CHAPTER I

INTRODUCTION
CHAPTER I

INTRODUCTION

At the present day we are living in that may be described botanically as Angiosperms of flowering plants. The members of this group now significantly widely distributed over all the land surface of the earth. (Agnes arber, D.sc F.L.S, 1920).

The aquatic environments include the all water bodies which are seasonal and permanent, flowing and standing, natural and man-made. Each water body contain its own annual hydrological cycle which is characterised by its own community of aquatic organism. The aquatic environments are very important part of natural and cultural heritage (Saini D.C et al, 2010). They play an impartment role in shaping the identity of our land in the form of rivers, lakes, ponds and wetlands.

1.1. ECOLOGY

Now a days Ecology is rapidly being an advancing science. In the modern sense ecology is the ‘study of structure and function of nature’ (Odum, 1963). The term ecology was coined by the combination of two Greek words “oikos” (which means ‘house’ or ‘dwelling place’) and “logos” (which means ‘the study of’) to denote such relationship between the organisms and their environment. (Sharma, P.D., 2008-2009). As far as the ecology concerned with my work so it must be describe here that what ecology is? and what is the importance of it? here few definitions are given defined in various ways. Ecology may be defined as the branch of biology related with the relations between living organisms and their environment. It can be also said that the mutual relationship and interactions between living organism and their non living environment. Moreover ecology has been defined in many different ways on the Web, some of them are as follows: (Sharma, P.D., 2008-2009).

Ecology is the branch of science that studies the distribution and plenty of living organisms, and the interactions between organisms and their environment. The environment of organism includes both its physical habitat, which can be described as the sum of non living factors like climate and geology as well as the other organisms which share its habitat. (en.wikipedia.org/wiki/Ecology). The investigation of the connections between living life forms
and their surroundings, particularly the completely or example of communications; a view that incorporates all plant and creature species and their interesting commitments to a specific environment. The study of the interrelationships among plants, animals, and other organisms and their interaction with all aspects of their natural environment. (www.animalinfo.org/glosse.htm).

In 1859, Geoffroy Saint Hilaire used the term ethology to refer to the study of relationships between organism and environment. Reiter (1868) introduced the term ökologie. E. Haeckel (1869) put the first precise definition of ecology (Sharma, P.D., 2008-2009). Ernst Haeckel define the word ecology, refers to the surrounding outer world called environment, which consist of organic and inorganic conditions called biotic (living) and abiotic (non living) factors respectively. Biotic factors include organism of same or different species, whereas abiotic factors include physical and chemical condition such as temperature, moisture, gases etc... The four basic concept of ecology are holism, ecosystem, succession and conservation. (Misra, R. 1991). The atmosphere of our great Earth possesses many physical factors, among them the climate and the soil greatly affect the physiological activities of the plant in all manifestations so that plant ecology is a phase of plant physiology under natural as well as controlled conditions.

Freshwater ecology is the vast subject. While we are discussing about freshwater ecology it must be consider that freshwater ecology is greatly connected with three main threads. Firstly the characteristics of aquatic habitats and, crucially, how these depend on the surrounding land and its use. Secondly, the ecology of the plant and animals communities and their links to the physical and chemical world and interactions with other wildlife. Thirdly how human activities can disturb, damage and destroy the habitats, their plants and animals and how these effects can be minimized. (Michael Jeffries and Derek Mills, 1992). Moreover freshwater ecology emphasized mainly the study of relationship between organisms and freshwater environment.

1.1.1. HABITATS

While we are talking about ecosystem first of all it should be know what is habitat and what does it mean? So here definition of habitat is given. Originally the term ‘habitat’ means the natural home of an organism. In other words it is also said as the place, locality or station, in which an organism or the community lived. While we are talking about it in scientific term it involves all conditions which affecting an individual or community that are incidental to the place in which
that individual or community lives. Thus the habitat is made up of various type of environmental factors having any type of influences upon life within it (Nicholas Polunin, 1960). There are four major types of habitats in biosphere, such as freshwater, marine water, estuarine and terrestrial. Among these all freshwater habitat is related with present study which is described in various means.

1.1.2. AQUATIC HABITAT

Our planet earth has the life supporting environment. The biosphere which is composed of air, water and soil. These three media are the components of atmosphere, hydrosphere and lithosphere respectively. Among them hydrosphere is composed of all of the water on the earth or near the earth, which include rivers, lakes, ponds, oceans and even the moisture present in the air. Water forms the habitat for an enormous variety of organisms, which are called aquatic organisms. The aquatic habitat are of two types, fresh water and marine water. The fresh water habitat may be lentic and lotic habitat. The lentic habitat means slow moving still or standing water habitat such as ponds, lakes, reservoirs etc.... Lotic habitat means running water habitat which include spring, streams and rivers. The living organisms such as plants and animals present in water bodies are depends upon the nature of water and habitat. Vast standing water bodies and flowing water bodies support the life of aquatic species. Aquatic angiosperms are delivered from terrestrial intimates and have adopted the aquatic habit at various times sub-sequent to their first appearance as flowering plants.(Agnes Arber, 1920).

1.1.2.1. CLASSIFICATION OF AQUATIC HABITAT

Aquatic habitat is broadly classified in main groups of Fresh water habitat, Marine water habitat and Estuarine habitat. The intermediate form between fresh water and marine water is ‘brackish’ which considered with salt waters. The degree of salinity can greatly affect the habitat and community. Joshi and Patel (2012) stated that fresh water habitats occupy relatively small portion of the earth’s surface while it compare to marine and terrestrial habitats. They are very important to man and other living organisms. As well as fresh water is the most suitable and cheapest source which fulfil domestic and industrial needs. Moreover they also provide very convenient waste disposal system.
(1) Freshwater habitats are provided with water. Fresh water habitats are of two types: (i) Standing water or (Lentic) which comprise lakes, ponds, reservoirs, where water is relatively stagnant. While the other type of fresh water habitat is (ii) Running water or (Lotic) which include rivers, streams where water is more or less dynamic.

(2) Marine waters include seas and oceans where water is salted and hard.

(3) Estuarine habitat include the region where fresh water mix with the sea water. The water of these area is brackish in nature.

1.1.2.2. MANAGEMENT OF FRESHWATER BODIES

R.S. Ambasht, 1969 stated that the inland water bodies like ponds, pools, lakes and rivers are the common occurrences all over the world. They are very important for man and other organisms that abound in them. Moreover the demand of growing human population for space and food are ever rising. Freshwater bodies are used being increasingly for these purposes. Management of freshwater bodies should aim to maintain them in useful form at high productive level with provision for a high rate of removal of plants and animals for human use. A well managed river or lake serve in multipurpose way the human society. Rivers are used for irrigation, transport, supply of drinking water, hydroelectric power, bathing fishing, for draining out municipal and industrial refuge etc. Therefore it is essential that aquatic ecosystems should be properly studied and management should be done considering the interrelations among multiple items of utility.

1.2. ECOSYSTEM

Ecosystem define in different way and different words keeping the same meaning. Such as very simply it define as the interaction between biotic and abiotic factors living in their environments. The organism of any community besides interacting among themselves always have functional relationship with the external world or the environment. This structural and functional system of communities and their environment is called an *Ecological system* or in short the *Ecosystem*. The term ecosystem was very first proposed by A.G. Tansley in 1935, he defined ecosystem as “The system resulting from the integration of all the living and non-living factors of the environment.” Thus he regarded in his definition that ecosystem including not only the organism complex but also the entire complex of physical factors which form the environment. Ecosystem
also define as “the composite of a group of organisms and its environment functioning as an ecological unit.” In other words as stated by Sharma, P.D. (2008-2009) that “An Ecosystem is the whole biotic community in a given area plus its abiotic environment.” Therefore it includes the physical and chemical nature of the sediments, water and gases as well as all the organisms. It is a dynamic system in which biotic and abiotic components are constantly interacting and reacting with each other bringing structural and functional changes. The central theme of ecosystem concept is that at any place where the organisms live in their environment, there is continuous interaction occur among them to produce and exchange materials between plants, animals and the environment. In nature there are many types of ecosystems exist, such as Forest ecosystem, Desert ecosystem, Grassland ecosystem, Pond ecosystem etc. under terrestrial ecosystem and aquatic ecosystem.

1.2.1. TYPES OF ECOSYSTEM

The ecosystems of nature are broadly classified in two types (1) Natural ecosystem and (2) Artificial (man-made) ecosystem

(1) Natural ecosystems:- These type of ecosystems are operated by themselves under natural conditions without any major human disturbance. Depending upon particular habitat they are divided as

(i) Terrestrial ecosystem, which include forest, grassland, desert etc.

(ii) Aquatic ecosystem, which is based on water which is further sub divided in freshwater and marine water ecosystem. Here aquatic ecosystem only focused and described because it is closely concerned with the present work.

(2) Artificial ecosystem:- These are maintained by man on artificial aspects where addition of energy and manipulation causes the natural balance disturbance regularly such as croplands like maize, wheat, rice-field etc.

1.2.1.1. AQUATIC ECOSYSTEM

Due to over use, lack of care and mismanagement of our natural resources with ever increasing population many undesirable modifications has been introducing to aquatic environments. Most
of the freshwater resources under stress of human activities like urbanization and uncontrolled industrialization. The new environmental problems developed as a result of these above discussed reasons have given rise to new thinking in the field of monitoring and evaluation of aquatic ecosystems. The overall condition of aquatic ecosystems is determined by the interaction of its physical, chemical and biological components, which are responsible to make up its ecosystem. Information on understanding of environmental change is necessary for the protection and utility of ecosystems. Ecological assessment considered all components of the ecosystem helps in entering appropriate conservation strategies and reinstallation methods towards the preservation, management and sustainable use of natural resources.

Aquatic ecosystem is a group of biotic organisms and abiotic factors interact with each other, dependent on one another, and inter connected with each other in their water environment for nutrients such as nitrogen and phosphorus as well as for shelter. It is based in water. Aquatic ecosystem involves pond, lake, river and ocean. Aquatic ecosystem comprises living aquatic organisms which constitute as living or biotic factors and their relationship with their environment, which can be referred as abiotic factors. Aquatic ecosystems are very much diverse in species and complexity in interaction between their physical, chemical and biological components.

1.2.1.2. TYPES OF AQUATIC ECOSYSTEM

Depending upon the differences in their salt contents the aquatic ecosystems are broadly classified as follows:

- Freshwater ecosystems
- Marine ecosystems
- Estuarine ecosystems

Freshwater Ecosystem:-

Freshwater ecosystems cover about 0.80% of the Earth’s surface and inhabit approximate 0.009% of its total water. According to (Lieth, 1975) freshwater ecosystems covers only 0.2% of the total earth’s surface area with the volume of 2.04x105 km³, despite of which lentic ecosystem supports a variety of endangered and exotic species which contributes to aesthetic and
environmental quality in every state. Freshwater ecosystems include ponds, lakes, streams, rivers, puddles, canals etc. Moreover they also include the areas such as wetlands and floodplains, which are flooded or saturated with water for all or only a part of the year. Freshwater ecosystems are again subdivided into two categories.

(i) **Lotic ecosystem (running waters)**  (ii) **Lentic ecosystem (still waters)**

(i) **Lotic ecosystem** (running waters):- The running water bodies are called lotic. Rivers, streams and their likes are the examples of lotic systems. Their physical forms and life are dominated by a strong and unidirectional flow. The lotic ecosystems comprises of springs, rivers, rivulets, creeks etc. In the beginning they start their course from being narrow, shallow and relatively rapid and later on increasingly being broad, deep and slow moving. Moreover waterfalls are also common example of lotic ecosystems. Thus lotic ecosystems are differ from lentic ecosystem by the dominance of linked flow, erosion deposition and substrate processes.

**Rivers and streams:-**

Rivers and streams are the water-bodies of fresh running water. The water flow permanently or seasonally in natural channel and later on it mix into another water body such as a lake, ocean or sea. Moreover rivers and streams are found more oxygenated than lakes or ponds or any other stagnant water-body. This is the reason that they contain the organisms which are adapted to the fast running waters.

(ii) **Lentic ecosystem (still waters) :-**

The standing water bodies are called lentic. Ponds, lakes, wetlands alike are the examples of lentic ecosystem. The beauty of standing water-body often attraction point for organisms including human being. According to their histories and their uses forced to put them with various names such as ponds, lakes, lochs, meres etc.

**Ponds:-**

Despite the fact that everyone knows what is pond and what is lake? Although it quite difficult to provide a precise and technical difference between these two. (Paul Lemon, 1962) stated that relatively they are shallow, still bodies of water, there may be an appreciably larger fraction of
the bottom inhabited by rooted or sessile plants. Some authors (Wetzel, 1975) describe ‘Pond’ as simply an old term for shallow water bodies that are none the less lakes. Ponds are found in most region and they may exist either seasonally or persist for year to year. He has given the specific characters of pond as follows:

(1) Many ponds are artificially made and do not have the long history of larger lake underlying their current form.

