CHAPTER - TWO
REVIEW OF RELEVANT LITERATURES, PERIODICALS,
JOURNALS, NEWSPAPERS ETC.

2.0 INTRODUCTION

At the apex of Ganga delta, in Central West Bengal, Murshidabad district is the only linking gateway between North and South of West Bengal. Geographically the district is crucial for Bengal’s agro-economy. It is also known as one of the granaries of West Bengal. The stratigraphy of the study area \(^7\) [after Biswas (1963) and \(^29\) Lindsay et al. (1991)] starts with deposition of the pre- Jurassic Gondwana deposits, which are overlain by the Late Jurassic to Early Cretaceous amygdaloidal basalts and andesites and the ~ 250m thick Late Cretaceous alternating sandstones and mudstone sequence of the Rajmahal Group. The Rajmahal Group is followed upward by a thick, uninterrupted arenaceous-argillaceous sedimentary sequence from the early Paleocene to the end of the Pliocene period, comprising the Jaintia Group (Paleocene-Eocene) and Bhagirathi Group (Late Eocene to late Pliocene). The sediments of the Bhagirathi Group are clumsily overlain by the Pliocene-Pleistocene Barhind Formation. This Holocene sediment of Bengal alluvium forms the surficial lithostratigraphic and geomorphic unit throughout the Bengal basin. The fluvial processes have formed extensive Holocene flood plains with a dominance of coarser grained sediments overlapping a number of sub deltas \(^{35}\) (Morgan and Mc Intire, 1959). In the study area avulsion of major streams which are tributaries and distributaries of river Ganges, within a time scale of 100 years resulted in a thick layer of tens of meters \(^2\) (Allison et al., 2003) of recent over bank silt and clay incised by channel sands \(^{14}\) (Coleman, 1969; \(^{55}\) Umitsu, 1987; \(^{23}\) Goodbrewd and Kuehl, 2000). The Bhagirathi’s recent surface area have sediments confined to the present channels and comprises of a narrow belt of terraces about 3-5 km in width, slope 0.2 per km \(^6\) (Bhatacharya, A. and Banerjee, S.N., 1979). The terraces can be mapped as; a) the lowest level along the Bhagirathi, very much flattened due to erosion, b) a little higher well preserved flat land is observed. No soil development takes place and the surface is composed of loose and completely unconsolidated sediments. Big meanders
scars, cut off backwaters, ox bow lakes, abandoned channels and natural levees are some important sedimentary structures of the study area. River Bhairab in plate no. 2.1 is one of the typical channels in the ‘bagri’ regions of Murshidabad.

![Terrace formation of river Bhairab due to silting.](image)

Plate no: 2.1 Terrace formation of river Bhairab due to silting.

