CHAPTER 8 – FARM AND AGRICULTURE ENGINEERING
Farm and Agriculture Engineering

- **Farm power**

Various types of agricultural operations performed on a farm can be broadly classified as:

1. Tractive work – such as seed bed preparation, cultivation, harvesting and transportation.
2. Stationary work- such as silage cutting, feed grinding, threshing, winnowing and lifting of irrigation water.

These operations are done by different sources of power, namely human, animal, mechanical power (oil engines and tractors), electrical power and renewable energy (solar energy, biogas, biomass and wind energy).

- **Human power**

Human beings are the main sources of power for operating small tools and implements at the farm. They are also employed for doing stationary work like threshing, winnowing, chaff cutting and lifting irrigation water. Of the total rural population in India, only 30% is available for doing farm work. The indications are that the decline in number of labourers employed for agriculture. On an average, a man develops nearly 0.1 horse power (hp).

  - **Advantages**: Easily available and used for all types of work.
  - **Disadvantages**: Costliest power compared to all other forms of power, very low efficiency, requires full maintenance when not in use and affected by weather condition and seasons.

- **Animal power**

The most important source of power on the farm all over the world and particularly in India is animal. It is estimated that, nearly 80% of the total draft power used in agriculture throughout the World is still provided by animals. India is having 22.68 crore cattle, which is the highest in the World. Mainly, bullocks and buffaloes happen to be the principle sources of animal power on Indian farms. However, camels, horses, donkeys and elephants are also used for the farm work. The average force a bullock can exert is nearly equal to one tenth of its body weight. Power developed by an average pair of bullocks is about 1 hp for usual farm work.

  - **Advantages:**
1. Easily available.
2. Used for all types of work.
3. Low initial investment.
4. Supplies manure to the field and fuels to farmers.
5. Live on farm produce.

**Disadvantages:**
1. Not very efficient.
2. Seasons and weather affect the efficiency.
3. Cannot work at a stretch.
4. Require full maintenance when there is no farm work.
5. Creates unhealthy and dirty atmosphere near the residence.
6. Very slow in doing work.

- **Mechanical power**

It is available through tractors, power tillers and oil engines. The oil engine is a highly efficient device for converting fuel into useful work. The efficiency of diesel engine varies between 32 and 38%, whereas that of the carburettor engine (Petrol engine) is in the range of 25 and 32%. In recent years, diesel engines, tractors and power tillers have gained considerable popularity in agricultural operations. It is estimated that, about one million tractors of 25 hp range are in use for various agricultural operations in India. Similarly, total number of oil engines of 5 hp for stationery work is 60 lakhs. Normally, stationery diesel engines are used for pumping water, flour mills, oil ghanis, cotton gins, chaff cutter, sugarcane crusher, threshers and winnowers etc.,

**Advantages:** Efficiency is high; not affected by weather; cannot run at a stretch; requires less space and cheaper form of power

**Disadvantages:** Initial capital investment is high; fuel is costly and repairs and maintenance needs technical knowledge.
- **Electrical power**

Now-a-days electricity has become a very important source of power on farms in various states of the country. Electrical power is used mostly for running electrical motors for pumping water, dairy industry, cold storage, farm product processing, and cattle feed grinding. It is clean source of power and smooth running. The operating cost remains almost constant throughout its life. Its maintenance and operation need less attention and care. On an average, about 1/10th of the total electrical power generated in India, is consumed for the farm work, approximately it is 4600 megawatt.

**Advantages:** Very cheap form of power; high efficiency; can work at a stretch; maintenance and operating cost is very low and not affected by weather conditions.

**Disadvantages:** Initial capital investment is high; require good amount of technical knowledge and it causes great danger, if handled without care.

- **Renewable energy**

It is the energy mainly obtained from biomass; biogas, solar and wind are mainly used in agriculture for power generation and various agricultural processing operations. It can be used for lighting, power generation, water heating, drying, greenhouse heating, water distillation, refrigeration and diesel engine operation. This type of energy is inexhaustible in nature. The availability of wind energy for farm work is quite limited. Where the wind velocity is more than 32 kmph, wind mills can be used for lifting water. Main limitation for this source is uncertainty. Average capacity of a wind mill would be about 0.5 hp. There are about 2540 windmills in India. It is the cheapest sources of farm power available in India.