(2) Their life history and characteristics have a speed and intensity that allow factors other than the dominating pace of lake productivity to be dominant. Particularly their huge number but small size results in variable communities.

(3) Many small ponds are transitory ephemeral habitats with an unusual, specific biota that does not occur in lakes.

Many ponds are entirely artificial and their original purposes diverse. Now a days ponds have increased in urban areas, specially small ponds in back of gardens. In some areas urban ponds may sustain the majority of amphibians and provide valuable habitats (Michael and Mill, 1992).

Lakes:-

Lakes are an extensive bodies of still water with considerable depth in some parts and the greatest area of the bottom being free from attached plants. They are bounded by land and fed by rivers, springs or by local precipitation. The surface of lake has a significant effect on its biological, chemical and physical characters. Lake ecosystems are divided in three different zones. These zones of lake are classified on the basis of availability of light such as (1) Littoral Zone which is the shallow zone near the shore. This is the marginal shallow region where abundant light is available for plant growth. This zone is commonly covered by macrophytes and their different growth forms such as emergent, floating leaved and submerged plants. The offshore region is further divided in two zones like, (2) Limnetic Zone or Photic (pelagic) Zone. It is also known as Open water zone which lies above the sediments and outside of the weed beds is the Photic zone. This zone up to the depth where effective light can penetrate. This zone consist of large and small organisms, in which sunlight supports photosynthetic algae and the other organisms that feed on them. (3) Aphotic (Profundal) Zone or Deep water zone. This
zone lies beyond the depth of effective light penetration. Plant life is not possible due to paucity of light. Moreover this zone often absent in ponds. Lakes can be classified depending upon the variety of features including their formation and chemical or biological condition, as Oligotrophic lake and Eutrophic lakes.

**Oligotrophic lakes:-** These type of lakes are deep. These lakes are characterised by relatively poor productivity and low in nutrient concentration, dominated by cold-water bottom fishes. They are characterised by slow growth, low metabolism and with population density. They offer very low levels of nutrients, which include deep oceanic sediments, caves, glacial and polar ice Where as

**Eutrophic lake:-** These are highly productive and very rich in plants. These lakes are relatively shallower and found dominated by warm-water fishes. They include explosive growth of plants and algae. The natural processes which are responsible for the formation of natural lakes commonly include glacial, volcanic force while human made lakes are created by reservoirs or dig of basins.

**1.2.1.3. WETLANDS:-**

Wetland the word is very simple but what actually wetland is and is not? This question still remains much confusion over the various scientists and workers. As a part of this confusion numerous definitions have been proposed and even though always do not agree with the definitions. (Anderson, 2012). Wetland often confuse with the word Water-body. Wetlands with these two terms which possess historical meaning make very easy to understand more specifically. Both of these terms having specific meanings. Among them one is ‘Marsh’ the wetlands dominated by herbaceous vegetation and other is ‘Swamps’, which are wetlands generally dominated by trees and shrubs. However in some parts of the world they are found dominated by herbaceous vegetation. Rather than many of terms ‘Wetlands’ is more scientific term. Whereas the term ‘waterbody’ has very broad meaning. It comprises all types of aquatic and wetland systems. Thus waterbodies include wetlands, rivers, streams, deep lakes, ponds, canals, man made reservoirs, paddy field and oceans. As for an example paddy fields, ponds, swamps, marsh are not only considered as wetlands but along with wetlands they are also considered as the types of waterbodies.
Chapter I

Introduction

It has been very long history of people defining wetlands. Someone simply thought that the wetland is the land area, if it is wet enough get a duck’s feet wet, then it is a wetland. (Anderson, 2012). Many workers have variously define the wetlands according to their view, which include as follows:

(1) The Ramsagar Convention presents broad interpretation of wetland and stated “wetlands include a wide variety of habitat such as marshes, peatlands, floodplains, rivers, lakes and coastal areas such as saltmarshes, mangroves and seagrass beds, but also coral reefs and marine areas which deeper less than 6 meter, as well as human made wetlands such as waste water treatment ponds and reservoirs.”

(2) Nathaniel shaler define the word wetland in his General Account of the Fresh Water Morasses of the United States (1890), as “The areas in which the natural declivity is insufficient when the forest growth is removed to reduce the soil to measure of dryness necessary for agriculture. Wherever any form of engineering is necessary to secure this desiccation, the area is classified as swamps.”

There are more two definitions stemming from the U.S. that have been widely accepted by majority of wetland scientists. These definitions have slight modifications and used in other contexts. (Anderson, 2012). U.S. Fish and Wildlife Service definition is quite comprehensive and emphasizes hydrological, botanical and soil characteristic. They define wetlands as “lands transitional between terrestrial and aquatic system where the water table is usually at or near the surface or the land is covered by shallow water.” Anderson stated that the above definition limits the water depth of 2 meters or less than it because of that to classify wetlands, they must have these attributes. Such as

1. At least periodically the land supports predominantly hydrophytes.

2. The substrate is predominantly undrained hydric soil and

3. The substrate is non soil and is saturated with water or covered by shallow water at sometime during the growing season of each year.

Importance of wetlands:-
Chapter I
Introduction

The importance of wetlands cannot be overestimated as they aid in preventing floods, keep river flowing during mid-summer, restore water to underground reservoirs and hold the water table to the appropriate level. But the very existence of these wetlands is under threat due to various developmental activities and human population pressure (National Wetland Atlas, 2010). Wetlands are often considered as the kidneys of the landscape because they play an important role in water cycle and chemical cycle. Wetlands also filter out the sediments and pollution from the surrounding environments, so that the water discharged is cleaner which enter into the wetland. Thus they act as both a sink and source, storing and passing on vital resources to their local environment (Saini, D.C. et al., 2010). The wetland habitats support varied flora and fauna and are highly productive ecosystems similar to the tropical rainforest in terrestrial ecosystems (Ramachandra et al., 2005).

1.2.1.4. NATURAL AND ANTHROPOGENIC THREATS TO AQUATIC FLORA

Usually stagnant water bodies have more complex and fragile ecosystem while compare with running water bodies as they lack self cleaning ability, thus accumulating large quantities of pollutants. Increased human activities in the form of various anthropogenic activities in water bodies damage the aquatic ecosystem as well as it affect the hydro-chemical properties of water, which leading to huge influx of nutrients and causing harm to the prevailing aquatic biodiversity (Sidnei et al., 1992).

According to Organic Farming Research Foundation (OFRF) only 2% of farms are organic. This indicate that about 69% our fresh water supply is being contaminated by chemical pesticides & fertilizers and herbicides. These are added in water bodies and badly affect the vegetation and aquatic fauna living in. Moreover these chemical compounds give acid rain. Acid rain adversely effects on plants, animals and aquatic life. Acid rain also contaminate our limited freshwater and thus causes water pollution and unbalance water cycle. These points lead to a poisoned and un-inhabitable environment for aquatic flora and fauna, along with these it also affects land animals and human which survive on these systems.

Sediments occur in water bodies both naturally and also as a result of various human activities. They are also produced in large amount due to changes in land use and also agricultural practices. Some human activities such as farming, deforestation, urbanization and mining can
add too much soil and other matter in rivers and these sediments which settled at the bottom of river harm to the plants and animals live in river by carrying toxic chemicals in river. Moreover these sediments also responsible in raising water temperature and reducing the total amount of sunlight penetrating the water. So the aquatic plants living in water are not able to get sufficient sunlight for the process of photosynthesis. Because of this their growth will be reduced and ultimately it is resulted in destruction of aquatic flora and indirectly leads to destruction of aquatic ecosystem.

1.3. AQUATIC PLANTS:-

Aquatic plants are very remarkable forms of plants life, mainly on account of the fact that due to the aquatic habitat in which they spend most of their lives are practically unaffected by climatic and seasonal changes or at least much less affected the land plants (Saini D.C et al, 2010). So it become possible to study such plants more or less throughout the year. It is very difficult to define aquatic plants and the difficulty came from the existence of numerous borderline species.

Muenscher, (1944) considered aquatic plants as "Those species which normally stand in the water and must grow for at least a part of their life cycle in water either completely submerged or emerged". Similarly this view has been expressed by Reid(1961), who defined water plants as "those whose seed germinate in either the water phase or the substrate of a body of water, which must spend part of their life cycle in water. This ecological grouping included plants which grow completely submerged (except when flowering) as well as a variety of emergent types". (Agnes Arber, 1920) in his book "Water plants a study of aquatic Angiosperms" described the hydrophytes, plants which have changed terrestrial life for aquatic life. Those which have embraced this change must systematically live with their leafy shoots completely submerged and in some cases stopped to take root in the base layer, so that their vegetative life is passed freely float in the water which is to them what environment and term in the receiving of aquatic conditions is reached in certain hydrophytes with embedded flowers in which even the pollination process is aquatic, water replacing air as the medium through which the pollen grain is transferred to the stigma. The result has been that the aquatic flowering plants have come from a distinct assemblage varying widely among themselves but characterised broadly speaking by number of textures associated with their peculiar mode of life. (Saini D.C, 2010) define hydrophytes as "plants living in flowing and standing deep water with excessive water supply do
not face the problems of water loss due to transpiration withing and drought are known as hydrophytes.

According to climatic condition facilitates the prevalence of many types of flora. Aquatic plants also called hydrophytic plants or hydrophytes. They are living on or under water for that it has requires numerous special adaptations. Aquatic vascular plants can be ferns or angiosperms. Aquatic plants are found in lakes, streams, rivers, canals and reservoirs.

1.3.1. CHARACTERISTICS OF HYDROPHYTES:-

1. A thin cuticle layer. Cuticles prevent water loss, thus most hydrophytes have no need for cuticles.
2. Stomata are open most of time because water is plenty and therefore there is no need for water to be reserved in the plant, which proved that guard cells present on the stomata are generally dormant.
3. An increased number of stomata which can be present on either side of leaves.
4. A less rigid structure, water pressure support them to be that.
5. Flat leaves on plants for easily float on water surface.
6. Air sacs for floation.
7. Smaller roots: water can diffuse directly into leaves.
8. Feathery roots: no need to support the plant.
9. Particular roots which able to take in oxygen.

1.3.2. ADAPTATIONS IN HYDROPHYTES:-

Free floating plants:-

In a pond community, these plants receive more sunlight than submerged plants. They also have to struggle with one another to get sunlight. In most of the free floating plants roots and stems are poorly developed. In Wolffia and Salvinia the roots are entirely absent. Abundant aerenchyma cells maintain high buoyancy for easy floating.

Submerged plants:-
Chapter I

Introduction

Submerged plants receive low amount of sunlight because light energy diminishes while passing through a water column. In submerged plant leaves are thin, long and ribbon shaped as in Vallisneria sp. In Nymphaea and Nelumbo leaves are large, flat and coated with waxy material. Their petioles are long and flexible. In Hydrilla the stem is long, slender, spongy and flexible, where as in Eichhornia the stem is stoloniferous and spongy.

1.3.2.1. CLASSIFICATION OF HYDROPHYTES:-

Aquatic angiosperms are classified in different categories depending on surrounding area. Different workers have classified aquatic angiosperms in various categories. According to Doubenmire the aquatic angiosperms of the Lalbandh lake, West Bengal have been classified into 7 different categories as follows.

(1) Floating hydrophytes: These type of plants are in contact with water and air only and not with soil. Such plants are as Eichhornia crassipes (Mart) Solms, Trapa natans Linn., Pistia stratiotes Linn., Spirodella polyprrhiza Schleid., Wolffia arrhiza (Linn.) Wimm. etc...

(2) Suspended hydrophytes: These plants are rootless and found suspended under water such as Ceratophyllum demersum Linn., Utricularia flaxuosa Vahl, U. Stellaris L.f. etc...

(3) Submerged anchored hydrophytes: These plants are entirely or for the most part remain in contact with soil and water only such as Vallisneria spiralis Linn., Hydrilla verticillata (Linn. F.) Royle, Ottelia alismoides (Linn.) Pers., etc...

(4) Floating leaved anchored hydrophytes: These type of pants are attached with soil, most of the part submerged in water except the leaves and flowering parts. Such plants include Nymphaea nouchali Burm. F., N. Stellata Willd., Nelumbo nucifera Gaertn., Nymphoides cristatum (Roxb) O. Kuntze, etc...

