

1.1 Introduction

Present day resource management is an important aspect to fulfil the demands of the growing population and to keep the resources available for future generation. The resource is generated by human and its progress depends on the intelligence of human beings. Moreover, people are the consumer as well as the destroyer of resources. People are constantly depleting resources for his inefficiency, unconsciousness, mismanagement and excessive needs. As a result, there is a crisis of resource availability for future generations. So, resource management is the process of regulating and managing of activity of human in the creation of resource and use of resources. In order to that the environment is balanced and the availability of resources is assured for future generation. The main objectives of the resource management are the proper utilisation of resources, increases the prosperity of resource and sustainability of resources.

Sustainable development has the most important contribution in the development of environment and economic growth. Now, in every country, it is the most important subject heading. Sustainable development is a technique where achieved the sustainability in any activity. Sustainable development is the process of long-term, holistic and real development system in compatibility with the natural environment through which socio-economic development is possible. The report of Brundtland (1987) known as “Our Common Future” under the United Nations World Commission on Environment and Development (UNWCED, 1983) mention the important policies and guidelines on sustainable development. Sustainable development was first defined by the Burdtland Report in 1987. According to report, sustainable development is a plan adopted to fulfil the demands of present generation and of course to maintain the needs of future generations without any compromising. The

explanation of the report was to re-examine the critical condition of different problems related to environment and development and to determine the proper policy and realistic proposal to overcome them. According to Repetto. R, (1986) in his creation 'Global Possible', sustainable development is a way that drives all the natural and human resources towards meeting a certain goal or objectives. This development way will never be detrimental to the environment. Rather, it should be coordinated with natural production processes. Food and Agriculture Organization (FAO, 2012) also stated that sustainable development can be defined by an appropriate balance between food self-sufficiency and food self-reliance, employment and income generation, and natural resource conservation and environment protection. The term 'Sustainable Development' was the main topic of discussion in different subsequent international conferences like, Rio Earth Summit or United Nations Conference on Environment and Development (UNCED, 1992), Convention on International Trade in Endangered species of wild Fauna & Flora (1973) IUCN Report (1980, 1990), World Commission on Environment and Development (WECD) Report named 'Our Common Future' (1987) and Basle Convention (1998) etc. However, the most significant conference in the world is Rio Earth Summit, Brazil on sustainable development and management. The convention produced a draft of 700 pages known as the Agenda-21. The Agenda-21 has a number of significant programs. Some important programs are followed,

1. Proper planning and management of land resource.
2. Development of agro-natural resource through the rural development and sustainable management.
3. Development of water resource.
4. Conservation of Biodiversity.
5. To give more importance to social forestry and agro forestry.
6. Making Decisions for Sustainable Development.

Sustainable agriculture is the production system in sustainable way based on understanding the environment, economy and society. A sustainable agriculture must strengthen the economy which meets social needs, and maintain the balance of the environment. Sustainable agriculture is the process of successful management of agricultural production to satisfy the changing human needs and maintaining or enhancing the quality of that resource and conserving the resources. According to Pretty (2008) sustainable agricultural system need to implement of technologies and practices in agriculture that do not have adverse effects on the environment, are easy use to and effective for farmers, and lead to growth in food productivity. Sustainable agriculture system is incorporated by both concept resilience and persistence. The FAO definition of a sustainable agricultural system is the orientation of management and conservation of the resources and the integrated use of technological and institutional method, thereby achieving human needs for present and future generations and ensuring continued satisfaction. Sustainable agriculture conserves and enhances the quality of land, water, and plant and animal, and is environmental friendly, technically suitable, economically stable and socially acceptable. It therefore, requires the development of technology, policy, infrastructure, management system and financial structures that help agricultural producers and resource managers involved in the dynamic process of innovation.

Sustainable management of natural resources is an important and most essential subject which is governed by the Environment Act in every country. The main theme of sustainable management of natural resources is the use of natural resources in a sustainable way that maintains and enhances the quality and quantity of those resources and fulfil the needs of present and as well as future generations. The opinion of FAO, sustainable use and management of natural resources is a significant strategic approach to fulfil the present and

the future needs. It is essential to build it in the face of population growth and increasing pressure on land, water, forest and fishery.