**Renewable sources of energy:** Energy sources which are continuously and freely produced in the nature and are not exhaustible are known as the renewable sources of energy. Eg: solar energy, biomass and wood energy, geo thermal energy, wind energy, tidal energy and ocean energy. But main attention has to be directed to the following sources of renewable namely, a) solar photovoltaic,

1. wind, and
Advantages of renewable energy

1. These sources of energy are renewable and there is no danger of depletion. These recur in nature and are in-exhaustible.
2. The power plants based on renewable sources of energy don’t have any fuel cost and hence negligible running cost.
3. Renewable are more site specific and are used for local processing and application. There is no need for transmission and distribution of power.
4. Renewables have low energy density and more or less there is no pollution or ecological balance problem.
5. Most of the devices and plants used with the renewables are simple in design and construction which are made from local materials, local skills and by local people. The use of renewable energy can help to save foreign exchange and generate local employment.
6. The rural areas and remote villages can be better served with locally available renewable sources of energy. There will be huge savings from transporting fuels or transmitting electricity from long distances.

Disadvantages of renewable energy

1. Low energy density of renewable sources of energy need large sizes of plant resulting in increased cost of delivered energy.
2. Intermittency and lack of dependability are the main disadvantages of renewable energy sources.
3. Low energy density also results in lower operating temperatures and hence low efficiencies.
4. Although renewables are essentially free, there is definite cost effectiveness associated with its conversion and utilization.
5. Much of the construction materials used for renewable energy devices are themselves very energy intensive.
6. The low efficiency of these plants can result in large heat rejections and hence thermal pollution.
7. The renewable energy plants use larger land masses.

New sources of energy:
The new sources of energy are available for local exploitation. In many cases, autonomous and small power plants can be built to avoid transmission losses. Most prominent new sources of energy are tidal energy, ocean waves, OTEC, peat, tar sand, oil shales, coal tar, geo thermal energy, draught animals, agricultural residues etc., The total energy production in India is 14559×10¹⁵ joules. 93% of India’s requirement of commercial energy is being met by fossil fuels, with coal contributing 56%, and oil and natural gas contributing 37%. Water power and nuclear power contributing only 7% of total energy production. Comparing the total energy production in India from commercial sources with that of world, it is only 3.5% of total world production.

- **Biomass**

Plant matter created by the process of photosynthesis is called biomass (or) all organic materials such as plants, trees and crops are potential sources of energy and are collectively called biomass. Photosynthesis is a naturally occurring process which derives its energy requirement from solar radiation. The plants may be grown on land (terrestrial plants) or grown on water (aquatic plants). Biomass also includes forest crops and residues after processing. The residues include crop residues (such as straw, stalks, leaves, roots etc.,) and agro-processing residues (such as oilseed shells, groundnut shells, husk, bagasse, molasses, coconut shells, saw dust, wood chips etc.,). The term biomass is also generally understood to include human waste, and organic fractions of sewage sludge, industrial effluents and household wastes. The biomass sources are highly dispersed and bulky and contain large amounts of water (50 to 90%). Thus, it is not economical to transport them over long distances, and conversion into usable energy must takes place close to source, which is limited to particular regions.

- **Availability of biomass**

The total terrestrial crop alone is about 2×10¹² metric tonnes. These include sugar crops, herbaceous crops and silviculture plants. The terrestrial crops have an energy potential of 3×10²² joules. At present only 1% of world biomass is used for energy conversion. The estimated Production of agricultural residue in India is 200 million tonnes per year and that of wood is 130 million tonnes. At an average heating value of 18 MJ / kg db, a total potential of energy from agricultural residue is 6×10¹² MJ/ Year. At a power conversion rate of 35%, total useful potential is about 75,000 MW. This can supply all our villages with power at a rate of 30,000 kWh per day per village against the present meagre consumption of only 150 kWh per day per village. The cattle production in India is nearly 237 million. Assuming the average wet dung obtained per animal per day to be 10 kg and a collection rate of 66%, the
total availability of wet dung in the country would be 575 million tonnes per annum. Thus it would enable to produce 22,425 million tons of biogas, which can replace kerosene oil to an extent of 13,904 million litres per year. In a biogas plant, apart from the gas that is produced, enriched manure is also obtained as a by-product. It is estimated that, 206 million tons of organic manure per annum would be produced in biogas plants, which would replace 1.4 million tons of nitrogen, 1.3 million tons of phosphate and 0.9 million tons of potash.