(5) Floating shoots anchored hydrophytes: These plants are rooted, attached to the margin of water bodies and remain floating with their shoots on the water surface. They are found in contact with soil, water and air. These type of plants become terrestrial with reduced leaves and stunted growth as soon as water recedes during the dry season. Such plants are Jussiaea repens L., Neptunia natans Lour., Ipomoea aquatica Forsk, Hygrophila polysperma (Nees.) T., Anders, etc...
(6) Emergent anchored hydrophytes: The root, the flower part of the stem and the lower leaves of plants are usually found submerged in water, e.g. *Aeschynomene indica* Linn., *A. aspera* L., *Ammania baccifera* Linn., *Cyperus corymbosus* Rottb. *C. cephalotes* Vahl., *Limnophila indica* Druce., *Polygonum barbatum* L., *Scirpus articulates* L., etc...

(7) Wetland hydrophytes: These type of plants spend their life fully or at least in the early part of life in the soil which is saturated with water. These plants include *Canscora diffusa* R. Br., *C. decussate* Roem. & Schult., *Hygrophila articulates* Heine, *Melochia corchorifolia* Linn., *Rumex dentatus* Linn., *Gnaphalium indicum* Linn., etc.

**R.S.Ambasht, 1969** classified hydrophytes on the basis of life form into phytoplanktons and macrophytes. Among them macrophytes are predominantly vascular plants. Further they are divided on the basis of their habit and location in ponds or lakes. They may as follows:

(1) **The marginal emergent hydrophytes**: - They are found around the ponds and lakes where the level of water has gone down considerably and about 2 to 15 cm. Of the basal part of the plant body is immersed. The rest part lies straight up emerging in the air. This type of plants keep on extending down as the pond water receds on drying. The common species of this category are *Eleicharis plantaginae*, *E. Pallustris*, *Isoetes* sp., *Typha* sp., *Cyperus* sp., *Fimbristylis* sp., *Polygonum* sp., wild *Oryza*, *Zizania*, etc.

(2) **The submerged rooted hydrophytes**: - These rooted hydrophytes remain submerged in water are restricted to shallow regions where light is abundantly available to the plants up to the bottom. These submerged hydrophytes are divided into (a) plants with long stem covered with leaves and roots arising from nodes. These plants include *Hydrilla* sp., *Potamogeton pectinatus* and *Najas*. And (b) tuberous stem with cauline leaves such as *Vallisneri*, some species of submerged *Aponogeton* etc. In these plants leaves are ribbon shaped, thin and flat.

(3) **The rooted hydrophytes with floating leaves**: - These type of plants are restricted to more or less shallow regions of ponds or lakes up to 3 meters depth. The leaves emerge up and keep floating. These plants may be fixed in mud (I) by rhizomatous structures eg. *Nymphaea stellata*, *Nelumbium speciosum*, *Aponogeton* sp., etc. or by (II) trailing type of stoloniferous structures where leaves are fixed on short petioles eg. *Nymphoides* and *Potamogeton natans*.
(4) The free floating hydrophytes:- These plants occur scattered everywhere in ponds and lakes keep changing their position due to water and wind currents. In small ponds they may be aggregated more in the centre. In form and structure these plants may be larger with rosettes of (I) big leaves either floating or rising above in air as in *Trapa bispinosa* and *Eichhornia crassipes*. (II) slightly smaller forms are *Pistia* and *Salvinia* with spongy floating leaves. (III) very small surface floating plants with the body reduced to thallus like structures eg. *Lemna*, *Wolffia*, *Spirodela* and *Azolla*. Moreover some species may remain just below the water surface or come up periodically and sink down for perennation eg. *Utricularia*.

*Agnes Arber, 1963* have given the Biological classification of hydrophytes as follows: (1) **Plants rooted in the soil:-**

(A). Plants which are basically terrestrial, but are able of living as submerged aquatic plants, though without clear adaptation of the leaves to aquatic life. Such plants are *Achillea ptarmica*, *L.* (Sneezwort), *Cuscuta alba*, J. and C.Presl (Dodder), *Glechoma hederacea*, L. (Ground ivy).

(B) Plants which are sometimes terrestrial but sometimes produce submerged leaves differ from terrestrial type. The aerial leaves are connected with the flowering stage. Such as *Sium latifolium*, L. (Water parsnip).

(C) Plants which produce three types of leaves like, submerged, floating and aerial according to the internal or environmental conditions. (i) Plants in which leaf is of aerial type is associated with flowering stage. Such as *Sagittaria sagittifolia*, L. (Arrowhead). (ii) Plants in which floating type of leaf is associated with flowering stage. E.g., *Nymphaea lutea*, L. (Yellow water lily), *Castalia alba*, Green (White water lily), *Potamogeton natans*, L. (Pondweed) etc.

(D) Plants which may occur as aerial forms, but are basically submerged and are characterised by a creeping axis with long, branched, leafy shoots without floating leaves, rooting shoots with no creeping rhizome. (i) Leafy aerial shoots produced at the flowering period. E.g. *Myriophyllum verticillatum*, L. (Water milfoil), *Hippuris vulgaris*, L. (Mare’s-tail). (ii) Inflorescence comes out of water, but no aerial leaves except in the terrestrial forms. E.g. *Myriophyllum* (except *M. Verticillatum*), *Hottonia palustris*, L. (Water Violet). (iii) Inflorescence submerged, but vital organs raised to the water surface. E.g. *Elodea Canadensis*, Michx. (Water Thyme). (iv)
Inflorescence completely submerged and pollination of hydrophilous. E.g., *Najas, Zannichellia* (Horned pondweed), *Zostera* (Grass-wrack), *Halophila*.

(E) Plants in some cases may occur as terrestrial forms, but are very commonly submerged and characterised by reduced axis from which linear leaves arise. (i) Inflorescence comes out above the water or born on a land plant. E.g. *Lobelia dorimanna*, L. (Water lobelia), *Littorella lacustris*, L. (ii) Inflorescence raised above the water or sometimes submerged. E.g. *Subularia aquatic*, L. (Awlwort)

(F) Plants which are wholly submerged as regards the vegetative organs and have a thallus attached to the substratum with aerial flowers.

**2. Plants not rooted in the soil, but live unattached in the water.**

A alteration between 1 and 2 is found in *Stratiotes aloides*, L. is rooted during some part of the year but float freely during another part. There are also numerous rooted plants such as *Elodea Canadensis* and *Hottonia palustris* are capable of living unattached for considerable time period.


(B) Plants fully or partly submerged. (i) Rooted, but roots not piercing the soil. Floating shoots raise the flowers into the air such as *Lemma trisulca*, L. (ii) Rootless. (a) Inflorescence raised out of water like *Aldrovandia, Utricularia* (Bladderwort). (b) Flowers submerged, Hydrophilous pollination e.g. *Ceratophyllum* (Hornwort).

Mohammed, H.A. noted in his review that Pyne, (1986) & Nather Khan, (1990) classified the fresh water macrophytes into following described four categories:

I. **Free-floating**: These are the plants in which roots if present found hanging in water and the plants which float on water surface their roots are being swimmers. Such plants include *Azolla africana, Pistia stratiotes, Lemna pausicostata, L. perpusila, L. trisulca, Eichhornia crassipes, Salvinia sp* etc. II. **Submerged species**: These type of plants are usually rooted in soil with vegetative part permanently submerged. E.g. *Ceratophyllum dermatersum, Potamogeton crispus*,
**Chapter I**

**Introduction**

_P. Pectinatus, Najas marina_ etc. **III. Emergent species:** These plants are rooted in shallow water with vegetative part of the plant remain emerging above the water surface. E.g. *Nymphaea* sp., *Typha australis*, *Phragmites* sp., *Echinochloa stagnina*, *E. Pyramidalis*, *E. Obtusiflora*, *Cyperus* sp etc. **IV. Marginal species:** These plants can survive on land or water. Most of them belong to the families Araceae, Cyperaceae, Poaceae.

**1.3.2.2. MEDICINAL AQUATIC PLANTS:**

Human beings have been utilizing plants for basic preventive and curative health care since time immemorial. Recently it is estimated that over 9000 plants have known medicinal applications in various cultures and countries. Medicinal plants are used at the household level by women taking care of their families, at village level by medicine men or tribal shamans and by the practitioners of classical traditional system of medicine such as Ayurveda **John Gonsalves (2010).** The threats caused by natural or anthropogenic reasons now become question to the sustainability of the medicinal aquatic plants has emerged very strongly in the recent years. The plant resources have become important domains of intervention and are increasingly attracting the attentions of public and private sector policy researchers, policy makers and development program implementers **Shahidullah (2007).** Now a days more attention is given by scientist and research workers in special aspect to the field of medicine have widely established that there are numerous plants which have been proved to possess tremendous and positive effects on different critical diseases. It is estimated that about 80 % of the ingredients of Indian system of medicine are provided by the various plants either terrestrial or aquatic. Aquatic and semi-aquatic plants which possess potential medicinal value are also used by local community in the treatment of various diseases. Some of the important medicinal aquatic plants include _Alternanthera sessilis_, *Bacopa monniner*, *Centella asiatica*, *Commelina benghalensis*, *C. diffusa*, *Colocasia esculenta*, *Eclipta prostrata*, *Cyperus iria*, *C. rotundus*, *Heliotropium indicum*, *Hydrolea zeylanica*, *Glinus oppositifolius*, *Grangea maderaspatana*, *Limnophila indica*, *Ipomoea aquatic*, *Lindernia anagallis*, *Marsilea minuta*, *Monochoria hastate*, *Ludwigia adscendens*, *Nelumbo nucifera*, *Nymphaea pubescens*, _N. nauchali_, *Nyphoideas indica*, *Phyla nodiflora*, *Pistia stratiotes*, *Polygonum barbatum*, *Trapa natans*, *Typha domingensis*, *Vallisneria spiralis* etc. above listed plants are useful in some way or other way. **Cook (1996)** in his aquatic and wetland plants of India has given some short notes on the utility of the plants. **Bhrigu Prosad Sarmah et al., 2013**
stated in their paper that in NE India there are so many plants whose medicinal value is not known properly, which may be the source of medicines of deadly diseases like cancer, AIDS etc. In NE India there are sufficient employment potentialities through medicinal plant gardening. The tribal people of this area have sufficient knowledge on herbal medicines and that will be helpful in establishing medicinal plant garden successfully.

1.3.2.3. UTILIZATION OF AQUATIC PLANTS:-

Aquatic vegetation is an essential component of the aquatic ecosystem with positive as well as negative implications on the water body. The extensive growth of aquatic plants may cause a nuisance in the ecosystem and may reduce the flow of water in irrigation canal. One of the most solution of such problems is the positive economic utilizations of such aquatic plants. However aquatic plants proved beneficial for human. Aquatic plants may serve more functions. They provide food, fodder, shelter to the other aquatic organisms. Aquatic plants serve as primary producers in aquatic ecosystem. They play an important role in enriching the aquatic ecosystem by fixing carbon and increasing those food required for energy expenditure. The aquatic plant also produce oxygen by photosynthesis which is necessary for aerobic organism. Aquatic vegetation is an essential component of aquatic ecosystem with positive as well as negative effects on water bodies. Aquatic plants are primary producers of aquatic ecosystem. They function as similar with that of the other plant forms like terrestrial plant. Aquatic plants may in the form of algae, mosses, ferns or angiospermic plants and they perform various functions. Moreover efforts should be made to cut the excessive growth of aquatic plants so that they can be prevented from becoming a nuisance in the ecosystem. This problem can be solved by positive economic use of such plants. Boris, 1996 stated that it is estimated there are 2,50,000 to 5,00,000 species of plants on the earth. Relatively a small percentage about 1-10% of these is used as food by both humans and other animal species.

Aquatic plants can be harvested and used for fibre and building material or as food for farm animals or directly for human consumption. (National Academy of Sciences, 1976). Aquatic plants have economic and environmental utility depending on their natural characteristic. Some of them are consumed by human while other species possess medicinal value and other species are proved as good resources of minerals and vitamins. Rahman et al. (2007) revealed that because of rich content of carbohydrates and proteins in aquatic plants they can be utilized as
food and feed such as Alternanthera, Philoxeroids, eichhornia etc. Some aquatic macrophytes such as Hydrilla verticillata, Potamogeton crispus, P.pancinatus play an important role in increasing sedimentation of water reservoirs at accelerated rates (Ashiq, et al. 2003). Moreover the vegetation of submerged aquatic plants found in association with the other aquatic plants where aquatic ecosystem is healthy because they provide habitat to many aquatic animals, insects. These plants also built an essential level and work as primary producers in aquatic ecosystem and become source of food for many aquatic animals, birds, mammals, fish and insects. Along with food requirements aquatic plants also provide oxygen to the aquatic animal for respiration which they produced by photosynthesis and also provide protection by maintaining temperature against hot and cold weather. The plants like Wolffia, Lemma and Spirodella of family Lemnaceae have been used as fresh fish feed which help in very good production of fish. This type of utilization may possess many reasons which include that these plants has ability to grow fast even in sewage effluents or in rich organic pollutant water-bodies, in which they play an important role as biological filter in sewage effluents. Some plants like Pistia stratiotes, Eichhornia crassipes and Hydrilla verticillata can be used for removal of heavy metal pollutant from polluted water.

