction on drinking water - 500 ppm

limit drinking water – 1,000 ppm

limit agriculture irrigation – 2,000 ppm brackish water - 500 - 30,000 ppm

sea water - 30,000 - 50,000 ppm

brine > 50.000 ppm,

The field investigations revealed that the salinity levels of samples varied from below 5,850 to exceeding 48,000. No. 1 is 15,500 ppm. It is possible to assume that values exceeded 2,000 ppm due to sea water (tidal water) flow reaching up to about 8 km inland from the Deduru Oya Estuary. However, the sodium content of the drinking water has not been specified. It was revealed that due to salinity and electrical conductivity the water is not suitable in many locations for drinking.

The following is a list of water sample locations: 1. Deduru Oya Bridge (Left Bank), 2. Siripura Saw Mill (to east), 3. Gajanayaka Stores (Back Side, 4. Sirirpura, 5. Old Bridge (Deduru Oya), 6. Temple (Well), 7. Rathmal Canal, 8. Daduru Oya, 9. Manuangama (East), 10. Manuangama (East), 11. Weherakale, 12. Weherakale Close to Deduru Oya, 13. Wilatthawa Mankada (Deduru Oya), 14. Isurugama Dematapitiya, 15. Diganwewa Mankada, 16. Weherakale, 17. Weherakale In front of China Pump House (Southern Band), 18. Weherakele, 19. P.V.A Ariyarathna (Praja Sala Road), 20. Waragodella Mankada, 21. Ariyagama North, 22. Ariyagama (Just to Mr Ariyarathna's Land), 23. Rambepitiya, 24. Rambepitiya, 25. Ariyagama (Jalashakthi Water Tank – not purified. 26. Ariyagama (Jalashakthi Water Tank) – purified, 27. Ariyagama (Jalashakthi Water Tank) – Purification Center. 28. Ariyagama South. 29. Manuwangama East, 30. Manuwangama East, 31. New Bridge, 32, Chilaw Fishery Harbor.

Even in some sample locations for example, electrical conductivity is below 2,000 and the salinity is also below 5,850, which indicates that such water supplies cannot be used even for bathing and washing purposes. Inability to use soaps and similar material and coloring of white cloths are the major problems in many locations (Katupotha 2006). If this water, supplied with sodium, iron and carbonate concentrations is used for leafy vegetables, they will be easily exposed to sun-burning. Nevertheless, many farmers in the LDOB continue their agricultural activities using low quality water, resulting from the depletion of surface water and lowering of the groundwater table. Further, laboratory analysis reveals that salinity exists even in water samples, obtained from tubewells 10-15 m deep. This is a result of tidal water flow up to Ariyagama, Rambepitiya (left bank) and Dematapitiya (right bank), about 8–10 km inland from the Deduru Oya mouth.

Findings of the Study

Many prevailing environmental issues in the LDOB can be identified. Some of these are related to physical processes and others are related to anthropogenic activities. Table 4 shows environmental issues in the LDOB (by DS Area), which are definite causes for acute water shortage in the LDOB.

Changes in Land Use

During the early 1950s to 1990s, adequate water was available in the Ebas, and other surface water bodies in the LDOB. Irrigated paddy cultivation was the major type of crop cultivated by

Table 4. Environmental issues in the LDOB (by DS Area).

GSDs and GNDs	Deforestation	Encroached forest reserves	Flash floods	Soil erosion (river bank)	Water deficit	Groundwater pollution	Lowering of groundwater level
Pallama							
Pallama	H	H	H	H	M	L	H
Wathupola	H	H	H	H	M	L	H
Puliyankulama	H	H	H	H	H	L	H
Tammana	H	H	H	H		L	H
Arachchikattuwa							
Elivitiya	H	H	H	H	H	M	H
Dematapitiya	H	H	H	H	H	H	H
Diganwewa	H	H	H	H	H	H	H
Mukkandaluwa	H	H	H	H	H		H
Bingiriya							
Molaeliya	H	H	H	H	H	H	H
Getulawa	H	H	H	H	H	H	H
Pahala Thalampola	H	H	H	H	H	H	H
Ihala Galwewa	H	H	H	H	H	H	H
Pahala Galwewa	H	H	H	H	H	H	H
Bingiriya	H	H	H	H	H	H	H
Chilaw							
Weerapandiyana	H	H	H	H	H	H	H
Manuwangama West	H	H	H	H	H	H	H
Manuwangama East	H	H	H	H	H	H	H
Nariyagama North	H	H	H	H	H	H	H
Nariyagama South	H	H	H	H	H	H	H
Parappanmulla	H	H	H	H	H	H	H
Thissogama	H	H	M	H	H	H	H
Deduru Oya	H	H	H	H	H	H	H