Now, sustainable agricultural and natural resource management is the biggest challenge, especially in the developing country. Purba Medinipur district of the state of West Bengal in India is the study area of the research which is faced in different types of problems related to agricultural and natural resources management, such as land management, crop management, forest management, water management, soil improvement, fishery management, coastal management and as well as development of agro-economic activities. All these managements have to face many problems. On the one hand, insufficient technology, lack of awareness, misconception about resource, weak infrastructure, delay of planning and institutional failure causes the mismanagement of resources. In the same manner exploitation of resources, over use of resource, misuse of resource, pollution also quickly contributes the depletion of the resources and crisis of resources. So, sustainable development required to be strengthened through appropriate use of resources by conquering all these problems.

Remote sensing and Geographical Information System (RS & GIS) is an important compatible technology that can be used to perform resources management. With the help of this technology, detailed information of about these resources can be collected and by analyzing them, the problem of resources and its solution can be determined.

1.2 Theme of the study

Now the main subject of the study is analyzing the present situation of agricultural resources, natural resources and assesses the sustainability of these resources in the context of the environment as well as geographical compatibility. The main goal of the study is to prepare a suitable techniques for managing resources from its grassroots level. As a result of

which resources can be used properly, made usable, used as optimum and resources can be enhanced its prosperity and finally the level of livelihood of the local habitants is much improved.

1.3 Selection of the study area

The study area is Purba Medinipur district of West Bengal state in India. Purba Medinipur district is agriculturally more significant due to its appropriate physical and cultural environment. In the district, fertile soil, adequate water, favourable climate and available skilled labour are very conducive to agriculture. Besides, there are also appropriate environment for the development of fisheries and forests in various places of the district. But, there are many problems related to agriculture as well as natural resources that have hindered the proper use and management of resources. Therefore, a proper infrastructure and management technique is needed that will work for the proper utilization and development of the agricultural and natural resources and it must be directed towards meeting the goals of future generations.

1.4 Problem selection

Despite being suitable in agriculture, there are some problems which interrupt the sustainable development of this region.

1. Geographically, this region is very much suitable for agriculture. But a large amount of cultivated land remains vacant in different seasons in an agricultural year due to lack of fresh water.
2. Nevertheless, it is observed that the amount of crops produced here is not used properly due to lack of proper management. Otherwise, there is no economically demand of these resources. Even, it is also the same problem in the case of forest

resources. Therefore, the nature of growth rate of different crops as well as fruits has remained the same for several years.

3. Almost the entire part of the district is inundated by tidal water. But there are no proper methods or management to use it.
4. Day to day the crop land is constantly changing in the area of fisheries, and as a result of this, different environmental problems is rising due to the land conversion as well as fishery.

1.5 Objectives

1. To study the distribution of agro-natural resources, cropping pattern and its nature in the study area.
2. To analysis the nature of agricultural land uses.
3. To depict the situation of agro-natural resource production and utilization.
4. To identify the agricultural land conversion and its causes and environmental impact.
5. To prepare a physiographic micro-zonation of the study area for sustainable agro natural resources management.
6. To study the methods of agricultural land use management.
7. To control the environmental degradation mainly due to the fisheries.

1.6 Literature review

Now, it is very important to know whether any types of research have been done before in the field of agro-natural resources management of Purba Medinipur district or others. Many previous research papers have been collected from different libraries, different publications, different websites and by the intensive study it has shown that this district does not have the expected research papers in terms of agro-natural resources management. There are many

research publications on other subject of the district from which the knowledge can be gained which enriched the present research activity.

Bisai et al., (2016) showed that in his paper the bulk density of the collected soil samples in Purba Medinipur district tends to little value. For this analysis the 'Core method' has been applied. The analysis reveals that the relation between the bulk density and volumetric water content and porosity indicates a strong negative relation. So the analysis stated that proper maintain and pre-management is required for maintaining the balance agro-ecological practice.

Purkait et al., (2017) discussed in his paper how different geomorphic processes such as floods, shifting of shoreline, shifting of sand dune, salt water invasion, coastal and river bank erosion etc. change the land use pattern and agricultural practice in Purba Medinipur district. He estimated that in coastal area, about 75 sq. km of agricultural tract has been changed.

Sahu (2014) depicts the status of soil in Purba Medinipur district in his research paper. The study described the properties of soil texture, phosphorus, potassium, organic matter, pH and electro conductivity, of Purba Medinipur. The study reveals that land degradation, increased in salinization, decline in water holding capacity of soil, loss of micro nutrients etc. are the serious problem in agriculture. She suggests that cultivation of covered plants, rotation of crop cultivation, use of organic fertilizer should be introduced for soil conservation. She also suggests method of water supply to the soil for Kharif, Rabi and summer crop cultivation.