The submerged hydrophytes Hydrilla verticillata is eaten by some freshwater fish and may be used as manure where it occurs in large quantities. It also become a serious menace to navigation in large lakes and in irrigation canals as it reduces the rate of waterflow (Ghafoor, 1985). Submerged aquatic plants constitute an essential component of ponds, streams, lakes and riverbanks. These aquatic flora provide nourishment and protection for aquatic animal life. The habitat of such plants are threatened by the scarcity of water and anthropogenic activities of human population (Marwat, 2011). Native aquatic plants provide valuable fish and wildlife habitat, (Savino & Stein, 1982., Heitmeyer and Vohs, 1984., Dibble et al., 1996), improve water clarity and water quality, reduce the rate of shoreline erosion and sediment re-suspension and help in preventing the spread of nuisance exotic plants. these plants can prevent nuisance of exotic plants directly by the principle of competitive exclusion (Smart,1995). Thus submerged aquatic plants are the clear habitat and good food source for various organisms such as fish and many invertebrate animals. Moreover (Mark, 2008) stated that submerged aquatic plants are beneficial in predicting the impact of various habitat alterations. These plant added organic
matter to sediments, manipulate light climate and reduced nutrient loading. They also exhibit photosynthetic adaptations to the aquatic environment.

Aquatic plants may serve many functions. They provide good shelter other than algae. Such as floating and rooted plants are used by fish as shelter which save them from predators. In similar manner submerged plants also proved as good shelter for aquatic invertebrates, fish and algae. Many species of algae remain attached to the stems of aquatic plants and grow. Rooted aquatic plants also eaten by some species of snails. However the emergent aquatic plants food sources for terrestrial as well as aquatic organisms. These aquatic plants remove various heavy metals in large amount from the water and gather them in their tissues and they released when the plants decays. However they may be transferred through the ecosystem by the organisms which feed on them.

Mohammed, H.A. remarked in his review that Payne, (1986) and Okojie, (1998) have reported a variety of products, services and many benefits in various way offered by aquatic macrophytes, which include the following described points. (1) **Food for fish and other aquatic vertebrate:-** It has been proved that aquatic plants play an important role in the life cycle of fish. A free floating aquatic plant *Lemma pausicostata* is eaten by some species of fish whereas other fish species feed on periphyte algae growing on aquatic plants. Moreover microphytes also serve food for microfauna, larva of insects and other small aquatic animals. (2) **Breeding ground for aquatic life:-** Aquatic vegetation also provide breeding substrate for a large number of insects and other invertebrates which are used as food by fishes moreover Imevbore and Bakare in 1974 had reported that fish fry used aquatic vegetation for shelter purpose as well as their spawning ground. (3) **Aquatic plants as Bio-Fertilizer:-** Aquatic plants possess large amount of nitrogen and phosphorus in their tissues. Therefore they will definitely improve soil quality if they applied in soil as soil adjectives. *Azolla* sp. is a free floating fern which fix the nitrogen in symbiotic relationship in combination with Cyanobacterium *Anabaena azollae* is widely used as bio-fertilizer for rice crops. Maltby, in 1986 reported that *Azolla* sp has been used to large extent to fuel rice production in waterlogged areas in china. (4) **Sources for Human or Animal food:-** The most popular aquatic plant *Oryza sativa* is widely used as food. Other aquatic plants offer various food items which include *Echinochloa stagnina* seeds are collected for food in many parts of the world. Kio and Ola- Adams, (1987) reported
that the rhizome, floral receptacle and fruits of *Nymphaea lotus* are eaten raw or cooked for food. Water hyacinth can be used in mixture with other in limited quantity feed by cattle, sheep, goats etc. some other aquatic plants used as fodder are *Leersia hexandra, Bracharia mutica, Vossia cuspidate, Echinochloa pyramidalis, E. Stagnina, Sorghum arundinaceum* etc. (5) Medicinal Value:- Number of aquatic plants contain medicinal properties which is widely used in the treatment of many diseases. A considerable numbers of these ethno-botanic materials have been reported to yield compounds, which could be used as modern drugs and pharmaceuticals (Okojie, 1998). Kio & Ola-Adams in 1987 noted that *Polygonum senegalense* is pounded with hydrated sodium carbonate and rubbed on limbs for the treatment of rheumatism and other swellings. *Althernanthera nodiflora* is used for simple stomach disorders, whereas *Pistia stratiotes* is used for ulcerative conditions of mouth and tongue. While the other use of *P.stratiotes* is reported by Obot and Ayeni in 1987 that the plant is used as a part of concoction for the treatment of flu. The emergent plant *Neptuntia oleracea* is used in the treatment of yellow fever and Guinea worm infection. Moreover there are so many aquatic macrophytes which contain medicinal properties and have been used in modern drugs and pharmaceutical industries. Bubayero in 1986 remarked that stems and roots of *Polygonum senegalense* and *Nymphaea lotus* are used in eruptive fevers and for urethral discharges, while decoction of flower is narcotic and sedative in nature. The juice of *Ethulia conyzoides* can be squeezed into the eyes for the relief in headache and when the roots mixed with red pepper it treats constipation and the leaves are effective in prevention of abortion if it is given in food.. *Heliotropium indicum* is used in the treatment of fever in children and also as vermifuse and eye-lotion. *Cyperus articulates* is effectively used in the treatment of cough. While dried and crushed *C. articulates* is widely used as fumigant and it can be mixed with scented resins for the clothing and air-fresheners in rooms. It is reported by Dalziel in 1937 that the bark of mangroves is widely utilized in the treatments of diarrhoea and dysentery in children, in sore throat and also for urethral infection. Moreover Kio & Ola-Adams in 1990 noted that mangrove bark is effective in leprosy. (6) Sources of Recreation, Tourism, Aesthetic and Other uses:- Some aquatic plants have been noted possessing a great potential in recreation and in horticulture, which include some members of the family Orchidaceae such as *Eulophia caricifolia, E.angolensis* etc. Other smaller plants like *Najas* sp may also useful in the aquarium as an ornamental plant and also as agent of aeration (Okojie, 1998). On the other hand the presence of aquatic plants in water bodies have added the
aesthetic and tourism value to the water bodies. The water bodies rich in aquatic flora being
developed in tourism centres which will include sport, fishing, bird watching, nature
photography, moreover the aquatic plants with beautiful flower have been added a great aesthetic
value to the water bodies.

The aquatic plants are also very valuable as energy source depending on their uses as fuel for
fish smoking and for domestic energy. It has been reported that the stems of some plants like
Aschynomene crassicaulis, Echinochloa sp. and Cyperus papyrus are used as fuel specially for
cooking and fish smoking (Kio & Ola-Adams, 1987). In NIFFR, Eyo (2000) described the use
of water hyacinth in the production of biogas and proposed the construction of dome type biogas
digester to use of water hyacinth for biogas production which will provide energy to local
communities and that will be ready sources of fertilizer for the farmland.

1.3.2.4. TRADITIONAL AND MEDICINAL KNOWLEDGE/USES OF AQUATIC
PLANTS IN ACCORDANCE OF TRIBAL PEOPLE:

Aquatic plants are used by tribal people in many way. Plants used by primitive and aboriginal
people since a long term. These people applied traditional knowledge, their skill and practices in
the utilization of plants. The study of botany of primitive human race is known as ‘Ethnobotany’.
In other words ethnobotany is the study of how people of particular culture and region make use
of the indigenous plants growing their surrounding areas. Prof. P.C.Trivedi and Dr. Niranjan
Sharma (2011) stated in their book of Ethnobotany that living close to the nature the traditional
scientists have acquired the sole knowledge about the utility of wild flora and fauna, most of
them are not known to the people living very far from such natural ecosystems. Such knowledge
and practices were subjected to further modifications with new knowledge by succeeding
generations and became the part of the traditions, culture, art based on these traditional
communities. Jain (2001) stated Ethnobotany deals with the study of total natural and traditional
interrelationships between man and plants and his domesticated animals. These people use
aquatic plants as food, fodder, medicines, fuel, and in house hold uses in different ways. The
tribals also prepare medicine from the different parts of plants, which used to cure various
diseases. Other than medicines and food the aquatic plants also provide many type of material
which could be used for construction, matting, bedding and in pulp or paper making. Obot,
(1984) reported that the silky inflorescence of *Typha australis* are used in stuffing pillows and mattresses. The dry tuber of *Cyperus maculates* is sold as perfume along with that the underground stem of *C. articulates* also provide perfume, whereas the leaves are burnt over the fire as mosquito repellent and the aerial stems are used in weaving of mats commonly sold in northern part of Nigeria. *Cyperus papyrus* and *Eichhornia crassipes* has been possess economic potentials for pulp, paper and fibre. Obot also noted that the inflorescence of *Nypa fruticans* has been reported to yield palm wine and sugar and *Raphia vinifera* provided row material which used in making brushes, brooms and mats.

1.4. PHYSICO CHEMICAL PROPERTY OF WATER:-

Ironically, the planet we inhabit is called Earth. What makes planet three of our solar system special is water. Moreover the presence of water on other worlds has a patchy history from the imagined seas of the Moon, canals of the Mars and fetid, steamy forests of the Venus to more recent and definite exploration of the atmospheres of some planets and their satellites. But only Mars landscapes are very suggestive to have surface water processes very long ago. (Michael Jeffries and Derek Mills, 1992).

The Earth is the only planet which retains surface water on it. Water is most essential substance for life of all organisms living on the Earth. In nature water appears in all three forms of matter and take in many different forms on the Earth. It appears as vapour and clouds in the Sky, as sea water and icebergs in the polar oceans, rivers and glaciers in the mountains and as liquid form on the ground. Among all water present on the Earth most of it occupies by Oceans, but the whole mass is not fixed. Water cycle play an important role in occurrence of water on the Earth. Water evaporates from the sea and land, then vapour clouds move in the atmosphere and after cooling rain falls on the Earth and refill the seas, icescapes and underground stores and then the stored water to supply the lakes, ponds, rivers and streams. Among these water freshwaters are only a tiny proportion of the total water on the Earth. And they are the unique habitat of distinct plants and animals. Water is universally present everywhere. More than about 75% of our earth’s surface is covered by water in the form of sea, lakes, rivers. Water is by far the most important substance which necessary for life. All the physiological processes takes place in the medium of water. Water is the universal solvent and nutrients enter into plant body in dissolved form. Thus water helps in nutrient absorption. Water is found everywhere in atmosphere in the form of
vapour or cloud. It is also present in the form of ice in large amount on North and South poles, 
on the tip of mountains and in temperate parts of the Earth.

water is the most precious gift to mankind. Life on the earth is not possible without water. It is 
the soul of nature. Water is vital resource used for drinking, irrigation, fish production, power 
generation and many others Sathe et al., (2001). Water is very peculiar substance. It is the only 
liquid commonly found on the surface of the planet apart from occasional tar pits, molten, rock, 
bubbling mud and the metal mercury, none of which is conductive to life (Michael, 1992). 
Approximately 97% water of the earth is in oceans, 2% is in glaciers and polar ice, 0.009% in 
lakes and 0.00009% in rivers and the residue in ground water (Subrahmanyam and 
Sambamurti, 2004). Among these we are using only 1% of total water present on the earth. So 
we must maintain the quality of water resources and save them from being polluted. It is also 
said by Kudessia in 2003 that if we provide pure drinking water about 98% diseases can be 
eliminated automatically. Arumugam, 2014 stated in his book ‘concept of ecology’ that water is 
described as the mother of life. It is regarded as the liquid gold. It is universal solvent and is a 
largest medium of life. It occupies 71% of the earth surface. The availability of fresh water to 
man is only 0.3 to 0.5% of the total fresh water present on the earth. Therefore its careful use is 
very important and it become our moral duty. In present scenario rapid unplanned urbanization, 
industrialization and indiscriminate use of artificial chemicals cause heavy pollution in aquatic 
environment which leading to deterioration water quality and destruction of aquatic flora and 
specially fauna including fish. Without the knowledge of water chemistry it is very difficult to 
understand the biological phenomenon because water chemistry indicate the metabolism of the 
ecosystem and also helpful in explaining the general hydrobiological interrelationship, 
(Deshmukh and Ambore, 2006). Many human activities required water in various way. The 
properties of water and dissolved substances make it very useful for industrial purposes and daily 
use. After use in home, agriculture and industry the water get contaminated. The used water 
contain waste and harmful substances called pollutants, which pollute our environment in one 
way or other. So in order to conserve water efforts should be made to minimize pollution of the 
Sources of water. the quality of water is now the concern of scientists all over the countries. The 
recent decision of WHO emphasizes that water given to people should meet high requirement of 
modern hygiene and it must be free from toxic substances and pathogenic organisms. Water 
balance is causing changes due to human activities like industrialization, deforestation and over
population (Trivedi, P.R. 1989). The properties of water create physical and chemical conditions to which wildlife must be adapted to utilize freshwaters. These physico chemical properties are abiotic components of ecology and they affect all aquatic habitats. Moreover, the dominant influences may vary from habitat to habitat. In rivers force of water’s flow may be most important, whereas in lakes the depth to which light can penetrate may be most important. Thus good quality of water is most essential for living organisms and the water quality can be estimated by examine the physical and chemical characteristic of water. This include to find out the various physico-chemical parameters of water by analysis of water. According to Kotadiya et al. (2013) Physico-chemical parameters are very important in relation to the occurrence and abundance of the species. Temperature in fresh water habitats does not show much variation due to several unique thermal properties of water. Transparency is directly related to turbidity of water which depends upon the kinds and amount of suspended materials, mostly as salts, clay particles and living organisms etc.