L = Low, M = Medium, and H = High

Source: Field observations 2006

farmers. Paddy is a lowland crop which needs relatively more water than other crops. Due to the unavailability of water, farmers gradually shifted to cultivate upland crops such as pumpkin, maize, and leafy vegetables etc. (Annex 1, E and F), which consume a lesser amount of water. In the meantime, farmers also started to cultivate perennial crops such as coconut, mangoes etc. At present irrigated paddy cultivation is only a minor agricultural activity. Due to insufficiency of water, only a few farmers cultivate paddy using rainwater and water from tubewells.

Abandoned Surface Irrigation

The survey revealed that almost all surface water bodies such as Ebas, Kaliyas, Gala Lin, tanks, anicuts and irrigation canals were abandoned. In many places, these appear as ruins of waterways and water bodies which are now filled with soil and other debris. In many cases, shrubs and small trees have covered these irrigation structures. The encroachment of reservations for settlement, for cultivation practices and for sand and clay mining continued in or around such structures. The banks of the canals and water bodies have been destroyed. These water bodies were neglected for a long time without proper maintenance and management, and no steps have been taken to rehabilitate them for a long time.

Extensive Use of Tubewells

Extracting water from tubewells for surface irrigation has been a common practice in the LDOB. The information gathered indicated a gradual shift of water sources by farmers from, surface water bodies in the early period to large diameter agro-wells and finally to shallow tubewells. The drying up of large diameter agro-wells compelled the farmers to shift to the practice of tubewells. At present farmers use tubewells with depths of 20 – 30 m (or more) to extract groundwater (Annex 1, G – J). Hundreds of tubewells exist in both banks of the study area and almost all the surveyed households have tubewells to extract water.

Lowering Groundwater in the Deduru Oya

The groundwater level in the area was around 8–12m historically. This was increased up to 30 m. The amount of water flow in the Deduru Oya also has reduced. Moreover, in some places, water is not flowing due to a lesser amount of water and due to the deepening of the river. About 20 years ago, the river bed was about 6–8 m from the surface level and today the depth of the river bed is 12–15 m below the river bank. This has resulted in groundwater flowing into Deduru Oya through lateral seepage (Annex 1, D).

Soil Erosion

Soil erosion in the Lower Deduru Oya Basin (LDOB) has a close relationship with slope units on a geomorphic surface. Hence, undulating terrains with gentle to moderate slope (3^{o}– 8^{o}) with 1 in 20 to 1 in 5 and 3 gradients experience sheet erosion or sheet wash. The sheet erosion removes surface debris at relatively slow speeds and over long periods occurring concurrently with rains. During heavy rainfall, sheet erosion becomes flash flood in which case soil erosion becomes extremely severe. As a result, well-drained, cultivated and built-up crests of the undulating terrain becomes barren land with the formation of rills and gullies, and the surface debris that is transported along the slopes gradually fill or silt up wide valley bottoms, flood plains, marshes, and downstream resulting in severe floods and water pollution in flat and undulating landscapes (Annex 1, A and B). The human activities such as illegal forest felling, inefficient agricultural practices and overexploitation of sand from the banks and the river bed of the river have accelerated the above physical processes.