Das et al., (2014) study the morpho-dynamic behaviour of Purba Medinipur coastal belt and is also studying the erosional pattern in this coastal region in his paper. The output of the study represent that the geology and morphology of coastal area are in dynamic nature. So it needs the assessment of the coastal region.

Mondal (2012) has shown in his paper how to develop the existing land use system and the range of livelihood option of local resource users in the Purba Medinipur district. This paper

also described the dynamics nature of the resource uses and factors which helps the planners and decision makers to design management plan. He also gives out many problems for poor quality of life, such as lack of infrastructure facilities, flooding, poor development of non-agricultural activities etc.

Bandyopadhyay et al., (2003) demarcated the coastal boundary in Purba Medinipur through the intensive experiment of soil salinity fluctuations, ground water table condition, natural vegetation, cropping practices, watershed areas draining into coastal water and other features relevant to coastal agro-ecosystem. According to their research paper coastal soil lies along the boundary of the district and are distributed over Mahisadal, Sutahata, Haldia, Nandigram-I, Nandigram-II, Khejuri-I, Khejuri-II, Contai-I, Contai-II (Deshapran), Contai-III, Ramnagar-I and Ramnagar-II blocks and partial part of Egra, Bhagawanpur and Tamluk.

Chatterjee and Paul (2011) highlight the pattern and growth of floriculture in Purba Medinipur district, especially in Panskura and Kolaghat block in their paper and also assess its economic importance. According to this study the area under floriculture has increased gradually till 2004-05. This paper also depicts the different problem related to floriculture such as lack of cold storage, deficiency of market facilities, insufficient road in the field, lack of transport facility etc.

Mondal et al., (2015) has classified the land capability using the method of V.R. Sing (1970) and also described the relation of agro-economic developments of Purba Medinipur district. For classification they use different positive factors such as soil quality, rainfall and availability of irrigation and negative factors such as ruggedness number, slope, soil erosion, water logging, drought, flood and forest density. Finally, the blocks of the district have classified into four land capability areas such as high, medium, low and very low.

Vijayalakshmi (2017) explains in her research article that the extent of land utilization depends on different factors such as rainfall, irrigation, soil, cultivation, practices etc. He

estimates the factors influencing rate on land use and cropping pattern. He says that a new appropriate cropping pattern should be introduced according to the nature of soil, availability of water, topography, and other local situation.

Kumari (2014) pointed out that landuse change and its controlling factors provide essential information which helps to landuse planning and sustainable management of resources. The output of the analysis reveals an increase in area under forests, miscellaneous tree crop and groves non-agricultural use, net sown area, total cropped area and area sown more than once by 0.06, 0.18, 1.00, 3.11, 0.66, and 2.45 from 1998-99 to 2010-11 in Andhra Pradesh.

Jegankumar (2015) analysed the cropping pattern of Salem district through calculating of cropping intensity, crop concentration, using crop combination by J.C Weaver (1954) and crop diversification by Gibbs – Martin Index. The analysis depicts that fourteen crops widely occupies in the study area. Highest cropping intensity is more than 150 percent found in four blocks, medium intensity 130 percent to 150 percent found in six blocks and lower intensity less than 130 percent found in eight blocks of the district. The district has four to twelve crop combinations. Crop diversification rate in most of the blocks is high.

Kumar (2017) assessed the cropping pattern, crop combination, and crop ranking in the Samb river basin with the help of geospatial technique. He pointed out that near about 52 percent of the total area of the basin is under cultivation with kharif and rabi crop. The study also pointed out that this region is under six crop combination region and wheat, paddy and sugarcane is the first, second and third crop ranking respectively.

Bisai et al., (2016) studied the spatio-temporal change of crop diversification in Paschim Medinipur district using the Jasbir Sing's (1976) index of crop diversification method. The blocks of the district have been grouped into five classes such as very high, high, moderate, low and very low level. From the study, it is observed that crop diversification index in the district has increased from 2007-08 to 2010-11.

Karan and Bandyopadhyay (2019) explain the agricultural land conversion into fishery from 2005 to 2018 using the Normalised Difference Vegetation Index (NDVI). They use for the analysis image of Landsat – 7 ETM+ and Landsat – 8 OLI. The study reveals that in this period, the fishery land is increased from 268.79 to 4637.34 hectares out of the total land 15263.69 hectares at Mayna block of Purba Medinipur district. This study also pointed out the reasons of land conversion. They also viewed that there are many problems arising due to the fishery, like land degradation, deforestation, water pollution, smell pollution, highly toxic chemical water and different disease like allergy, skin disease, gastric problem etc.