Discharge of metropolitan, agriculture and industrial wastes have accelerated the quantum of various chemicals which enter the receiving water, which noticeably change their physico-chemical characteristics. The main sources of water pollution are sewage and other waste, industrial waste, agricultural discharges, thermal power plant and nuclear power plant. Each of these origins cause pollution which enter in our water body (Sharma, P.D., 2003). Chemicals can also disturb the aquatic ecosystems or can be accumulate in aquatic organism used by human as a food. It has been noted that the total demand for water may double every twenty years, or in some countries the period for doubling may decrease and take place in 10 years. The frightening and exponential growth of population and industry not only increase demand for water quality but also puts high requirements on water quality (Stanley, M., 1975). Moreover the other reasons of surface water pollution is the discharge of waste water may either from domestic activities or from industries. Mostly all industries generally produce highly polluted water contaminated by heavy metals as well as organic and inorganic substances. Now a days there is a propensity to use more surface water rather than ground water as a source of community water supply and for other activities. The industrial effluents include poisonous chemicals, heavy metals, acids, alkalis etc. In similar manner the pollutants come from agricultural sources contain various pesticides and fertilizers. The pollutants present in water adversely affect the water bodies as well as ecosystem depends on it. They highly contaminate our valuable freshwater
sources like ponds, lakes, rivers, ground water, streams and ocean water. These pollutants impart colour, turbidity, unpleasant taste & odour and foamness to water-bodies. They may damage aquatic life and affect the composition of flora and fauna living in. They may also cause various diseases in human and in other organisms. They need to be removed by water purification system, but although some of the pollutants cannot be effectively removed by conventional treatment processes. The most convenient method of water purification is chlorination. Chlorination can remove bacteria, but is not able to destroy industrial chemicals, along with this chlorination may also responsible for the removal of some beneficial bacteria. Hughes, 1985 stated that generally water contains Ca, Fe, Mg, Mn, Si, fluoride, nitrate, phosphates, sulphates and chlorides. When the quantity of these substances increase they affect the body system and cause destruction of health.

1.4.1. THE NECESSITY OF WATER ANALYSIS:-

One question arise in our mind that why the water should be analysed? Why it is so important? The analysis of the most common industrial solvent water is extremely important as it contains a large number of impurities or pollutants which are necessary to be checked before the water is used for any specific purpose. For example in municipal water which is used for drinking purpose, is most essential to determine colour, turbidity, dissolved solids, hardness, alkalinity or acidity, iron, manganese, fluoride, free chlorine etc. In addition, a complete mineral examination as well as bacteriological examination is also necessary (Sharma, B.K. 2006).

1.4.1.1. PHYSICAL CHARACTERISTIC OF WATER:-

Water has several important physical properties which are very familiar because of the omnipresence of water. most of the physical properties are quite typical.

Physical Properties Of Water:-

1) Pure water is a colourless, transparent, odourless and tasteless liquid.
2) It is a compound of hydrogen and oxygen.
3) It is neutral to litmus.
4) Pure water is a bad conductor of electricity.
5) Ice is less denser than water and ice floats on water.
6) In fresh water the maximum density of water occurs at 4° C, between 4° C and freezing temperature it becomes less dense as more of it becomes structured.

7) Its molar mass 18.0151 grams per mole.
8) Its melting point is 0.00 °C.
9) Its boiling point is 100.00 °C or 212 °F
10) Its freezing point 0 °C or 32 °F.
11) The maximum density (at 3.98 °C) 1.0000 grams per cubic centimetre.
12) Its vapour pressure (25 °C) 23.75 torr
13) Its Heat of vaporization (100 °C) 40.65 kilojoules per mole
14) Heat of fusion (0 °C) 6.010 kilojoules per mole
15) Its viscosity 0.8903 centipoise.
16) Surface tension (25 °C) 71.97 dynes per centimetre.

Freshwaters are in liquid phase, though many regularly solidify and all turn gaseous in part. Most living things also consist of water so they have a density very close to medium itself.

**Turbidity:-** Turbidity in water is due to the colloidal and extremely fine dispersion. Suspended matter in water such as clay, silt, finely divided organic and inorganic matters, planktons and other microorganisms are responsible to contribute turbidity. Generally turbidity found strong in sewage effluents and causes very worst effects. So the degree of turbidity of a water course may be used as a measure of the intensity of pollution. Turbidity measurements are helpful to follow the course of self purification of rivers or streams. It can be measured by visual methods and instrumental methods such as absorptiometrically or nephelometrically (Sharma, B.K. 2006).

**pH:-** It is the most important factor in water analysis since it come into the calculation of acidity, alkalinity, coagulation etc. pH is a measure of hydrogen ion activity is used to express the intensity of acidic or alkaline condition of solution. The knowledge of pH is very essential because most aquatic plants and animals live in pH ranges between 5.0 and 9.0. Biological activities may also responsible to change pH levels. During photosynthesis CO₂ removed from water and the removal of CO₂ results in higher pH, thus become helpful in reducing acidity of water. Changes in pH level is the indication of an industrial pollutant, photosynthesis, or respiration of algae. The pH of sample can be determined electrometrically or colorimetrically. Most of the ecosystems are greatly affected by the changes in pH.
Electrical Conductivity (EC):- Electrical conductivity is a measure of the capacity of water to convey electric current. It is an important physical water quality parameter, explaining the ionic status of water. There are many sources of EC which include plenty of dissolved salts which accumulate due to poor irrigation, minerals come from rainy water and evaporation of surface water, concentrate the dissolved solids in the remaining water, causes high EC. Hard water consisting extra salts therefore it has higher EC. It is also an important guide to check the purity of distilled water. It also play an important role in maintaining the biota of aquatic ecosystem.

1.4.1.2. CHEMICAL CHARACTERISTIC OF WATER:-

Chemical properties may be observed and measured by performing a chemical change or chemical reaction.

Chemical Properties Of Water:-

1) Water reacts with metals like Na, K, Mg, Ca by producing hydroxides.
2) It combines with many salts and form their hydrates.
3) Chemically water is compound of hydrogen and oxygen containing the formula H₂O.
4) Pure water has a neutral pH of 7, neither acidic nor basic.
5) All the major components of the cell such as protein, DNA, polysaccharide etc. are also dissolved in water.
6) Chemically water is very stable under the ordinary conditions of temperature and pressure.
7) TDS is the amount of non-volatile substances present in water, which are expressed in mg/l.
8) Salinity of sea water is high and of fresh water is low. Salinity remains constants in sea water, but it varies in fresh water and estuaries.

Water dissolves a vast variety of chemicals, in clouds before reaching the aquatic habitats as rain, or in the soil deeper underground or over the land and drip through trees. The chemical constituents in water are of two categories such as Major constituents and Minor constituents.
Major Constituents:- The cation and anion constituents analysed for water are such as Calcium (Ca), Magnesium (Mg), Sodium (Na), Potassium (K), Chloride (Cl) and Total Alkalinity ($\text{CO}_3^{2-}$+$\text{HCO}_3^{-}$).

Alkalinity ($\text{CO}_3^{2-}$+$\text{HCO}_3^{-}$):- Alkalinity of water is the capability of water to counterbalance a strong acids. The alkalinity of water is generally due to the presence of carbonate and hydroxide ions. It is characterized by presence of hydroxyl ions which able to combine with hydrogen ion. Generally it is conveyed by the presence of salts of weak acids such as carbonate, bicarbonate, phosphates etc. with hydroxyl ions. The CO$_2$ released from carbonates and bicarbonates is also utilized by aquatic plants for the purpose of photosynthesis activities. But in turn after the death of organism CO$_2$ is released by decomposition, which form carbonates and bicarbonates.

Total hardness ($\text{Ca}^{2+}$+$\text{Mg}^{2+}$):- Hardness of water is an important parameter for indication of suitability for industrial and domestic purposes. Calcium and magnesium ions are the major cations imparting hardness of water. Natural water is either hard water or soft water. The water which gives good foam with soap solution is soft water and the other not gives foam easily with soap solution is hard water, which is not suitable for domestic use in washing, cleaning and laundering. High concentration water hardness leads to the eutrophication of the aquatic ecosystems.

Total Dissolved Solids (TDS):- Total dissolved solids indicate the various types of minerals, salts, metals, anions and cations diluted in the water. generally the salts carbonate, bicarbonates, chlorides, sulphates, phosphates and nitrates of calcium, magnesium, potassium, sodium, iron etc. are found dissolved in natural water. The higher content of dissolved solids increases the concentration of water and influences osmoregulation of fresh water organisms.

Calcium ($\text{Ca}^{2+}$):- Calcium is one of the most important nutrient essential for the organisms. The occurrence of calcium in water mostly due to the presence of limestone, dolomite, gypsum and other gypsiferrous material. Its concentration reduces at high pH due to its precipitation as CaCO$_3$. Sharma et al., 2004 stated that it is an essential element and human body requires approximately 0.7 to 2.0 gm of calcium per day as food elements. Calcium deficiency is most common nutritional problem in many parts of the world. It is essential for normal plant growth and is required in water for irrigation. However water with high content of calcium is not
suitable for household uses such as washing, bathing because of excessive consumption of soap and other clearing agents.

**Chloride (Cl⁻):** Chlorides are usually present in water. Natural source of chlorides in water are dissolution of salts deposits such as MgCl₂, KCl, NaCl and weathering of sedimentary rocks (Solanki, 2001). They are also added in domestic water as bleaching agent which kills bacteria and control bad odour. A very minute quantities of chlorides are necessary for normal cellular activities in plant and animal life. It is stored in the body of organisms as sodium chloride (NaCl). Thus chloride in drinking water is not harmful to human beings. A higher concentration of chloride is an indicator of pollution from domestic sewage or industrial waste water.

**Sodium (Na⁺):** Sodium is presents in most natural water either in tiny or noticeable amounts. It is important to check the salinity or TDS in water. sodium is much important regarding with irrigation water, but less important in drinking water and water used for industrial purposes. Excess amount of sodium in water causes adverse effects on sediments properties and reduce its permeability. Mostly it is found in the form of chloride and sulphate in marine water. sodium play an important role in survival of aquatic organisms by maintaining osmoregulation.

**Potassium (K⁺):** It is also an essential nutritional element. Mostly it is formed through weathering processes. The quantity increases in polluted water. Potassium is one of the important parameter decide the presence of many species of aquatic organisms. It is noted that more concentration than desirable limit caused foaming in boilers, but low concentration of potassium is essential for plant nutrition in irrigation water.

**Minor constituents:** The minor constituents analysed from water sample in present study is Phosphate (PO₄⁻³),

**Phosphate (PO₄⁻³):** It is an important nutrient which regulate the growth of phytoplanktons. Its concentration level is useful to expect the biomass of phytoplanktons. The high concentration of phosphate increase algal bloom and leads to eutrophication. Total phosphates in water may be organic and inorganic phosphates. Kotadiya, 2013 stated that phosphates are generally found as phosphorus in natural water. It is a common component of fertilizers, manure and organic material in sewage and industrial waste. It can cause eutrophication such as a decrease in
dissolved oxygen in water bodies. Sources of phosphorus include human and animal waste material like sewage, industrial effluent, soil corrosion and agricultural fertilizers.

**Indicator parameters:**

**Dissolved Oxygen (DO):** Dissolved oxygen is highly important parameter in water quality assessments. Oxygen dissolve in water but the amount may varies with temperature. It is the most important factor which control the presence or absence of species of aquatic flora and fauna. It is essential for plants and animals. Its amount depends on the physical, chemical and biological activities of water bodies. Physical influences also affect the amount of oxygen along with that oxygen in natural system varies with mixing, turbulence, photosynthesis and respiration. The oils, soaps and detergent from industries and urban area have damages and disturbed the vegetation growth and life of animal in water bodies, because the oils and others appear as a layer on water surface have decreased the amount of DO. If water is transparent sunlight is being easily taken by plants for photosynthesis to prepare food, but if water is coloured it check sunlight penetration which finally affects the plant and animal world under water.