### 2.1 STRATIGRAPHY

Stratigraphic classifications are available in many literatures. Aquifers in the alluvial are part of probably i) late Pleistocene to Holocene Ganges sediments and ii) early to middle Pleistocene coastal and moribund Ganges delta, deep aquifer composed of stacked, main channel, medium to coarse sands to depth more than 130m (Mukherjee et.al., 2007). The aquifer is highly productive with water table within 15m below ground level (bgl) in Murshidabad. The annual rainfall ranges from about
<1200mm to 1611mm \(^{(13)\text{CGWB, 1997}}\). Year after year the ground water levels tend to be similar, which suggests sufficient recharge replenishing the groundwater system \(^{(5)\text{(BGS/DPHE/MML, 2001), CGWB; }^{9,10,11,12}\text{(1994a, b, c, d, e) and }^{53}\text{SWID, (1998) }}\) estimated that transmissivity (T) values in \(\text{m}^2/\text{day}\) vary from 3300 to 7000 in Murshidabad with average storativity (s) of 0.03 unit. The hydraulic gradient is about 1 m/km in the northern part of Bengal Basin. The present day, natural, regional water flux to the Bay of Bengal has been estimated by mass- balance calculations to be \(2\times10^{11}\ m^3/\text{year}\) (equal to about 19% of the total surface water flux of \(1.07\times10^{12}\ m^3/\text{year}\) \(^{(4)\text{(Basu et.al.2001)) and }1.5+ 0.5\times10^{11}\ m^3/\text{year}\) (equal to about 15% of Ganges-Brahmaputra river flux) \(^{(17)\text{(Dowling et.al., 2003). }^{59}\text{J.J.van Wonderen (2003), Sir Mott Macdonald Ltd. had commented that due to low elevation intermediate groundwater flow may not be distinguishable from regional scale flow. The flow is mostly vertical and lateral and may be limited to local scale. }^{36}\text{Mukherjee et.al. 2007 (July) had modeled a complex 3_D hydrostatigraphic framework for subsurface of western Bengal Basin. Hydrostatigraphic units have been defined as bodies of rock with considerable lateral extent that compose of a geologic frame work for distinct hydrologic system }^{31}\text{(Maxey, 1964). The result drawn shows that blocks such as Raghunathganj-II, Lalgola, Bhagawangola-I and II and Raninagar-II have topmost sand layers which extend from near the surface to a depth of about 65-75m. Below this unconfined aquifer is a basal clay \(^{54}\text{*aquitard extending from 80m to more than 300m in the west and got divided into multiple layers towards the east (Bangladesh). The upper clay layer is very thin and mostly replaced by a sandy clay layer between thick sand layers in Raninagar-2. A thick aquitard extends near Beldanga and Kaliganj in Jalangi Block. Isolated aquifers are noteworthy at depth of ~200 to 230m and ~240m to 265m extending from Bhagawangola to Berhampore through Murshidabad-Jiaganj with possibility of southward extension. These shallow aquifers have water chemistry distinct from the shallower aquifer }^{(37}\text{Mukherjee, 2006; }^{38}\text{Mukherjee and Fryar, 2007).}

\*aquitard- A saturated but poorly permeable stratum that impedes groundwater movement and does not yield water freely to wells, but that may transmit appreciable water to or from adjacent aquifers and where sufficiently thick, may constitute an important groundwater storage zone; sandy clay is an example. ‘tard’ Latin word tardus meaning “slow”. (Todd,D.(2003); “Groundwater Hydrology”, pp: 26).
2.2 DEFINITION OF HYDROMORPHOLOGY

Hydromorphology encompasses the field of geomorphology and the impact of anthropogenesis on hydrologic system. It is closely related with social sciences like geography, urban planning and environmental economics as well as all the common scientific disciplines which are central to hydrology. “A landform of a region is characterized by the present of earth surface topography or relief, the genesis, geomorphologic structure and its compounding material. Each compounding material of the landform will affect the groundwater condition, either the quality, the depth of groundwater movement, hydro-chemical type, or its aquifer permeability. Hence, the condition of groundwater in a region can be shown with the hydromorphological conditions of that region” (Santosa, L.W., 2006). Based on the spatio-temporal variations, landform unit can be used as the basis for the arrangement of hydromorphological unit, especially in unconfined groundwater. Landform unit, generally affect the distribution of groundwater. The variation or the difference of lithology will affect the difference of groundwater quality (Hem, 1970) and the aquifer permeability coefficient can be treated as measurement of the relative potential of groundwater (Todd, 1980). In Murshidabad, sole problem of hydrology and morphology are sedimentation, arsenic contamination with groundwater and reducing recharges of groundwater.

The morphological change i.e. cropping pattern change in the study area affects the direction of the movement and the depth of surface of unconfined groundwater. In sedimentation topography the analysis of groundwater hydro-chemistry is necessary to relate hydrological and geological environment of a particular spatial region. Ganges-Brahmaputra river basin is fed by sediments deposited by the rivers during the late quaternary or Holocene age. Sand, silt and clay combined with minerals like quartz, feldspars, illite and kaolinite and the fine grained over bank facies are rich in organic matter. Numerous rivers, those are originated from the Himalayas both in the north and northeast, deposit thicker newer alluvium of sand, silt and clay. (Singh, A. K., 2006). The dynamic morphology of a fluvial system evolves both due to natural and anthropogenic influences.
2.3 PROBABLE MECHANISM OF ARSENIC CONTAMINATION IN GROUND WATER