Bera et al., (2015) analysed the paddy-fish farming system of Mayna block in Purba Medinipur district. According to them it is eco-friendly and has the largest environmental benefits. It also helps the sustainable development of this area. In this system fish production is much higher than in other traditional system of culture, such as 4200 kg to 4900 kg/hector within six months.

Islam and Yasmin (2017) pointed out in their paper that the effect of aquaculture on environment in Bangladesh such as destruction of natural habitat, depletion and salinization of potable water, huge bycatch, stress on ground water, nutrient pollution, salinization in agricultural land, disease and parasitic infestation etc. They also mention the process of solution using HACCP (Hazard Analysis and Critical Control Point) and GAP (Good Aquaculture Practice) guidelines.

Gang et al., (2005) discussed that nitrogen in aquaculture wastewater may cause many environmental problems. Generally, effluents from aquaculture in Hawaii exceed this limit which affects the environment. They introduced a wind-driven reverse osmosis (RO) technology to remove nitrogenous wastes from the culture water.

Bhan et al., (1997) says that remote sensing and GIS technology has an important role in sustainable development and management of agricultural. They pointed out that a sustainable

increase in crop production can be achieved by adaptation of suitable agronomic management. They also explained the cropping system of Madnur watershed in Andhra Pradesh, agro-ecological zone based land use planning of Doon valley of Uttarakhand, soil conservation priority of Song watershed in Uttarakhand and integrated agricultural drought mitigation etc.

Dutta and Sing (2007) made the statement that sustainable development of any region needs micro-level information and level of planning. They also highlight that sustainable development can only be achieved by successful implementation and integration of spatial and non-spatial data into GIS domain and with proper planning at the micro-level. They try to make a suitable sustainable development plan for the land of Blue hills of Assam and Red river at the micro-level using micro-level information through the Geographical Information System (GIS).

Johnson et al., (2007) expressed an opinion that small island Mauritius is the most vulnerable region in the world in respect to the natural and environmental disasters. They marked different environmental concern of Mauritius, such as degradation of coastal ecosystems, depletion of fishery resources, reduction of forest cover, loss of biodiversity, natural disaster etc. They have tried to proper management plan using remote sensing and GIS such as ecosystem management of coastal area, forest resources management, water resources management, disaster management etc.

Binda (2019) has delimited the Nagaur district of Rajasthan into four micro-physiographical zones to reduce or remove the disparities and to achieve all-round development. They use different physical parameters like geological structure, slope, topography, soil texture, vegetation, drainage pattern and density, sand dune, wasteland, landuse and land cover, rainfall etc. and the cartographic technique of superimposition is used to demarcate the physical region.

Behr and Jokela (2011) give the valuable definition about 'Micro-region' in their book 'Regionalism and Global Governance: The Emerging Agenda'. They defined region as a territorial unit that is smaller than the state. They also mentioned the different parameters for revealed of micro region.

Kallert (2005) in his literature made the statement about micro-regional planning. He pointed out the innovative, flexible approach to micro-regional planning, by which planning is determined as a communicative process involving many stakeholders and representatives of all actors.

Sharma (2016) delimited the Jaisalmer district into three micro-physiographic regions based on natural criteria such as geological structure, landscape, soil, climate etc. superimposition technique is used for the demarcation of micro-physiographic region. The three regions are western longitudinal sand dune region, south eastern plain region and north-east irregular sand dune region. The main objectives for the delimitation of micro-physiographic region at district level is the micro-level planning and to maximum use of local resource.

Harris and Fuller (2014) have given various information about the definition, evolution and type of agriculture in their literature. According to them agriculture is a method by which global human collect food and others product to survive. They present a model from foraging to agriculture in which the transitions to agriculture, cultivation and domestication can be separated.

Skidmore et al., (1997) reviewed the current use of remote sensing for sustainable land management. They also described the importance of satellite system for sustainable development. Therefore, they analysed the resource inventory and monitoring through preparation of various maps such as global mapping and monitoring, regional mapping and monitoring, and local mapping and monitoring. They also explained about the importance of advance remote sensing for sustainable development.