**Biological Oxygen Demand (BOD):** It is a measurement of the quantity of dissolved oxygen required by biological organisms for aerobic respiration. The excessive nutrients like nitrates, phosphates produced from domestic sewage, domestic fertilizers, waste material of animal feed etc. These are greatly responsible for water pollution, this is because they increase the growth of various micro-organisms, which increase Biological Oxygen Demand (BOD). It is a determination of the organic substance found in water. BOD test is extensively used as a signal of organic quality of water. It is very easy and approximate index of organic pollution. it causes eutrophication which become excessive due to abnormal increase in nutrient come from sewage, fertilizer, animal waste etc. Thus it is responsible for bloom of micro-organisms and aquatic vegetation. The difference in BOD result shows dynamism in aquatic life present in pond or lake. More number of anaerobic bacteria will increases BOD level in water body. The BOD value is found high during summer because of high bacterial activities and heavy input of organic material. (Sankar et al., 2002) stated that high BOD may be due to the increase demand of oxygen for the degradation of organic waste dumped in water.
Chemical Oxygen Demand (COD):- The chemical oxygen demand find out the amount of oxygen required for the chemical oxidation of organic matter. It is an index of the total organic content of water oxygen essential for the substances present in water. Sharma, 2006 stated in his book COD has been found to be more scientific than BOD. It is not necessary for COD value to correlate with BOD value. Textile waste and paper mill waste having higher levels of cellulose have been found higher COD values than BOD value, because cellulose is not readily attacked in BOD test. Distillery and refinery waste often have higher BOD than COD. The BOD of given water decrease faster than its COD value.

Free Carbon Dioxide (Free CO$_2$):- Mostly all natural waters contain some amount of carbon dioxide in several way. Carbon dioxide gas that is CO$_2$ is present in the air naturally and as rain falls through the air it absorb some of this gas. Carbon dioxide is a normal component present in natural water. Whereas in polluted water it is formed by biological oxidation of various organic matters. CO$_2$ concentration manipulates the acidity of water and thus it is also responsible for the corrosion in the distributional system. Its influence on pH of water also means that its concentration also can manipulate the amount of lime which is added to soften the water. Free CO$_2$ can be measured by titrimetric methods. It reacts with sodium carbonate or sodium hydroxide to form sodium bicarbonate. Physically CO$_2$ can be removed by using aeration as well as chemically it may be neutralized by the addition of lime or soda.

1.4.2. IMPACTS OF HUMAN ACTIVITIES ON SURFACE WATER QUALITY:- Now a days it become a great challenge to mankind how to improve water quality by rehabilitation and by protection of water bodies such as lakes, ponds, streams, rivers, wetlands, reservoirs is a growing global concern. A large number of services have been continue to seriously badly affect our natural water resources. Many services among these are primarily found the results of human activities which include unbalanced ecosystem, various pollution, sedimentation, changes in landscape, change in climate. However the problem of surface water pollution is relatively widespread particularly in developing countries. Humans have been used air, water, and land resources as ‘sinks’ in which we are continuously disposing waste produced by us till today. These disposal practices leave large amount of waste causing pollution. This in turn affects precipitation in surface water as well as ground water and most adversely badly affects and degrading ecosystem. Thus the risk of pollution is being created to both the system like aquatic
system and through this system also to human and the environment. Moreover the removal and destruction of natural ecosystem is being the greatest cause of adverse effects on our natural water resources. So it is necessary to identify the main sources of pollution and mitigation techniques should be apply to reduce the impact of pollution on the water resources.

1.5 SIGNIFICANCE OF THE STUDY

We all animals directly or indirectly depend on plant world. Plants forms the producer level in ecosystem. Plants utilized by human being in various ways, in various forms, for various purposes to continue their daily routine. India is a vast country abounding in plant wealth, therefore it is very important to utilize these plant resources for the welfare of country men. Plants are categorized in various forms depending upon their habitats. Many researchers worked on plant science. In Gujarat state many workers have presented the good taxonomic work on plant wealth and biodiversity. In Anand district also considerable work is recorded, but the study of aquatic plants along with water characteristic have not done by any researcher till today, so this area still virgin. Therefore I have decided to choose Anand district as my study area for the present piece of work. Through the present work, I tried to study aquatic vegetation and natural water quality of the Anand district.

The present study focus on taxonomy of aquatic angiosperms, traditional knowledge of such plants, ethnomedicinal knowledge of such plants and water chemistry of the water bodies bearing such flowering water plants. The record of ethnomedicinal important plants along with their utility methods would be helpful for research students, Botanists, Botany teachers. Moreover it is also helpful to the local people also, who are not aware of plant science. Along with this water parameters of selected water bodies are also measured and prepared the report about the quality of such water, which would be proved as important information for the farmers, local people living near by the water resources and they become aware of the water quality of the ponds, canals, lakes. By this people would came to know the current water status, whether the water is suitable for use or not? The people also become aware about uses of the aquatic plants growing in nearby waterbodies. The present piece of work tried to make the documentation, which would be helpful for the next research students as well as the botanist working in this field. In future it can be use as reference for the further work in related field. So regarding with
the ‘Eco-Taxonomic study aquatic angiosperms of Anand district’, the present investigation has been undertaken with the following objectives:

**OBJECTIVE:-**

1. To inventories the floristic and medicinal aquatic flora.
2. To document traditional and medicinal knowledge associated with the aquatic flora.
3. Physico Chemical property of water
4. To identified natural and anthropogenic threats to the aquatic flora.
5. To study the commercially utilized aquatic flora.

**SCOPE OF THE STUDY**

Plants have numerous and diverse uses with direct or indirect bearing on human civilization. In present scenario more attention have been given on plant world. So many workers have done valuable research in different interested areas in relation to Botany. In all over India many researchers have contributed in floristic study and biodiversity. Many of them have prepared the floras of their particular area. The botanist of Gujarat have been actively engaged in studying the flora of different parts of the state. Many botanist have prepared the regional flora. Then after such an adequate work had not been published separately for the entire Gujarat state. G.L.Shah started the journey and presented his great efforts in the form of the ‘Flora of Gujarat State’ in 1978. Many district had their own flora, but Anand district is lacking such separate flora till today. However the floristic study of Anand district was made by Anjaria in 2002. Anand district the natural resources have not been given more attention in special reference to aquatic plants, and therefore potential remains unexplored. Moreover aquatic plants are taxonomically difficult and Anand district lacks such an adequate herbarium till today, which represent the information about the taxonomical characters and utilization of aquatic plants in medicinal aspects. Aquatic flora in Anand district with special aspect to taxonomy, ecology, floral survey and aquatic plant habitat study along with physical-chemical study of water is almost not recorded till today. Moreover no one was tried to search out these type of work and so this area is still virgin. Therefore, I decided to study this area for my present research work. The present effort would be useful in future to the botanist, researchers and also for students. The present work focus on
taxonomic study of aquatic plants and water analysis of different water bodies spread over the district. The present piece of work presents taxonomic study of aquatic plants including ethnomedicinal uses, which would make aware the people to the traditional uses of plants. Moreover the study also focus on water quality of different water bodies located in Anand district. So the people would came to know the current water status and suitability of water of the ponds, lakes or canals. This would also useful for farmers by providing the information regarding with quality is it advisable for irrigation or not? Along with this the people also would be aware for the utility of pond water as well as plants growing their nearby. In future it can be use as reference for the further work in related field. So regarding with the ‘Eco-Taxonomic study aquatic angiosperms of Anand district’ the present investigation has been undertaken.

**STUDY AREA**

1.6. BRIEF HISTORY OF GUJARAT:-

Gujarat is a state of India. The name of Gujarat state is derived from Gujjaratta, which means the territory of Gujjars. It is believed that a tribes of Gujjars migrated to the India around the 5th century AD. It is believed that the real cultural history of these people have begun much earlier. Relies of historic and prehistoric times are found at many places in the state, such as many relies of ‘Harppanculture circa 2004-1600 BC are found at Dholavira, Lothal, Patan, Siddhpur etc. Many Indus valley and Harappan centers have been discovered in this state like as Lothal, Dholavira, Rangpur, Lakhabaval, Amri and Rozdi have established the history of Gujarat around 3000 BC to 2200 BC. At that point of time Lothal was the main harbour of this civilization.

This state have achieved high prosperity during the time of Solankis in the 9th century. In the 12th century AD, the Sultan of Delhi Allauddin Khilji defeated the Waghela king of Gujarat, so on long era of Muslim have started over Gujarat. Then in 18th century the Marathas have ended
Chapter I  

Introduction

the Muslim rule only to be handed over to the British in 19th century. Gujarat was the part of Mumbai state till 1960. When the people of Gujarat have decided to have their own state on the basis of their different language and culture. So On 1st May, 1960, the Gujarat state was created out of 17 northern districts of the former state of Bombay. Which led to formation of two new distinct states of Gujarat and Maharashtra.

1.6.1. DEMOGRAPHIC INDICATORS:

The population of the Gujarat State was 50,671,017 as per 2001 census data, whereas Gujarat population Census Data 2011 show Gujarat has Estimated Population 6.03 Crores and its Actual Population is 6,03,83,628, which is about 4.99 % of the total Indian population. The current population of Gujarat in 2014 is 63,891,303. Its Density is 308 sq km. sex ratio of the state is 918 as per 2011 population census. Literacy rate in Gujarat has seen upward trend and it is 79.31 % as per 2011 population census. Among them male literacy rate found at 87.23 %, whereas female literacy rate stands at 70.73 %. Urban population of this state is 42.6 % and rural population is 57.4 % as per 2011 data.

1.6.2. GEOGRAPHY OF GUJARAT:-

Gujarat is situated on the western coast of the Indian Peninsula. The Geographical area of Gujarat state is 1,96,024 sq km which is about 5.9 % of the total area of India. The Gujarat state is located between 20° 01' to 24° 07’ North latitude and 68° 04’E to 74° 04’North East longitude. The state is located on the west coast of Indian Peninsula. It has the longest coastline of 1,600 Km. It is bounded by the Arabian sea to the west, by Pakistan in north-west, by Rajasthan in north, by Madhya Pradesh in south-east and by Maharashtra in south. It has the Union Territories of Daman, Diu and Nagar Haveli along with Maharashtra towards the south. Gujarat is the only state where the major mountains of India are found. These include Aravalli, Sahyadri, Vindhya and Satpura. Apart from this Gir hills, Chotila hill, Barda hills, Pavagarh hill are also found in different parts of Gujarat. Girnar is very famous and tallest hill of Gujarat found in Junagadh District. Depending upon physiology and culture Gujarat can be divided into several regions like Kutch, Saurashtra, Kathiawad, North east Gujarat, South Gujarat, Madhya Gujarat. Kutch is located on the northwestern border of state bordering Pakistan with maximum altitude of 300 meters and almost desert like topography. In the north Rann of Kutch and in south little
Rann of Kutch. Kathiawad located between Saurashtra and Khambhat with maximum altitude of 180 meters. Southeast Gujarat receive highest rain in the state. Forest cover area is little about 9.61 %, still supporting more than 40 species of animals, which include Asiatic Lion, Wild ass and Blackbuck. Gujarat has 4 national parks and 21 sanctuaries. Apart from Africa Gujarat is the only present natural habitat of lions.

Gandhinagar is the capital city of Gujarat, which is located close to Ahmedabad. Ahmedabad is the commercial capital of the state. Ahmedabad is the most populated District in the state, with 7.20 million people. Currently the state has 33 Districts, 248 Talukas, 18,618 Villages and 242 Towns. In 2007 Tapi District was separated from Surat District, comprises five Talukas like Vyara, Songadh, Valod, Uchhal and Nizar. The Districts of Gujarat state are shown in the following (Table-1).

**Table - 1  Districts Of Gujarat State:**

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<tbody>
<tr>
<td>1</td>
<td>Ahmedabad</td>
<td>12</td>
<td>Gandhinagar</td>
<td>23</td>
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<td>2</td>
<td>Amreli</td>
<td>13</td>
<td>Gir Somnath</td>
<td>24</td>
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<td>3</td>
<td>Anand</td>
<td>14</td>
<td>Jamnagar</td>
<td>25</td>
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<td>4</td>
<td>Aravalli</td>
<td>15</td>
<td>Junagadh</td>
<td>26</td>
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<td>5</td>
<td>Banaskantha</td>
<td>16</td>
<td>Kheda</td>
<td>27</td>
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<tr>
<td>6</td>
<td>Botad</td>
<td>17</td>
<td>Kutch</td>
<td>28</td>
</tr>
<tr>
<td>7</td>
<td>Bharuch</td>
<td>18</td>
<td>Mahisagar</td>
<td>29</td>
</tr>
<tr>
<td>8</td>
<td>Bhavnagar</td>
<td>19</td>
<td>Mahesana</td>
<td>30</td>
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<tr>
<td>9</td>
<td>Chotta Udaipur</td>
<td>20</td>
<td>Morabi</td>
<td>31</td>
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<tr>
<td>10</td>
<td>Dahod</td>
<td>21</td>
<td>Narmada</td>
<td>32</td>
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<tr>
<td>11</td>
<td>Devbhomi Dwarka</td>
<td>22</td>
<td>Navsari</td>
<td>33</td>
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</table>

**1.6.3. RELIGION :**
Hinduism is the most dominant religion in Gujarat state with 89.1% of the total population being Hindus. Along with this other religions include Muslims 9.1%, Jain and Sikhs 0.1% of the total population of Gujarat. The official and primary language of Gujarat state is Gujarati, while Hindi and English are also widely spoken in Gujarat. Apart from this Kutchi, Bhilli and Gamit languages are also spoken in some areas like in Kutch region of Gujarat. Gujarat is one of the most developed State in the country.