Arsenic (As) contamination in sediment, a problem, is explained by a number of hypothesis- a) Release of As following oxidation of As-rich pyrite, b) reductive dissolution of iron hydroxides and release of sorbed As in to the groundwater and c) anion exchange of sorbed As with phosphate from fertilizers. Sediment analyses showed that extensive extraction of groundwater for agriculture favors mobilization of Arsenic (As) in the Bengal Basin. Singh (2006), further emphasized that the practice of drawing arsenic contaminated groundwater from tubewells for irrigation may ultimately lead to poisoning of surface soil and surface water, which are normally arsenic-free even in arseniferous region of West Bengal. Therefore, the environmental factors that recharge the aquifers are influenced by hydro-meteorological influences that include the intensity, duration and volume of the precipitation and the ambient atmospheric condition, hydro-geological influences that include the geomorphology, geology and pedology of the land surface where the precipitation occurs with runoff subsequently flow, and the type of vegetation cover and land use \(^{47}\) (Siebert.et.al.2010).

All the above references in various journals, thesis, booklets, proceedings explained the important aspects of hydromorphology including structure, stratigraphy, lithology, morphology, process, morpho-structure, morpho-arrangement, depth of water table, electric conductivity distribution, hydro-chemical quality and aquifer permeability. But the gap between scientific knowledge and actual grassroots level human knowledge remained.

2.4 SOCIETY AND HYDROMORPHOLOGICAL KNOWLEDGE

\(^{18}\)Samanta, K.(2010) additional director of research at Bidhan Chandra Krishi Viswavidyala, an agricultural university in Kalyani, West Bengal points out that state agricultural scientists were not consulted during the formulation of the new Green Revolution plan. What has been overlooked in the formulation of the plan is that most
farmers are small marginal landholders and do not have knowledge of farm mechanization. They are good crop manager but planning for long term sustainable agriculture is not their concern. Throughout the world, the environmental policy has tended to take the view that rural people are mismanagers of natural resources. The history of soil and water conservation, rangeland management, protected area management, irrigation development and modern crop dissemination shows a common pattern: technical prescriptions are derived from controlled and uniform conditions, supported by limited cases of success, and then applied widely with little or no regard for diverse local needs and condition (Pretty & Shah, 1994; Benhke and scones, 1992; Pimbert and Pretty, 1995).

Dr. Hopkins of the United States Department of Agriculture Extension Services (1949) stated that “The Landowner must think for land…..The agriculture of a state cannot be managed from a central office.” He realized that educating the farmers must be incorporated in national program to enhance the development and effective farming. Indian farmers choose crops mainly considering the cash return that secure their farming business operation, profit, standard of living and the opportunity of the family dependent on land. Adaptations of soil and climate were neglected during the introduction of high yielding variety of seeds and groundwater extraction technology during Green Revolution. FAO (1952) in a proceeding have commented that short term policies adopted by a government may result in unusually high prices for depletion of soil and water status of a particular space. If any policies which cannot be avoided because of national emergency then agricultural extension agencies should educate and encourage the farmers before hand so that they might optimize their resources use while using new technology, new improved variety of seed and fertilizers (e.g. the ‘boro’, crop should be introduced where the soil is not sandy). The excellent combination of geology; geomorphology and hydrology have helped in myriads of crop cultivation since pre-green revolution. Sen, J. 1988 have mentioned the activities like gradual installation of shallow tube wells and deep tube wells for irrigation in Murshidabad District without any prior soil test or training. Wheat cultivation and vegetable cultivation were introduced during late 1970’s followed by ‘boro’ paddy cultivation especially in ‘Kalantar’ region of Murshidabad (Beldanga I and II blocks and Nowda block). The changing land use (cropping pattern) in India with
the advent of assured groundwater availability, farmers tend to move from traditional crops to high yielding and water intensive crops. A better return on investment for farmers provokes them into new crop culture without local research (Dube, S.et. al., 2005).