Mouzam et al., (2015) described the dynamic nature of landuse pattern and cropping pattern in Andhra Pradesh from 1980 to 2010. They observed the declining trend of forest resources. They also observed net sown area and the area under barren had decreased. The cropping intensity is steadily rising. The cropping pattern has also shifted significantly. The changing pattern of different land use classes has estimated by applying the farmula: $Y = abt$, where, Y denotes the area under a landuse class ('000 ha), a denote constant, b denotes regression coefficient and t denotes time in years.

Sahu (2014) determines the water logging area in the Keleghai river basin of Purba Medinipur district using remote sensing and GIS technique. He used Landsat-8 imagery to identify the water logging area. NDVI, NDWI and NDMI are the important technique for this analysis. Total water logging area is 80 sq. km. According to him, the spatial distribution of water logging is related to canal density, but a disproportionate relationship with the slope, relief and settlement density.

Tiwari (2008) discusses the participatory community-based approach for watershed and natural resources management in Nepal on basis of existing literature and field observation. According to him it has two perspectives, one is the conservation of natural resources with the constructive and restorative and other is the social, women, community and livelihood development as well as good governance at local level. He said that it is mandatory for the people to participate in government policy to all natural resource management. Local people are the primary managers of the natural resources. They can maintain the quality of resources and improve resources. So, they should be encouraged to take different responsibility and participation in resource management.

Sing et al., (2016) says that in the last three decades, food grains production, horticultural production, livestock farming and aquaculture has increased significantly in India. But, the use of land and water is inappropriate and unscientific in the country. Prime agriculture land

is converted into non-agricultural use. Productivity of agriculture is decreasing due to bad impact of abiotic and biotic torment. Water is considered as a free uses leading to unscientific exploitation of the resource. He also suggest different strategies for managing and developing the natural resources of India such as, inventory, development of efficient and sustainable land-use plans for each agro-ecological zone, characterization and monitoring of natural resources, development of location-specific watershed models, improving the agronomic practices, development of integrated farming systems etc.

Kumar et al., (2015) has stated that remote sensing and GIS technique has an abundant opportunity to monitor and manage the natural resources in a constructive and effective way. This technique is very useful for identification and analysis of different factors that affects natural resources. They also described the application of this technique for different natural resources management, such as agriculture management, soil management, crop-irrigation demand monitoring, crop modelling, water resource management, water quality monitoring, forest and wildlife habitat management, and natural disaster management.

Shanwad et al., (2012) say that remote sensing and GIS technologies has significant role for management and scientific planning of the natural resources. They have analysed the different physical characteristics of the Medak Nala Watershed in Karnataka like hydro-geomorphology situation, land use/land cover characteristics, soil properties, drainage pattern, slope etc. For the analysis they used IRS 1D PAN + LISS III images and toposheet from Survey of India. The study highlight that there is adequate opportunity to develop the structure for water harvesting and to conserve the soil properties using different methods. They also give an agricultural resource plan which mentions the alternate land use practices such as agriculture, floriculture, agro-forestry, afforestation, agro-horticulture, pomumculture, olericulture, fodder and fuel and dry land horticulture etc.

Ahmad and Goparaju (2017) have identified the distribution of agro forestry of the Palamu district in the state Jharkhand using geospatial tools. They also determined the agro-forestry suitability of the open area. In this study, different data such as nutrient availability, slope, wetness, rainfall and elevation are used for the suitability analysis. Landsat data is used to extract the agro-forestry and open space through the land use land cover mapping. Near about 62 percent land out of the total open space is highly suitable for agro-forestry.

Mahaboob et al., (2003) estimated the area under agro-forestry practices in Madhupur using remote sensing technique. This analysis was conducted at Bangladesh Space Research and Remote Sensing Organization (BSRRO) in 2003. The SPOT image of March 3, 1999 with bands 4, 3, 2 and 1 is used. The unsupervised image classification technique is applied to discriminate the forest. The estimated amount of agro-forest is 24% out of total forest.

Kumar (1994) discussed about the principles and practices of agro-forestry in his literature. According to him agro-forestry is the combination of forestry and agriculture. The main objectives of agro-forestry are to increase the productivity and economic return and other social goals. Such practices have multiple output in respect of environment like ecological conservation, sustainable production etc.

Sameer et al., (2015) explain the different agro-forestry, rural industries and their marketing potentiality in India. They also focused on different activities related to agro-forestry industry such as supply of raw materials, processing of raw materials, transport system, wholesaling system, mid-channel activities etc. According to him rural people are directly and indirectly involved in this industry and with related activity which leads to their economic growth.