Occurrence of Flash-floods

About 30 - 40 years ago, the frequency of floods that resulted in the submergence of the area was one to three annually. But no severe damages were caused due to the existence of a forest cover. Frequent flooding had reduced since 1998. However, flash floods have attacked the banks, dams and other man-made structures occasionally. For example, during late October and early November in 2006, flash floods caused damage to river banks, dams, cultivated lands and other man-made structures (Annex 1, A and B). The absence of surface vegetation due to deforestation, reduction of infiltration of water into the soil, absence of proper draining systems, filling and siltation of reservoirs, canals and open water holes have aggravated flash floods. As mentioned by Chandrajith et al. (2008), the water from flash floods cannot be used for drinking and domestic use because of pollution from organic matter, phyllosilicates, and heavy minerals in the sediments.

Deterioration of Water Quality

Many farmers reported that turbidity, pollution and salt water intrusion are the major issues in tubewells. Using for irrigation the water from tubewells that are situated closer to banks and the river mouth has become a problem due to the high salt concentration in the water. This observation was confirmed by a laboratory analysis of water samples.

Thus, the absence of adequate water for agricultural, domestic, industrial and other activities was evident. Changes in land use, abandoned irrigation structures, extensive use of tubewells, and lowering of groundwater levels were recorded. All these are considered responsible for weakening socioeconomic activities and social milieu. This situation has been instrumental to slow down the development as well as to arrest the improvement of living standards of the people in the LDOB.

New Reservoirs in Middle Deduru Oya Basin (MDOB) Area

More than 50 years ago, mega irrigation projects were proposed to cross the Deduru Oya at Thunmodara in Wariyapola and Demodara, where the Hakwatuna Oya and Kimbulwana Oya met to irrigate the Kurunegala District, Puttalam District and the Rajanganaya. Despite several efforts, this project never materialized due to the protests of affected parties.

The proposals for the Deduru Oya scheme include plans to construct a dam across the Deduru Oya. The capacity of the reservoir will be about 75 MCM while it incepts catchments of about 1,400 km^2. The left bank canal will provide water for several small tanks. The Right bank canal will be a trans-basin diversion to the Mi Oya catchment, to feed the Inginimitiya tank. In addition, a power plant of 8 GWh is to be installed and is expected to provide drinking water for the two cities of Wariyapola and Nikaweratiya.

As mentioned above, the Deduru Oya flows through Intermediate and Wet Zones. The expected outcome of comparing parameters such as stream frequency, drainage density and numbers of stream orders etc. of the Deduru Oya, when compared with the same of the Kelani, Kalu, Walawe, Mundeni Aru, Maduru Oya and Mahaweli Ganga, are a daydream. This is because, the Deduru Oya Basin and its surroundings receive heavy rains during the 1st inter-monsoon and 2nd inter-monsoon and northeast monsoon periods, thereby ensuring a surplus of water. The trend lines of the average annual rainfall of the Deduru Oya Basin indicate decreasing trends in rainfall, and that the rainfall is insufficient to maintain mega irrigation works as well as proposed hydropower projects, which will be expected to be completed by 2010. Nevertheless, even after the completion of the Deduru Oya Reservoir by 2010, the Ridibendi Ela, Magalla Wewa and LDOB will face more severe water shortages than at present.

Recommendations

The formulation of recommendations under this study was done after an extensive analysis and evaluation of findings and consultations with relevant stakeholders in considering the magnitudes of the issues related to water shortage and deterioration of living standards.

The banning of sand mining in the Deduru Oya until the sand deposits at the river bed improve again, is one recommendation given that at present, there is no balance between the natural deposition of sand and human excavation and transportation. Around 1997 or 1998, the deposition of sand was greater than the transportation, and continued to be greater until the river had an adequate compilation of sand in the banks and river bed. But, since then and up to the present, more than 80 % of the braided sand deposits of the LDOB have been exploited by sand miners and transporters. Therefore, the following recommendations are needed to overcome the difficulties faced by the LDOB.