1.6.4. CLIMATE:-

The climate of the state is tropical, however considerably moderate due to the long coast line. Diverse climatic conditions with mild and pleasant winters, very hot and dry summers and with heavy monsoon are found in Gujarat. The climate is moist in southern part and dry in northern part. The temperature ranges between 1 °C to 46 °C . Three major seasons are winter, summer and monsoon. Winter season from November to February, with temperature range of 3 °C to 28 °C. the summers are very hot and dry with temperature around 45-46 °C. It starts from March and ends in July. The Monsoon bring relief from hot of summer , which starts around mid June or July. During this season humidity is high with lowered temperature about 30 to 35 °C. The rainfall received in this state varies from region to region, and depending upon rainfall received the state has been divided into different 8 Agro-climatic zones, such as

1. Heavy rainfall zone of South Gujarat with Average annual rainfall 1500 mm.
2. Moderate to Heavy rainfall zone of South Gujarat with Average annual rainfall 1000 – 1500 mm.
3. Moderate rainfall zone of Central Gujarat with Average annual rainfall 800-1000 mm.
4. Dry zone of North Gujarat with Average annual rainfall 625 – 875 mm.
5. Arid zone of North-West Gujarat with Average annual rainfall 250 – 500 mm.
6. Arid cum dry zone of North Saurashtra with Average annual rainfall 400 – 700 mm.
7. South Saurashtra zone with Average annual rainfall 750 – 1000 mm.
8. Bhal and coastal areas zone with Average annual rainfall 625 – 1000 mm.

(Forest status as per FSR – 2009, published by FSI Deharadun).

On account of the wide variation in geographical locations, Eco-climatic conditions and topography there are varieties of habitats, so the state is very rich in biodiversity. There is desert region found in Kachchh District whereas there are hilly regions found in the Saurashtra
peninsula and Sabarkantha District. Cultivated area in Gujarat is about 1,24,000 sq.km which is 2/3 of the total area. The forest areas of this state are unevenly distributed. The forests are found mostly in the districts like Dangs, Surat, Valsad and Junagadh. As per the forest classification given by Champion and Seth in 1968 out of 16 types found in the country, total four forest types are found in Gujarat. They are (i) Tropical moist Deciduous Forest, (ii) Tropical dry Deciduous Forest, (iii) Northern Tropical Thorn Forest and (iv) Littoral and Swamp Forest. The forest cover area in Gujarat is as: (1) Very Dense Forest with 376 sq km, (2) Moderately Dense Forest with 5249 sq km, (3) Open Forest with 8995 sq km and (4) Non Forest with 196022 sq km.

1.6.5. RIVERS OF GUJARAT:-
Number of rivers are flowing in various regions of the state. the major rivers flowing through the state include Mahi, Sabarmati and Narmada in central and northern Gujarat. Whereas Mithi, Bhadar, Khari, Shetrunji and Bhogavo flowing in Saurashtra and Tapi, Auranga, Purna, Ambika and Damanganga flowing in the southern part of Gujarat state.

1.6.6. CROPS OF GUJARAT:-
Tobacco, cotton and groundnuts are the major crops of Gujarat. Gujarat state is considered as the main producers of these crops in all over India. The other crops are rice, wheat, jowar, maize, bajra, tur, gram etc.

1.6.7. ATTRACTIONS OF GUJARAT:-
Gujarat has very long coast line in all over the country. it is notorious for its beaches, historical places, holy temples, architectural assets, national parks, wildlife sanctuaries and hill stations. Religious places include Dwaraka, Somanath, Ambaji, Shamlaji, Pawagadh, Bhadreswar etc. Jain temples are at Taranga, Palitana, Girnar, with this about 800 temples are spread on the sacred hill Shetrunjaya and also very oldest fire temple of Parsees at Udwada. Many memorable monuments with splendor of architectural and archeological aspect including Sun temple of Modhera, more than 5000 years old place Lothal and numerous monuments at Ahmedabad, Patan, Siddhpur, Vadvnagar, Dabhoi etc. Very beautiful beaches are at Mandavi, Chorwad, Ubharat and Tithal. Porbandar the birth place of Mahatma Gandhi and Karamsad the birth place of Sardar Vallabhbhai Patel in Anand District are memorable places. The national shrine of Mahatma Gandhi is located at Sabarmati in Ahmedabad. Saputara the hill station attract many
tourist to visit it. Gir national park in Junagadh, the leave of Asiatic Lion and Wild ass sanctuary in Kutch are major and various attraction in the Gujarat State.

1.6.8. FESTIVALS OF GUJARAT:-

Navratri, Diwali, Dussehra etc are the main festivals of Gujarat. Navratri is celebrated for 9 days which usually comes in October month. It an occasion when people worship the nine incarnations of the mother goddess ‘Shakti’ denoting cosmic energy. Dussehra comes soon after Navratri i.e. On the next day of last day of Navratri. Following to Dussehra the festival of lights, called Diwali. Both Dussehra and Diwali have their genesis from the same epic the Ramayana. Diwali is the only Hindu festival which falls on Amavasya, that is a moon less night. Other festivals of Gujarat include Dang Darbar, Saputara summer festival, Bhavnath fair, Madhavraj fair and Desert festival.

1.6.9. DANCE AND MUSIC OF GUJARAT:-

Gujarat state has very rich tradition of songs, dance and drama. Ras, Garba and Bhavai are popular Gujarati folk dance having their origin to the ancient period of Lord Krishna. The traditional dance Ras is the form of Ras Leela with different childhood antics of Lord Krishna at Gokul and Vrindavan are connected. The granddaughter of Lord Krishna is considered as the first dancer of the form, called Garba. This dance is performed by women with pots on their head decorated with lights in it called ‘Garbo’.

1.7. BRIEF INFORMATION ABOUT ANAND DISTRICT:-

1.7.1. HISTORY OF ANAND DISTRICT:-

The British rule came to an end on 15/8/1947 and India became independent. The new government integrated the royal states into the state of Bombay. Kheda district came into existence on 1/8/1949. Then after, some changes were made in the villages of certain talukas and villages were identified for different talukas of the district from 15/10/1950. The district of Kheda consists of Kambhat, Petalad, Borsad, Anand, Nadiad, Matar, Mahemdavad, Kapadvanj, Thasara and Balashinor talukas. State Govt. has formed six new districts from 1/10/97 and Anand has been carved out as a separate district from Kheda. The district of Anand comprises 8 talukas such as Umareth, Petalad, Sojitra, Borsad, Anklav, Anand, Kambhat and Tarapur.
Anand is also popularly known as Charotar. Some of the villages of Borsad, Petalad and Anand talukas are located in this region which are known as "Golden Leaf", this region of charotar has the highest production of tobacco in all over Gujarat. In Gujarati language, the word "Charutar" exactly means a pot full of gold coins. The entire region is very fertile and productive Some of the villages of Khambhat and Tarapur talukas fall within the "Bhal" region.

**Charotar Region:** The region stretching from the bank of Mahi river near Vasad up to the bank of river Vatrak near Mahemdabad is popularly known as ‘Charotar Region’. This region is very fertile and full of greenery.

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**Table-2 Fact File Of Anand District:**

|   | Population as per 2011 census | Male :- 10,88,119  
|   | Female:- 10,02,157  
|   | Total:- 20,90,276  |
|---|-------------------------------|-------------------------------------------------|
| 2 | Sex ratio as per 2011 cencus  | 921 Females per 1000 Males                      |
| 3 | Literacy rate                 | Male –91.82%  
|   | Female – 76.36 %             | Total –85.79%                                   |
| 4 | Languages                     | Gujarati, Hindi and English                     |
| 5 | Density of population         | 711 per sq.kms.                                 |
| 6 | Population Growth Rate (2001-2011) | 12.57 %                                      |
| 7 | No. of Villages               | 1058                                            |
| 8 | No. of Towns                  | 11                                              |
| 9 | Area of the District          | 2941 sq.kms.                                   |
|10 | Geographical Location         | 22.6° to 23.29° North (Latitude) and 72.2° to 73.12° East (Longitude). |
## Chapter I

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<th>District Headquarter</th>
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<th>8 – Talukas</th>
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<td>12</td>
<td>8 – Talukas</td>
<td>(1) Anand (2) Umareth (3) Borsad (4) Anklav (5) Kambhat (6) Tarapur (7) Petlad and (8) Sojitra</td>
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<tr>
<th></th>
<th>Average rain fall</th>
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<tr>
<td>13</td>
<td>Average rain fall</td>
<td>473 mm recorded in 2001</td>
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<tr>
<th></th>
<th>Farmers</th>
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<tr>
<td>14</td>
<td>Farmers</td>
<td>8.37 % of total population</td>
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<th>Important farm products</th>
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<tr>
<td>15</td>
<td>Important farm products</td>
<td>Tobacco, millet, wheat, rice and groundnut</td>
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<th>Important horticulture products</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>16</td>
<td>Important horticulture products</td>
<td>Fruits:- Banana, lemon, gooseberry, mango, papaya Vegetables:- potato, bringal, tur, Spices:- Mustard seeds, fenugreek, sesame Flowers:- Rose, lily, marigold</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Soil</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>17</td>
<td>Soil</td>
<td>Goradu, black and river bank soil</td>
</tr>
</tbody>
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<table>
<thead>
<tr>
<th></th>
<th>Rivers</th>
<th></th>
</tr>
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<tbody>
<tr>
<td>18</td>
<td>Rivers</td>
<td>Mahi, Sabarmati</td>
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</table>

<table>
<thead>
<tr>
<th></th>
<th>Maximum temperature</th>
<th></th>
</tr>
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<tbody>
<tr>
<td>19</td>
<td>Maximum temperature</td>
<td>40°C to 43°C</td>
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<table>
<thead>
<tr>
<th></th>
<th>Minimum temperature</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>Minimum temperature</td>
<td>9°C to 10°C</td>
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<table>
<thead>
<tr>
<th></th>
<th>No of research institutes</th>
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</tr>
</thead>
<tbody>
<tr>
<td>21</td>
<td>No of research institutes</td>
<td>4</td>
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<table>
<thead>
<tr>
<th></th>
<th>University</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>22</td>
<td>University</td>
<td>1. Sardar Patel University 2. Gujarat Agriculture University</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Educational institutes</th>
<th></th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Other industries</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>(22)</td>
<td>Other industries</td>
<td>Industrial Assets – 6 Milk cooperative societies – 355 Registered small industrial units – 5740 Large and medium units - 73</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Industrial Associations</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>(23)</td>
<td>Industrial Associations</td>
<td>9</td>
</tr>
</tbody>
</table>
1.7.2. ABOUT ANAND DISTRICT

It is one of the total 33 districts of Gujarat state, India. Its administrative head quarter is Anand. It is located about 93 km north towards the state capital Gandhinagar. It is 14th largest district in the state by population. its population is 2090276

DESMOGRAPHIC OF ANAND DISTRICT AS PER CENCUS 2011 :-

Total population of Anand District is 2090276 as per 2011 cencus. The district has population density of 711/ sq.km. Among them male are 1088119 and females are recorded 1002157. Literate people are recorded about 1382927. Its area is 2941 sq km. it is the 14th largest district in the state and 218th largest district in the country the in aspect to population. It is 11th largest district in the state by area. It is 3rd highest district in the state and 65th highest district in the country by literacy rate. Its literacy rate is 85.79

1.7.3. GEOGRAPHY OF ANAND DISTRICT:-

Its geographical location is 22.07° to 23.29° North (Latitude) and 72.15° to 73.18° East (Longitude). Anand district is sharing its border with Kheda District in north, Vadodara District in east. It is bounded with Ahmedabad District to the west and the Gulf of Kambhat to the south. Anand District occupies an area of approximately 2941 sq. km. This District is in 44 meters to 19 meters elevation range. Anand District is a coastal district. It belongs to Western India. Its major towns are Kambhat, Tarapur, Petlad and Sojitra..This district is divided in 8
Chapter I  

Introduction

Talukas, 381 Panchayats and 1058 villages. Among these 8, Tarapur Taluka is the smallest Taluka by population with 75850 population whereas Anand is the biggest Taluka by population with 513900 population. Gujarati is the local language of the district

1.7.4. CLIMATE:-

The climate is too hot in summer and generally in major parts of the year excluding monsoon months. Winter is too cold here. It starts from December and ends in February, in which minimum temperature recorded approximately 9°C to 10°C. Summer season from March to June. During summer highest day temperature remain in between 32°C to 45°C. This is followed by monsoon season, which ends in September. October and November represent the post monsoon season. During monsoon season climate become cool than of summer. The day temperature reduced due to the moisture in atmosphere, but post monsoon are considerably hot.