Ahmad et al., (2018) analysed the land suitability for agro-forestry in Samastipur district of the Bihar state, India. They used satellite data (Sentinel, Landsat-8 and ASTER DEM) and ancillary data (soil fertility) for the analysis. Sentinel data are used for Land use/land cover classes, Landsat-8 for wetness mapping and the ASTER DEM is used to determine the slope

percent. This analysis shows that 48.22 percent land is very high suitable, 22.83 percent high suitable, 23.32 percent moderate suitable and 5.63 percent is low suitable.

Gandhi et al., (2001) assessed the priority given to agro-industries in India and their role in rural as well as small farmer development. They mention the FAIDA report of the Confederation of Indian Industry (CII) and Mckinsey and Company (1997) both where stated that there is a lot of potential to develop different food processing unit and other agro-industry in India. However, the development of agro-industry in India is today facing difficult challenges, such as costly raw material, insufficient raw materials and market demand embarrassment or limitations etc.

Dhiman and Rani (2011) explain that agro-based industry is the sunrise sector in India and it has important contribution to improve the economy in view of its large potential benefits specially on employment and income generation. They estimated that, approximately 14 percent of the total work force is involved in agro-processing sector directly or indirectly in developed countries, whereas 3 percent of the work force is engaged in this sector in India. This study finds out the characteristics of agro-based industry in the Patiala district of Panjab state and also highlights the different problems which have to be faced.

Rao (2000) described the role of Remote sensing and Geographical Information System in sustainable development of agro-natural resources in his study. He describes the different sustainability indicators for achieving sustainability of any natural resources. He said that the information about the nature, extent, spatial distribution of resources and its potentiality and limitations is a pre-requirement for the achievement of the goals of sustainable development. Remote sensing and GIS is an ideal technique for integrating spatial and attribute data on natural resources and the environment.

Karan and Bandyopadhyay (2017) analysed the agro-economic pattern in the coastal zone of Purba Medinipur district, West Bengal using remote sensing and GIS technique. In this

study cropping intensity, crop combination has been analysed. This paper also discussed the distribution of different crop cultivation and fishery and related problem. Village wise agricultural data are used and Landsat-8 (2016, November) data also used for fishery and landuse/land cover mapping.

Karan et al., (2016) described the geo-economic aspect and services along the national highway-41 in Purba Medinipur district using remote sensing and GIS. This study revealed that the land use pattern on both sides of the highway is rapidly changing. An especially large number of various types small scale industries are developing.

Oruonye (2014) study the management and practices of fishery in Mayo Ranewo Community in Ardo Kola local overnment area, Taraba State, Nigeria. The study depicts the different problems related to fishery and also describes the artisanal inland fishery by the case study of Mayo Ranewo. The study provides important guidelines for small scale fisheries management in the face of social, economical and environmental changes.

Food and Agriculture Organization (FAO, 2012) gives some guidelines in the context of ‘Sustainable Assessment of Food and Agriculture system’ (SAFA). SAFA guidelines assist in achieving fair practices in food and agriculture production and trade. The guiding vision of SAFA is the sustainable development of food and agriculture sector, broadly sustainable production in agriculture, sustainability in forestry and fishery and sustainable manufacturing based on agro-product.

FAO (2017) made a statement in context of ‘Territorial tool for agro-industry development: A Sourcebook’ that agriculture and agro-business are the base of many economies. Agro-industry has the largest potential for economic growth in many developing countries. However, in the developing country this industry is facing various problems. Therefore, this sector has the low productivity in developing country compared with wealthier economies.

This sourcebook refers some guidelines for sustainable use of agro and forestry resources through the agro-industry.

Brundtland Report (1987) provides a key statement on sustainable development of environment, economy and society. The three basic components in terms of sustainable development are highlighted in the report, such as environmental protection, economic growth and social equality. The report focused on the idea of protecting nature and establishing the balance between protection and use.

Repetto (1986) made a statement in the “Global Possible Conference” on title “World Enough and Time: Successful Strategies for Resource Management” that’s how we can improve our livelihood and raise economic growth throughout the world by harmonizing the use of natural resources and maintaining the harmony and quality of the environment. This book also explained how governments and private citizen can help to the sustainable development of resources. It has also mentioned that we have sufficient resources, skill and knowledge. If it is used properly, we must achieve the global possible.