Strict Law Enforcement

Strict law enforcement by relevant institutions on sand mining and transportation is required immediately as regards the LDOB. At present, enough legal documents exist to protect and conserve the land, soil, air, water as well as fauna and flora. It is necessary to pursue law enforcement from the bottom and upwards. Therefore, the *Grama Niladhari* should be considered as the key officer at the village level. According to the Diary of the *Grama Niladhari*, (Section 4.14) he should “take actions in (the) conservation of reservation lands and rivers, streams and river banks”. Based on this power, if all *Grama Niladhari* Divisions of any DSD conserve the reservation lands and rivers, streams and river banks, invariably the natural resources will be protected. Therefore, it is necessary to organize the officers at this level to negate the interference of politicians, their followers and power groups and law enforcement officials of the relevant authorities.

Concerning the Deduru Oya sand robbery or sand terrorism, the agencies or officers such as GSMB, CEA, PEA (NWP), District Secretary, DS and GN are expected to implement rules and regulations through police officers. This has been a very difficult task because some police officers have close connections with sand miners and transporters. The DIG of the Northwestern (west) Division or SSP Chilaw Division is not willing to handle this responsibility (as evident during the Project period in 2007). Therefore, the Inspector General of the Police should take the power to control the environmental destruction of the LDOB.

All officials relevant to Deduru Oya sand mining and transportation, are familiar with the Supreme Court case (SC FR, Application No. 226/2006), proceedings of which are still continuing. Some letters of GNs and NGOs addressed to the DS, question as to how illegal sand miners and transporters could continue with their business against the wishes of institutions such as of GSMB, CEA, PEA (NWP) and the police when a Supreme Court case is ongoing. If some sand transporters are taken into custody by the police, the links established by the offenders enable them to escape easily. Sometimes, these alleged offenders would pay large amounts of money as bribes.

Protection of River Bank Reservations

The demarcation of river bank reservations by the Irrigation Department, DS and other provincial authorities, with the help of the Survey Department, should be pursued to protect the river banks. These reservations should be controlled by the GN, and it should be monitored by the DS and the Irrigation Department.

Rehabilitation and Restoration of Irrigation Structures

It is recommended that a barrage (dam) across the Deduru Oya (Manuwangama west is the most appropriate place) is built to divert water to irrigation canals. The location of this barrier should satisfy engineering suitability criteria on one hand, and people’s wishes on the other. This will enable to recharge the groundwater table, facilitate the gravity flow of irrigation water, reduce the input cost for irrigation through tubewells, discontinue the tidal water flow upstream and allow the rebuilding of sand deposits. Because of heavy damages already caused in many places of the LDOB, it is necessary to prohibit sand mining initially for a period of at least 5 to 8 years, and selective mining for a longer period of about 15 to 25 years or more under the supervision of the GN and DS.

If suitable sand deposits for mining exist, the locations for mining and quantities that could be taken out should be decided by GN and Community Organizations such as Farmers Organizations, Environmental Conservation Organizations at village level. Such sand should essentially be used to satisfy local requirements. Issuance of issuing licenses for such mining activities, the DS, and if necessary with the consultation of the Irrigation Department, should oversee such mining.

Delegation of Permit Issuing Authority to the Divisional Secretariat

The GN and DS are the most appropriate officers who have a wide knowledge on sand deposit and the balance of nature. The present license issuing system is not effective and efficient; it has created negative impacts to the environment creating acute water shortage, soil and bank erosion of the river, and break down of social coherence and social milieu. Past experience relating to LDOB sand mining, indicates that the GSMB issues licenses without proper consultation with local level authorities - GN and DS - and from the Irrigation Department. As the needed procedure is not in place, mining has caused heavy losses to the river bed and banks of the study area. Therefore, the license issuing authority for sand mining from river beds and banks should be taken away from the GSMB, and transferred to the Irrigation Department owing to the fact that the GSMB is preoccupied with earning incomes through issuing licenses, forgetting its responsibility as a service rendering institution.

Encourage Social Organization and Improve Coordination among Stakeholders, Public Organizations and Public Agencies

Although, many social organizations have mushroomed in the villages of the present day, they are not actively engaged in taking positive actions to mitigate the ill-effects of excessive sand mining. These community agencies should establish effective links with relevant public agencies in order to attain the desired objective of discontinuing the 'sand robbery' or 'sand terrorism' in LDOB.