**Biomass Conversion**

Biomass can either be utilized directly as a fuel, or can be converted into liquid or gaseous fuels, which can also be used as feedstock for industries. Most biomass in dry state can be burned directly to produce heat, steam or electricity. On the other hand, biological conversion technologies utilize natural anaerobic decay processes to produce high quality fuels from biomass. Various possible conversion technologies for getting different products from biomass is broadly classified into three groups, viz.

(i) **thermo-chemical conversion,**  
(ii) **bio-chemical conversion** and  
(iii) **oil extraction.**

These alternative technologies for biomass conversion offer sound and alternative options for meeting the future fuels, chemicals, food and feed requirements. Three main approaches can be adopted for generation and utilization of biomass:

(i) Collection of urban and industrial wastes as supplementary fuel in boilers and as a feed stock for producing methane and some liquid fuels.

(ii) Collection of agricultural and forest residues to produce fuels, organic manures and chemical feed stock.

(iii) Growth of some specific energy plants for use as energy feedstock and cultivation of commercial forestry, aquatic and marine plants for different products.

- Thermo-chemical conversion includes processes like **combustion, gasification and pyrolysis.**
  - **Combustion** refers to the conversion of biomass to heat and power by directly burning it, as occurs in boilers.
Gasification is the process of converting solid biomass with a limited quantity of air into producer gas, while Pyrolysis is the thermal decomposition of biomass in the absence of oxygen. The products of pyrolysis are charcoal, condensable liquid and gaseous products.

Biochemical conversion includes anaerobic digestion to produce biogas and fermentation to obtain alcohol fuels, the third approach is oil extraction. Edible and non-edible oils can be extracted from a variety of grains and seeds. They can be directly used as fuels by transesterification process to produce bio-diesel, which is a good substitute for conventional diesel oil. Thermal conversion processes for biomass involve some or all of the following processes:
- Pyrolysis: Biomass + heat charcoal, gas and oil
- Gasification: Biomass + limited oxygen fuel gas
- Combustion: Biomass + stoichiometric O₂ hot combustion products

Principles of combustion In general, the term combustion refers to the process of release of heat by the exothermic heat of reaction for the oxidation of the combustible constituents of the fuel. Practically the combustion process is an interaction amongst fuel, energy and the environment. Fuel may be defined as a combustible substance available in bulk, which on burning in presence of atmospheric air generates heat that can be economically utilized for domestic and industrial purposes. The common fuels are compounds of carbon and hydrogen; in addition variable percentages of oxygen and small percentages of sulphur and nitrogen are also present. Biomass fuels are normally thermally degradable solids. Combustion of organic materials not only generates natural components of air such as carbon dioxide and water but also produces carbonaceous residues, smoke and tar and gases of carbonyl derivatives, and carbon monoxide. The important parameters affecting combustion are moisture, organic compounds and minerals (ash).

Biogas Most organic materials undergo a natural anaerobic digestion in the presence of moisture and absence of oxygen and produce biogas. The biogas so obtained is a mixture of moisture and absence of oxygen and produce biogas. The biogas so obtained is a mixture of methane (CH₄): 55-65% and Carbon dioxide (CO₂) : 30-40%. The biogas contains traces of H₂, H₂S and N₂. The calorific value of biogas ranges from 5000 to 5500 Kcal/Kg (18.8 to 26.4 MJ /m³). The biogas can be upgraded to synthetic natural gas (SNG) by removing CO₂ and H₂S. The production of biogas is of particular significance in India because of its large scale cattle production. The biogas is used for cooking, domestic lighting and heating, run I.C. Engines and generation of electricity for use in agriculture and rural industry. Family biogas plants usually of 2-3 m³ capacity.
Advantages

1. The initial investment is low for the construction of biogas plant.
2. The technology is very suitable for rural areas.
3. Biogas is locally generated and can be easily distributed for domestic use.
4. Biogas reduces the rural poor from dependence on traditional fuel sources, which lead to deforestation.
5. The use of biogas in village helps in improving the sanitary condition and checks environmental pollution.
6. The by-products like nitrogen rich manure can be used with advantage.
7. Biogas reduces the drudgery of women and lowers incidence of eye and lung diseases.

Raw materials for biogas generation

Biogas is produced mainly from

(i) Cow dung,
(ii) Sewage,
(iii) Crop residues,
(iv) Vegetable wastes
(v) Water hyacinth
(vi) Poultry droppings and
(vii) Pig manure.