United Nations Conference on Environment and Development (UNCED, 1992) has made a draft on sustainable development of the environment, economy and society, which is known as ‘21-Agenda’. The Conference highlights a statement that sustainable development is a process and guiding principle for long term development of resources and environment. In fact, the term ‘Sustainable development’ has become prominence since the Earth Summit at Rio de Janeiro in 1992.

FAO (2011) explain the importance of land and water and some guidelines in the title ‘The State of the World’s Land and Water Resources for Food and Agriculture’. Availability of land and water is most important to meet national and global demands for food and agricultural product. The book gives instruction to measure the land and water quality through policy making and ensures food security and sustainable development.

1.7 Data base

Both primary and secondary data has been used to fulfil the stated objectives. All the data is collected in various ways and from different sources. The different data for different analysis are mentioned as follows:

Primary Data

1. The high resolution satellite image of the United States Geological Survey (USGS) has been used such as Landsat-8 OLI and Sentinel-2 sensor. The acquisition date of satellite images used for fishery mapping is April 2013, March 2015, April 2017 and May 2019. These are the image of Landsat-8 OLI sensor. The image of the Sentinel-2 sensor has been used to extract the vegetation cover area dated on June 2019. The image of the Sentinel-2 sensor dated on June 2019 also used for analysis the present situation of fishery in the study area.
2. The Google Earth image has been used to extract the different types of drainage such as river, tributaries, canal and roads.
3. Field survey has been done to collect soil and water samples and experimented in the laboratory.
4. Tidal water fluctuations in the internal river channel have been intensively observed to determine an average point of rise in each river channel.
5. Data regarding various types of environmental problems as well resources has been collected through household survey.

Secondary Data

1. Block map and village map of Purba Medinipur district have been collected from the Block Development Office (B.D.O) and other administrative information from the District Magistrate office.

2. Geological map, topographical and the soil map are used from National Atlas & Thematic Mapping Organisation (NATMO).
3. Drainage map has been collected from Irrigation Department and Natural Resources Data Management System (NRDMS) centre of Purba Medinipur district and also road map from NRDMS centre.
4. Monthly rainfall and temperature data from 2003 to 2014 has been collected from the Meteorological Department, Alipore, Kolkata, to determine the annual average rainfall and temperature of the district.
5. A village wise agricultural land use record (2015-16) has been used to collect from Assistant Director of Agriculture (ADA) of all blocks of the district.
6. Census report-2011 is used in different analysis.
7. The District Statistical Handbook (2003 to 2014) provides different statistical data in different years like the production amount of crops, vegetable, fruit, flower, timber, fuel and production of inland fish.
8. Different agro-industrial data is collected from micro, small & Medium Enterprises (MSMEs) of Purba Medinipur district.
9. Agricultural market data is used from the Agricultural Market Directory of Purba Medinipur district, Market Survey Report-2011-12.