Rehabilitation of Village Tank Network

Within the LDOB and MDOB area, there are a large number of small and medium sized tanks, but the water of these is not sufficient for paddy fields and other crops as well as domestic purposes. Although, the Deduru Oya Reservoir will be completed by 2010, the water shortage will arise in the right bank canal, of the proposed hydro power and drinking water supply projects. The project is carried out at a cost of Rs. 6,500 million. It is worth that this massive village tank network is rehabilitated by using this money of the proposed mega work. By this, it is possible to reduce flash floods and soil erosion, and in addition to, increase the groundwater table, which are helpful to minimize the water shortage in the LDOB.

Conducting a Community-based Awareness Program

Since a significant number of people are engaged in sand mining transportation, a large number of affected people are trying to keep the control of sand mining to a sustainable level. Before sand mining assumed hazardous proportions and provided an income source for politicians, power groups and some officials, it was a way of livelihood for some rural people. They used carts, tractors and small vehicles (like tippers) to transport sand on a small scale. With the beginning of commercial mining, the livelihoods of the people had been threatened. Due to the loss of their incomes, they are facing many socioeconomic problems. Therefore, it is necessary to introduce effective awareness programmes at different levels, especially for the victims as well as the beneficiaries in the LDOB. School level programs will also be very fruitful to induce long term results. All these will help to minimize the water shortage in the LDOB.

Conclusions

Many farmers have reported that turbidity, pollution and salt water intrusion are the major issues in tubewells. In some instances, due to a high salt concentration in the water of tubewells closer to the Deduru Oya and river mouth, extracting water for irrigation have become a problem. In order to evaluate the quality of water of the LDOB, the present study team examined the electrical conductivity, salinity and pH values of the water of 33 water samples from different locations. The result of these samples revealed that the quality of water is not suitable for drinking. In some locations, for example, where the electrical conductivity is below 2000 and the salinity is also below 5.85, water cannot be used for bathing and even for washing purposes. The inability to use soap and similar material and discoloring of white cloths are the major problems in many locations. If this water is used for leafy vegetables, the vegetables will be easily exposed to sun-burning. Further, laboratory analysis reveal that salinity is found even in water samples obtained from tubewells 10-15 m deep, where the tidal water flows up to Ariyagama, Rambepitiya (left bank) and Dematapitiya (right bank), about 8–10 km inland from the Deduru Oya mouth.

It has been revealed that the village society in the past has had a well linked social coherence. Accordingly, construction, maintenance and rehabilitation of rural tanks, roads, community work and other infrastructure improvements have continued with the participation of all. This has been changed due to the introduction of market based economic activities, especially the plantation of commercial crops. This process was aggravated due to excessive sand mining during the last decade, and damaged self-sustaining economic activities. The social milieu was also destroyed, creating several social issues, for example, the increased use of alcohol, hashish and similar things.

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Annex 1

Damages caused by flood water at the Deduru Oya dam close to Puliyankulama.

Example of a damaged river bank.

Sand transportation routes at the river.

Bank erosion threatening coconut trees and surface water flow towards the river bed.

Watering for leafy vegetables.

Leafy vegetables in paddy field at Manuwangama.

Silt and muddy water create water pollution by flash floods, bank erosion and sand transportation routes at the river (Photos A, B, and C). Photo [D] shows the lateral seep of water from the ground into the river due to deepening the river bed. Likewise, unavailability of water, farmers gradually shifted to cultivate leafy and other vegetables in paddy fields in the LDOB.

The farmers drop the instruments to the bottom of a former used well to obtain deep water.

Aspect of the dropped tubewell instruments (same well).

Lowering of water level of surface wells due to excessive sand mining in the area.

Aspect of the dried well and dropped tubewell instrument to the bottom.

Water of this well cannot be used due to the low salinity and other impurities.

Community water supply scheme at Ariyagama, The tubewell at this place is 30 m deep from the surface level.

Farmers put tubewell instrument at the bottom of wells to obtain deep water for cultivation and other purposes [Photos: G, H, I and J]. The tubewells and normal wells [Photo L] waters with suspended and dissolved impurities in are not suitable for irrigating crops and using for domestic purposes.