- Anaerobic digestion

The treatment of any slurry or sludge containing a large amount of organic matter utilizing bacteria and other organisms under anaerobic condition is commonly referred as anaerobic digestion or digestion. Anaerobic digestion consists of the following three stages.

The three stages are

(i) the enzymatic hydrolysis,
(ii) acid formation and
(iii) methane formation.

- Enzymatic hydrolysis
In this stage, a group of facultative microorganisms acts upon the organic matter and convert insoluble, complex, high molecular compounds of biomass into simple, soluble, low molecular compounds. The organic substances such as polysaccharide, protein and lipid are converted into mono-saccharide, peptide, amino acids, and fatty acids. Then they are further converted into acetate, propionate and butyrate.

### Acid formation

The microorganisms of facultative and anaerobic group collectively called as acid formers, hydrolyse and ferment the productions of first phase i.e., water soluble substances into volatile acid. The major component of the volatile acid is the acetic acid. In addition to acetate or hydrogen and carbon dioxide, some other acids like butyric acid and propionic acid are also produced.

### Methane formation

Finally, acetate or hydrogen plus carbon dioxide are converted into gas mixture of methane ($\text{CH}_4$) and $\text{CO}_2$ by the bacteria which are strictly anaerobes. These bacteria are called methane fermentations. For efficient digestion, these acid formers and methane fermentations must remain in a state of dynamic equilibrium. The remaining indigestible matter is referred as “slurry”. The following are some approximate rules used for sizing biogas plants or for estimating their performance:

1) One kg of dry cattle dung produces approximately 1 m$^3$ of biogas.
2) One kg of fresh cattle dung contains 8% dry bio-degradable mass.
3) One kg of fresh cattle dung has a volume of about 0.9 litres.
4) One kg of fresh cattle dung requires an equal volume of water for preparing slurry.
5) Typical rent ion time of slurry in a biogas plant is 40 days.

### The efficiency of biogas generation depends upon the following factors:
(i) Acid formers and methane fermenters must remain in a state of dynamic equilibrium which can be achieved by proper design of digester.

(ii) Anaerobic fermentation of raw cow dung can take place at any temperature between 8 and 55°C. The value of 35°C is taken as optimum. The rate of biogas formation is very slow at 8°C. For anaerobic digestion, temperature variation should not be more than 2 to 3°C. Methane bacteria work best in the temperature range of 35 and 38°C

(iii) A pH value between 6.8 and 7.8 must be maintained for best fermentation and normal gas production. The pH above 8.5 should not be used as it is difficult for the bacteria to survive above this pH.

(iv) A specific ratio of carbon to nitrogen (C/N ration) must be maintained between 25:1 and 30:1 depending upon the raw material used. The ratio of 30:1 is taken as optimum.

(v) The water content should be around 90% of the weight of the total contents. Anaerobic fermentation of cow dung proceeds well if the slurry contains 8 to 9% solid organic matter.

(vi) The slurry should be agitated to improve the gas yield.

(vii) Loading rate should be optimum. If digester is loaded with too much raw material, acids will accumulate and fermentation will be affected.

- **Types of biogas plants:** Biogas plants basically are two types.
  - i) Floating dome type Eg. KVIC-type (KVIC- Khadi Village Industries Commission)
  - ii) Fixed dome type Eg. Janata type (Chinese model)

- **Comparison between KVIC and Janata type model**

<table>
<thead>
<tr>
<th>KVIC- type</th>
<th>Janata type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capital investment is high</td>
<td>Capital investment is Less</td>
</tr>
<tr>
<td>Cost of maintenance is high</td>
<td>Cost of maintenance is minimum</td>
</tr>
<tr>
<td>Life span of the plant is expected to be 30 years and that of gas holder is 5-8 wars.</td>
<td>Life span of the plant is comparatively more.</td>
</tr>
<tr>
<td>Steel gas holder is essential which require maintenance such as painting, repairing, and replacements of damaged parts due to corrosion.</td>
<td>Steel gas holder is not required.</td>
</tr>
</tbody>
</table>
**Locally available materials can't be used for construction of digester.**

The entire plant can be constructed with locally available materials.