Sikder, et.al. (2001) reported that the presence of north-south regional flow near Calcutta had dramatically changed in 1980’s than in 1950’s. Ghosh and Mukherejee (2002) have called the river Bhagirathi-Hoogly a losing stream along most of its length and recharges shallow aquifers. Introduction of groundwater irrigation during 1960’s in Bengal Basin is appraised by A. Zahid and S.R.U., Ahmed, (2005). But later they discussed about the increasing problems of using such universally applicable technology. Almost 40 years had passed away where India had witnessed a phenomenal development of its groundwater resources. The later consequences of the adaptation is ‘deleterious’ effects of steep decline of water table especially in western and southern India. Dwindling yields, drying of water bodies and water quality deterioration are associated with technological adaptation (Romani, S. 2005). The need of data replacement and uploading at micro-level can help in the interpretation of water level, cross-section, current natural flow, reservoirs etc. (Zsuzsanna, N., 2007).

Water management cell both surface and subsurface can help in eco-efficiency assessments which help in environmental enlistment. In an International work shop by IWMI_ITP_NIH in Feb, 2005; it was proposed that “no model is universally applied”. Proper understanding of aquifer behavior in response to imposed or anticipated stresses is required for designing and implementation of management decision.

North-West and South India had numerous problems related to flow and contamination, pollutant transport, location of pumping, natural and artificial recharge and changes in groundwater quality. In Eastern part along the riverine terraces of Ganges, sedimentation, arsenic and fluorides contamination, agro-chemicals in sediments, salination are recorded since 1980’s. (Villholth,K.G. and Sharma, B.R.,2005). Tushaar Shah in the same workshop and other proceedings have discussed about a ‘daunting’ groundwater issues in Asian and African countries due to lack of preplanning about resource utilization. The groundwater crisis is mainly due to ‘crisis of governance’.
2.5 INTERNATIONAL SCENARIO OF HYDROMORPHOLOGICAL PROBLEMS AND SOCIETY

China, a water deficient country, drafted new water resource management to accommodate new challenges of water crisis in the country. The most important decision they applied was to enhance public awareness and knowledge of groundwater and create work environment for better communication among water managers, planners, decision-makers, scientist, and water users and reduce the official muddling among departments (Jin et al., 2005).

In Denmark in late 1960’s an agricultural transformation took place. They emphasize on knowledge and more information about soil, the field observation and recording the same, measurement of problem, conditions and development of resistant varieties of crops. An intensive interaction between scientific knowledge and knowledge generated by farmers in number of case studies in Denmark implies sustainable agriculture. Farmers, perception of risk, optimum use of resources, standard of living show a growth of local consciousness (Somer, N., 1998). In West Bengal traditional technologies of storing and extracting water for irrigation such as ponds, khal, beels, are prey to inattention and ignorance over time due to easy availability of ground water for irrigating the field causing morphological and chemical misbalance in water excepting few exceptions.

Hydromorphology seems to be a new term in geography but the content is age old since human civilization. Man is directly dependent on hydrology and morphology for its food, fodder and shelter. The invention of agriculture directly involves hydromorphology and in return hydro-morphology directly affects agricultural practice. The various ongoing programmes for and developing human standard of living has not resulted up to the expected level. Agro-climatic conditions, migratory character of rural people, lack of knowledge about the programmes being implemented and that to be launched; supervisions on the part of officer and officials ultimately create a gap between optimum utility of local physical resources and maintenance of the precious resources. In Awash basin of Ethiopia small scale irrigation was highly demanded for food and its sustainability. The irrigation scheme had worked efficiently but without proper technical training and proper water management, the small irrigation project
proved hazardous (Mekonen, W. A., 2004). The author observed that lack of technical knowledge, unawareness of interaction and interlinkages between agricultural factors, such as, crop rotation, pest management, introduction of new crops, water and vector borne diseases and environmental degradation have mismanaged the agricultural backbone of society.

A. Mitra (1979) in gazetteer of India, West Bengal Census Hand Book had discussed about geology of Murshidabad where he had quoted the absence of mineral of any economic importance in the district. He had forecast that the silts and clay mixed soil may be used for manufacturing of bricks and tiles.

Jones, J.A.A. (2010) has explained how ‘laissez-faire’ capitalist politics suffer from too much fragmentation among institutional responsibilities, inefficient management, overlapping interests, inter institutional rivalry, private profit making, lack of co-ordination between upstream and downstream users, inappropriate political interference, poor legal structure and lack of enforcement and empowerment mechanisms.