1.7.5. TEMPERATURE:-

Temperature may vary in different seasons. Minimum temperature ranged from 8°C to 10°C and minimum temperature is about 40°C to 45°C. At the end of winter that means after February the temperature rapidly increases. Among the all May and early part of June are the hottest part of the year. The maximum temperature in May was recorded about 43°C to 45°C and minimum temperature was about 26°C to 27°C. The monsoon season in this district may start by about the middle of June or starting of July. Sometime the time period may extend up to the initiation of August. During the rainy season considerable drop in temperature was recorded in the day, but at night it again continue to be as worm as in summer. After the withdraw of monsoon i.e. after about September there is sudden increase in temperature during day up to the end of October. However the nights gradually become cooler in October. During November there is a rapid decrease in day and night temperature. January is the coldest month of this district in which maximum temperature goes down at about 20°C , whereas minimum temperature at about 10°C

1.7.6. SOIL:-

The nature of soil greatly affect the agricultural production. It is of various type at various region. For higher productivity proper soil type should be choose. For example paddy crop mostly grown in medium to heavy black soil. The different types of soil found in this district is
Black soil, Medium Black soil, Clay loam soil, Sandy loam soil (Goradu soil), Sandy soil, Saline soil etc.

The soil is dominantly with average textured or loamy by fine textured or clayed. Soil drainage in Anand District is well to moderately drained. The soil of western parts of Anand District is medium saline in nature and towards north side it is found slightly saline in nature, while towards Kambhat crick the soil is moderate to deep saline. Soil salinity in Anand District is slightly to moderate and soil sodicity is slight sodic in all most all the district of Gujarat.

1.7.7. AQUATIC AREA:--

The Anand District is very rich in water bodies, which include ponds, lakes, rivers, canals etc. The entire area is drained by three rivers. Mahi, Sabarmati are the main rivers flowing through this district. Sabarmati river originates from Arvali hills and draining into the Gulf of Kambhat. It has a length of 371 kms. This is annual river. In Anand District Sabarmati River pass very close to the villages Galiyana, Motakalodara and Rinza of Tarapur Taluka. Thereafter it drain into the Gulf of Kambhat. Mahi river originates on the northern slop of Vindhyas and same as Sabarmati it also drain into the Gulf of Kambhat in Arabian sea. It has total length of 583 km. It passes through the villages Khanpur, Vaherakhadi, Vasad of Anand Taluka and then after it falls in the Gulf of Kambhat in Arabian sea.

1.7.8. RAIN FALL:--

Rainfall recorded in the district is vary in each year. The average rainfall of this district was 687mm. The rainfall in the district is received during June to September. The variation in rainfall from year to year. AICRP recorded the annual rainfall of Anand District from the year 2002 to 2012. Normal rainfall during 2002 to 2012 was recorded about 843.10 mm as per Annual progress report of AICRP on Agro-meteorology (2010). Here average rainfall is recorded for ten years. Hydromet Division New Delhi, India meteorological department presented their report with the record of rainfall of each year from 2009 to 2013. In the year 2009 annual rainfall was 357.1 mm. It increase in 2010 and recorded 863.7 mm. Again it decrease in year 2011 and recorded about 730.5 mm, whereas in 2012 it was 570.9 mm. The highest rainfall recorded in the year 2013, which was 1159.7 mm. The year 2009 was very poor in receiving sufficient rainfall, while the year 2013 received highest rainfall.
1.7.9. HUMIDITY:-

Humidity is related with wetness in atmosphere which is obviously high during rainy season. So during monsoon season humidity is found around or above 74%. Humidity is very low during rest of the period, because the air is generally dry except that of monsoon. The summer are very hot so relative humidity is found around or less than 25%.

1.7.10. MAJOR CROPS (KHARIF AND RABI):-

This district is main producer of Tobacco, Paddy and Banana. Paddy, Cotton, Pearl millet, Castor, Banana, Papaya, Tuver, Sesamum are the major kharif crops grown over an area about 161953 hectares. Rabi crops grown over an area 10848 hectares in 2014. Paddy is the main kharif crop covering about 76% of area among the total area under kharif crop. Whereas Wheat, Potato and Maize are the major Rabi crops of this district grown over an area approximately 64525 ha.

1.7.11. HORTICULTURE CROPS:-

Major horticulture crops in Anand Distric are Banana, Mango. Citrus, Papaya, Amla, Sapota, Lemon, Ber, Pomegranate, Jamun, Watermelon, Muskmelon etc. Among these Banana is grown over an area about 11696 Ha., which is followed by Mango and Citrus with an area about 1919 Ha. and 4290 Ha. respectively. Anand district had the third rank in the highest production of banana in the state with amount of 5,26,185 MT.on the other hand potato production was recorded about 1,88,940 MT. along with these it also produced considerable amounts of cereals, pulses and cotton.

1.7.12. MAJOR INDUSTRIES OF ANAND DISTRICT:-

Anand is recognized as home to the famous AMUL Dairy. Vitthal Udhyognagar, a very big industrial belt is located in the district. It contain many famous industries, which include Elecon, Vulcan industrial, Warm Steam, Charotar Iron Company, Milcent and Atlanta Electrics are found in this industrial belt

1.7.13. TOURISM PLACES :-
Amul Dairy – A symbol of white revolution is the main attraction place among all places. The advanced pasteurization process of milk and the production of processed milk foods can be seen in Amul Dairy. Anand is known as milk city. Today it has become a world renowned organization. Vallabhbhai Vidyanagar is known as the ‘Town of Education’. The name of the town Vallabhbhai Vidyanagar has been given in the memory of Sardar Vallabhbhai Patel. Here many educational institutes have been established including schools, colleges and other institutes. Some historical places are located in this region. Karamsad is located on Anand-Sojitra National Highway. The Sardar Vallabhbhai Patel and Veer Vithalbhai Patel Memorial is present in Karamsad. This place also possess library and surrounding beautiful garden creating a wonderful ambiences. Karamsad is the birth place of great Sardar Vallabhbhai Patel, the great freedom fighter, who is known as “Iron man”. This land has considerable contribution during freedom movement, so its name has been inscribed in golden letters in the history of India. Umreth is located on Anand-Godhara railway line. This village was steeped in culture with numerous Sants, Sadhus, Sanyasis contributing the richness of its culture. It is also considered a holy place of Jain culture. Bochasan is the ‘Karma Bhoomi’ for Shri Ravishankar Maharaj, who had dedicated his entire life for social work. This village play an important role in National Movement. Borsad is very important Historical Town. During the time of the Peshwas, Borsad had a sole place in Gujarat and also it reminded for the political fight in British Era. Adas is known as ‘The land of historical battles’. Every year 18th of August is celebrated as ‘the Martyr day’ in their memory. Kambhat is famous as an ancient port, tourist place and as a trade center. The region of Kambhat has its importance and become world famous for its textile products like silk, established in 11th Century.

The famous jain temple, Stambhan Parshvanath jinalaya is also present in Anand District. Bhadaran is the village of Borsad Taluka. It is said that this village comes into existence in Samvat 1232. There is temple of goddess Bhadrakali in this village. Lambhavel is located about 5 km away from Anand. It has very famous and popular Lord hanumanji temple. Many people come from far away places for ‘Darshan’ of Hanumanji. Other famous tourist places in the district are Swaminarayan mandir, BD Rao college Museum.

1.7.14. SELECTED STUDY SITES:-

Table – 3: Selected study sites (Talukas wise).
Table - 4: Selected Study Sites with Geographical location:

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Name of Taluka</th>
<th>Name of Village</th>
<th>Name of Sites (Pond local name)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Anand</td>
<td>Behdwa</td>
<td>Behdwa lake</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Chikhodra</td>
<td>Yogi sarovar</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Anand</td>
<td>Verai mata pond</td>
</tr>
<tr>
<td>2.</td>
<td>Borsad</td>
<td>Nahapa</td>
<td>Malav pond</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Borsad</td>
<td>Shahdullah shahid lake</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Bochasan</td>
<td>Village pond</td>
</tr>
<tr>
<td>3.</td>
<td>Sojitra</td>
<td>Gada</td>
<td>Gada village Pond</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sojitra</td>
<td>Muglai pond</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Piplav</td>
<td>Piplav Pond</td>
</tr>
<tr>
<td>4.</td>
<td>Petlad</td>
<td>Kasor</td>
<td>Kasor village Pond</td>
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<tr>
<td></td>
<td></td>
<td>Change</td>
<td>Changa lake</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sanjaya</td>
<td>Sanjaya pond</td>
</tr>
<tr>
<td>5.</td>
<td>Umreth</td>
<td>Lingada</td>
<td>Lingada village pond</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Navapura</td>
<td>Navapura village pond</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Umreth</td>
<td>Umreth village pond</td>
</tr>
<tr>
<td>6.</td>
<td>Ankalav</td>
<td>Kanhthariya</td>
<td>Kanhthariya lake</td>
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<td></td>
<td></td>
<td>Bhetasi</td>
<td>Bhetasi pond</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ambali</td>
<td>Ambali village pond</td>
</tr>
<tr>
<td>7.</td>
<td>Tarapur</td>
<td>Tarapur</td>
<td>Tarapur pond</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Bhudhej</td>
<td>Budhej village pond</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Malpur</td>
<td>Malpur village pond</td>
</tr>
<tr>
<td>8.</td>
<td>Khambhat</td>
<td>Kaneval</td>
<td>Kaneval lake</td>
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<tr>
<td></td>
<td></td>
<td>Mitali</td>
<td>Village pond</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Golana</td>
<td>Village pond</td>
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### Table 5: Annual rainfall of Anand district (AS per India Meteorological Department)

<table>
<thead>
<tr>
<th>SR.No</th>
<th>Year</th>
<th>Rainfall (mm)</th>
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<tbody>
<tr>
<td>14</td>
<td>Navapura village pond</td>
<td>22.683559</td>
</tr>
<tr>
<td>15</td>
<td>Umreth village pond</td>
<td>22.700314</td>
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<tr>
<td>16</td>
<td>Kanthariya lake</td>
<td>22.425614</td>
</tr>
<tr>
<td>17</td>
<td>Bhetasi pond</td>
<td>22.417477</td>
</tr>
<tr>
<td>18</td>
<td>Ambali village pond</td>
<td>22.399319</td>
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<tr>
<td>19</td>
<td>Tarapal pond</td>
<td>22.488008</td>
</tr>
<tr>
<td>20</td>
<td>Bhdhej village pond</td>
<td>22.434596</td>
</tr>
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<td>21</td>
<td>Malpur village pond</td>
<td>22.453037</td>
</tr>
<tr>
<td>22</td>
<td>Kaneval lake</td>
<td>22.489786</td>
</tr>
<tr>
<td>23</td>
<td>Mitali village pond</td>
<td>22.418537</td>
</tr>
<tr>
<td>24</td>
<td>Golana village pond</td>
<td>22.455844</td>
</tr>
</tbody>
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Chapter I  

Introduction

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<tbody>
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<td>1</td>
<td>2009</td>
<td>357.1</td>
</tr>
<tr>
<td>2</td>
<td>2010</td>
<td>863.5</td>
</tr>
<tr>
<td>3</td>
<td>2011</td>
<td>730.5</td>
</tr>
<tr>
<td>4</td>
<td>2012</td>
<td>571.1</td>
</tr>
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PLATE : 1
Plate 1: (1) Behdwa Talav (2) Chikhodara Talav (3) Verahi mata talav anand (4) Napa Pond (5) Borsad Lake (6) Bochasan Talav
Plate 2: (7) Gada Talav  (8) Sojitra Talav  (9) Pipalav pond  
(10) Kasor Pond  (11) Changa Lake  (18) Sanjaya Lake

Plate : 3
Plate 3: (13) Lingada Lake (14) Navapura Pond (15) Umreth Lake (16) Kanthariya Lake (17) Bhetasi Lake (18) Ambali Lake
Plate 4: (19) Tarapur Lake  (20) Bhudhej Lake  (21) Malpur Lake  
(22) Kaneval Lake  (23) Mitali Lake  (24) Golana Lake
Chapter I

Introduction

Fig. 1: Map of Study area