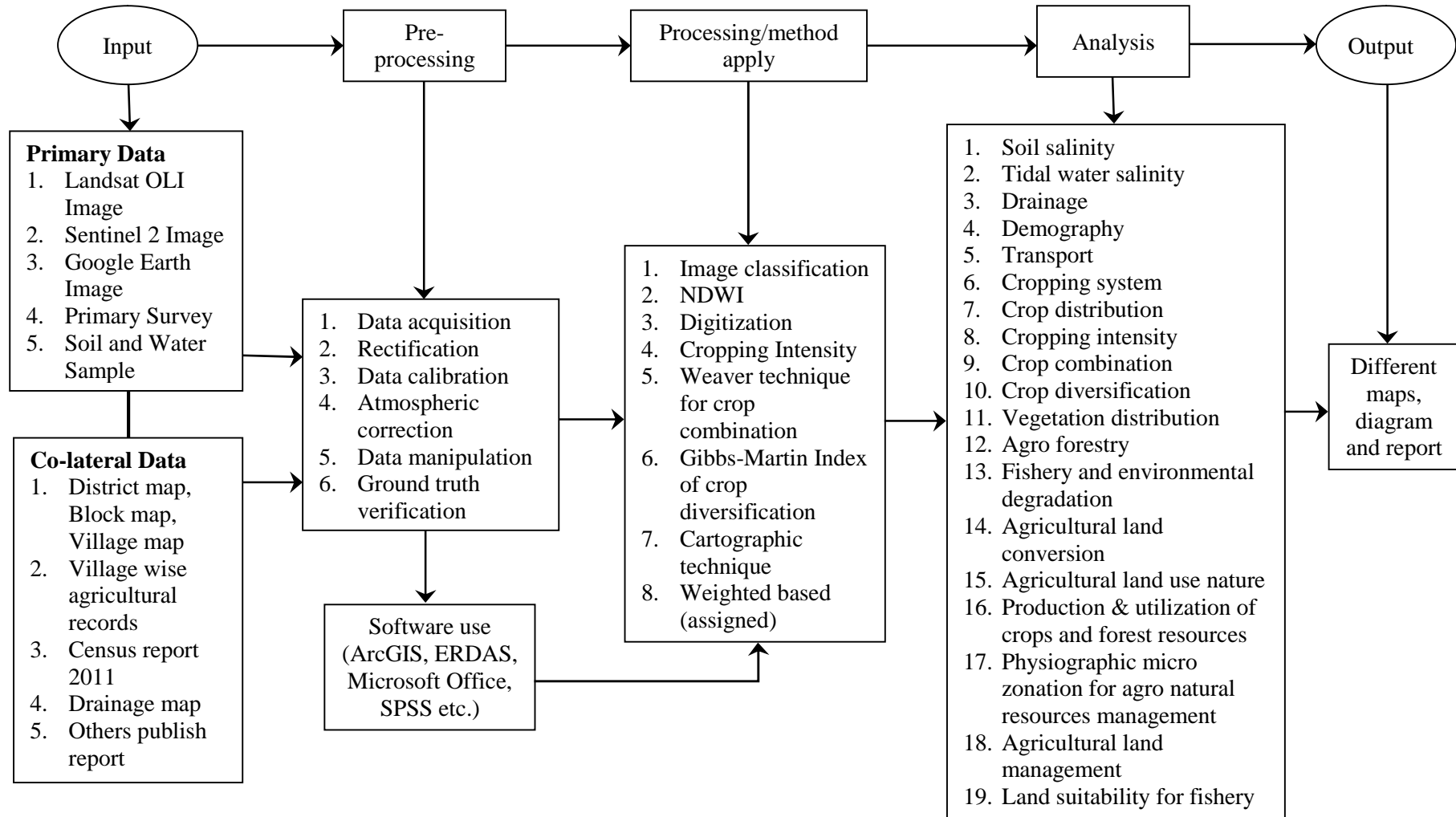
1.8 Methodology

Different methods are used for analysing the present research and these are stated as below:

1. Digitization method is used for the creation of the village, block, drainage and the road layer, location of market and agro-industry as a shape file in the ArcGIS software environment. Then all the related data are entered in concerned attribute table of the shape file.

2. Soil and tidal water sample are collected from field in accordance with the general rules for mapping of soil and tidal water salinity zone. Total soil sample is 65 and tidal water sample is 16. Sample point of soil is determined according to a grid method. Tidal water sample is collected along the river. Spatial interpolation method has been used for the both mapping.
3. The Supervised Image Classification Technique is used to extract the vegetation cover area from satellite image in ERDAS IMAGINE software environment.
4. The Normalised Difference Water Index (NDWI) is used to extract the water bodies from satellite images in the ArcGIS software environment.
5. For the analysis of cropping pattern in the study area crops distribution, cropping intensity, Weaver Technique (1954) for crop combination, Gibbs-Martin Index for Crop Diversification (1962) methods are used.
6. Change detection method is used to show the agricultural land conversion to fisheries.
7. Physiographic micro-zonation has been performed based on the drainage area. In this case, a set of the water course that flows over villages and all these villages together have been marked as the drainage area of that watercourse.
8. The Salinity level of soil and inundated tidal water in each village of the district has been determined by superimposition of both layers such as soil salinity zone and tidal water salinity zone.
9. Village wise land suitability for fishery has been prepared using the location factors such as land, drainage density, population density, road density and the number of worker population. Weighted based (assigned) method is applied for this analysis.
10. Lastly, different statistical diagram has been prepared using statistical software like Microsoft Excel.

1.9 Flowchart of the research work



1.10 Limitations

In this study, the pattern of agro-natural resources of Purba Medinipur district has been described in depth and also explained the various aspects of agro-natural resource management. Nevertheless, there are some limitations of this study.

1. This study discussed about agro-natural resources only those resources are related to the livelihood and income related to the local people.
2. Although, all agricultural resources are analysed here, but not all natural resources are described, such as ground water resource and coastal resources.
3. The village layer has been digitized manually using the software. So, the area of the villages in few cases may not same with the published area from government office.
4. Some analysis has been performed with the old data due to the unavailability of current information.