Therefore, scientific knowledge must be blended with people perception and practice because ultimately they are the affected and effected of all problems occurring in environment.

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*laissez-faire*- The view that a market economy will perform most efficiently if it is free from government intervention, and is subject only to market forces. This view is criticized because it takes no account of considerations such as environmental degradation except in so far as it might increase costs- or social justice. Furthermore, the model of the workings of the free market, on which laissez-faire economics are based, bear very little relation to reality; in the real world, markets are distorted by monopolies, lack of choice through cultural constraints, imperfect information and so on.
The hydromorphology of Murshidabad has been discussed by many authors separately as hydrological unit and as morphological unit. In this thesis, groundwater is taken as an important unit of study to justify the present hydrological and morphological problems. To know the knowledge and practice of people, schedule survey and questionnaires had been undertaken for perception study. Pal, S. and Bhattacharya, A. (2008) had analyzed that in spite of good ponding time, field moisture deficiency occurs, recharge volume is not very considerable. Due to small amount of rainfall within very long range of period (November to May), the ground water table is lowering each year. Moreover, human interference with aquifers, lack of knowledge about underground reservoirs has brought disaster in the district.

Mukhopadhyay. S.C. (2008) in his paper titled “Hydro-morphological problems and river basin management of West Bengal with special references to the Mahananda-Sankosh Interfluvial Areas” has stated that ‘management’ is a complex issue for the benefit of a basin as a whole. The issues are so widely spread out that a generalized solution is hardly possible. West Bengal is a state where different physiographic and climatic variations often puzzle the planners to implement a universal model for the whole district. Hence micro-level study and perceptual study is the latest trend of research to find probable solution of a particular space and time.

Stuben et.al. (2003), has chosen a small watershed (Gobranala) in the Murshidabad district (at and around Berhampore) and investigation was done on the measurement of major and trace element concentrations and stable isotope (O,H,S) composition of ground and surface water from the district watershed. River and groundwater samples are similar in their main hydro-geological composition but the Total amount of Dissolved Solids (TDS) in river water is slightly lower in surface water like Bhagirathi about 300mg/l; Gobranala about 500mg/l compared to groundwater up to 780mg/l. Many samples were taken out of them three samples form shallow (dug) well from new Hassanpur and twelve from a well that intercept the aquifer at a depth of 18m were collected. The three samples show higher concentration of SO₄ (40-168 mg/l) and NO₃ (33.0-87.4 mg/l), suggesting a partly anthropogenic source (agriculture, sewage) due to
infiltration and surface run off. Iron concentrations are extremely low in river samples (0.02-0.06 mg/l). The highest dissolved iron (Fe) content was registered in three samples from Daulatabad (6.4-7.0mg/l) and Kalupur (8.25mg/l) located in the east of Gobranala. Relatively higher iron (Fe) content was also recorded in samples from Chaitanpur (3.1mg/l), Bali (3.3mg/l) and Bhairabpur (2.7mg/l) and in the lower aquifer samples at new Hassanpur (2.1mg/l). The highest arsenic (As) concentration (104, 204 and 470 ug/l) were registered in the aquifer which tap at 18m depth. To the east of Gobra nala slightly lower arsenic (As) concentration was recorded at new Hassanpur (105ug/l) and Kalupur (106ug/l). The author has commented that arsenic (As) concentration has rose due to intensive irrigation and groundwater exploitation. Almost 75% of groundwater of Murshidabad is above 0.01ug/l (WHO permissible limit=0.01ug/l) and this content rises during the dry season December to May each year and again dilute during the rainy season.

A report by Kamal Bandhopadhyay in Anandabazar Patrika of 3rd August 1969, re-laid all the ‘beel’ of Murshidabad district with their area like Jalangi-Domkal ‘barabeel’ was 4800 bigha, ‘kakrajail’ was 2050 bigha, ‘dudhswar’ was 3850bigha and ‘ramna beel’ was 6700 bigha (1 bigha = 2.47 acres). Presently all these have turned into agricultural land. Drainage system is totally locked (Bandhopadhya, K., 2000 in Bengali). Probably, these water bodies used to flush the groundwater aquifers and surface soils during rainy season adding fertility to the soil and reducing environmentally existing arsenic contamination in groundwater. The philosophy of water management was guided by a reductionist and rather simplified notion of achieving total freedom from flood by channelizing the monsoon flow with embankments. This concept fails to take cognizance of the natural ecological functions that are equally important for the maintenance of the ecology and economy of the flood plains (Mc cully, 2007). Kuznets traces five distinct patterns in the growth in modern economic growth. They are a) scientific discovery or an addition to technical knowledge, b) an invention, c) an innovation, d) an improvement and e) the spread of invention usually accompanied by improvements. Presently, Murshidabd needs an improvement and spread of invention accompanied by improvements to boost up the
socio-economic upliftment (Halder, I. 2009) because “Water is life’s matter and matrix, mother and medium: nay water is life itself” (Jain, A.B., 2002).

2.7 CONCLUSION

Irrigation in India is victim of resource illiteracy and neglected commodity. The wastage occurring through storage, conveyance and distribution ultimately result in delivering hardly 35% to 40% stored water for the plant uptake. The age old practice that ‘more the water, higher the crop yields’ still persists with majority of cultivators. The government extension agencies have so far miserably failed in uprooting this notion. A. Vaidyanathan (2008), former member of the planning commission and a leading irrigation economist said” there is indeed a strong case for a major effort at renewing and improving traditional local systems. This can quite be fitted into the employment guarantee scheme and other schemes of land and water improvement”. He holds government apathy partly responsible for the present state of affairs and bemoans the fact that the “government has not given adequate attention or resources to keep the traditional minor irrigation systems in a state of good repair”. Groundwater irrigation is an appraisable fact of India since 1960’s. It has made the food deficient India into a surplus country. Today farmers are least dependent on rainwater. The purchasing power of diesel and kerosene ensures water for crops. Murshidabd has excellent groundwater layer if a slight attention is given on its recharge. More can be exploited from under ground with proper governance.

R.N. Athavale, (2009); National Geographical Research Institute, Hyderabad, Andhra Pradesh has said that the link between traditions and modern science cannot be ignored. “Traditional water harvesting system can be used to deal with contemporary water problems. With technological inputs, these ages old systems can become more efficient”. The author suggested that the problem of fluoride or arsenic in ground water will also be in reduced concentration through dilution. Rooftop biologically treated water harvesting and storage in multistoried building, artificial recharges, conversion of commonly occurring ‘pukurs’ (village ponds) into infiltration basins and construction of
hygienic open well to tap the phreatic (unconfined) aquifer. Arsenic level in groundwater presumably comes to the permissible limit. A. Vaidyanathan has further quoted “traditional water harvesting systems are by no means dead”. Flood plain wetlands are fast degrading but they are the rich source of biodiversity. These wetlands have greater values in groundwater recharge, flood control, prevent siltation and pollution and maintain habitat. Therefore to bring sustainability in groundwater irrigation and reduce hydromorphological problems their must be a bondage between science and society. 19Edited experts of ‘Down to Earth” (2011) has defined sustainable development very critically after a long journey since the term was first coined. The pious definition for ‘sustainable development’ is to understand the political content of the term. Sustainability can never be absolute. A society learns from its mistakes and rectifies its behavior. Learning from one’s mistake is crucial in understanding the pathway of sustainable development. One who learns faster will invariable is more sustainable than other society which takes longer time. No society can claim to be so knowledgeable that it will always manage and use its natural resources in a perfectly ecologically sound manner. New pressures will be exerted on the natural resource base; therefore, it is the responsibility of changing social, political, cultural and technological planners to use the natural resource base optimally. There is always a possibility of misuse or overuse and it is obvious that a society who is the decision maker is the sufferer of consequences of those decisions. Overuse and misused by a local community which is dependent on it for its survival and cannot easily relocate itself to another environment, the declining productivity of the resource will force the local community to change its ways. Sustainability therefore, demands creation of a political order in which first, control of natural resources rests to the maximum extent possible with local communities dependent on them and secondly, decision- making within the community is as participatory, open democratic as possible.

In chapter three along with the physical features explained, few relevant work of eminents on Murshidabad district is thoroughly discussed as a supporting documents of hydromorphological problem actually occurring in the study area.
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