<table>
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<th>Locally available materials can't be used for construction of digester.</th>
<th>The entire plant can be constructed with locally available materials.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fabricated gas holder is to be transported from nearby towns.</td>
<td>The space above the movable drum can't be used for other purposes.</td>
</tr>
<tr>
<td>The space above the plant can be used.</td>
<td>Effect of temperature during winter is more.</td>
</tr>
<tr>
<td>Effect of temperature during winter is less.</td>
<td>The space above the movable drum can't be used for other purposes.</td>
</tr>
<tr>
<td>The gas is released at a pressure of 8-12 cm of water column.</td>
<td>The gas is released at a pressure of 90 cm of water column.</td>
</tr>
<tr>
<td>It is suitable for processing animal dung.</td>
<td>It is suitable for processing other materials along with animal dung.</td>
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**Solar energy**

The fossil fuels in the world are depleting very fast by the turn of this century, man will have to depend upon renewable resources of energy which are free from pollution, low in cost of transmission and distribution. Sun is the primary source of energy and all forms of energy on the earth are derived from it. Our solar system consists of the sun, 9 planets orbiting around the sun. Satellites (or moons) orbiting around the planets, asteroids, comets and meteors. The sun is at the center of solar system and all these bodies revolve around it, and are held by its great gravitational pull, which governs their motion. Sun is heaviest body of the solar system around which all the planets revolve. The mass of the sun is $1.98 \times 10^{30}$ kg and its diameter is $1.392 \times 10^9$ m. It is about 109 times the diameter of the earth. The average distance of the sun from the earth is about $1.496 \times 10^{11}$ m., which is called one astronomical unit (AU). The sun rotates around its axis and completes one rotation in 25 days. The temperature and pressure in the interior of the sun are extremely high, and the temperature on the surface is 6000K. The sun continuously emits radiations in visible region and in the radio wave region in all the directions and the small fraction of it reaches the earth. The light emitted from the sun reaches the earth in 8.3 minutes, and it is the main source of heat and light energy for all the members of solar system including the earth.

Energy in the form of heat is one of the main energy requirements in the domestic, agricultural, industrial and economic sectors of our economy. Pyrometer: It is used to measure total radiation (direct and diffuse) in terms of energy per unit time per unit area on a horizontal surface. Pyrheliometer: It is used for measuring beam radiation. Solar energy is a very large,
inexhaustible source of energy. The power from the sun intercepted by the earth is approximately $1.8 \times 10^{11}$ MW which is many thousand times larger than the present consumption rate on the earth of all commercial energy sources. Thus, in principle, solar energy could supply all the present and future energy needs of the world on a continuing basis. This makes it one of the most promising of the unconventional energy sources.

- **The advantages of solar energy are**
  1. Environmentally clean source of energy and
  2. Freely available in adequate quantities in almost all parts of the world where people live.

- **The main problems associated with solar energy are:**
  1. Dilute source of energy and
  2. Availability varies widely with time. India,

Being tropical country receives solar insolation in the order of 1650-2100 kwh/m²/year for nearly 250-300 days. Solar energy can be used directly or indirectly.

- **Applications of solar energy**
  1. Heating and Cooling of buildings
  2. Solar water and air heating
  3. Salt production by evaporation of seawater
  4. Solar distillation
  5. Solar drying of agricultural products
  6. Solar cookers
  7. Solar water pumping
  8. Solar refrigeration
  9. Electricity generation through Photo voltaic cells
  10. Solar furnaces
  11. Industrial process heat
  12. Solar thermal power generation
Wind energy

Wind is the world’s fastest growing energy source today and it has been retaining this position consecutively for the last five years. The global wind power capacity has increased by a factor of 4.2 during the last five years.

Air in motion is called wind. The winds on the earth surface are caused primarily by the unequal heating of the land and water by the sun. The differences in temperature gradients induce the circulation of air from one zone to another. Winds are caused on earth due to:

1. The absorption of solar energy on earth surface and its atmosphere. The pressure and temperature gradients causes winds or wind flow.
2. Also the rotation of earth about its axis and its movement around the sun causes the flow of wind.

Energy derived from wind velocity is wind energy. It is a non-conventional type of energy, which is renewable with suitable devices. This energy can be used as a perennial source of energy. Wind energy is obtained with the help of wind mill. The minimum wind speed of 10kmph is considered to be useful for working wind mills for agricultural purpose. Along the sea coast and hilly areas, wind mills are likely to be most successful in Karnataka, Maharashtra and Gujarat.

The wind energy over earth is estimated to be $1.6\times10^7$ M.W, which is equivalent to the energy consumed. But, the wind energy is available in dilute form. The conversion machines are large. The wind energy varies from time to time and place to place. Due to this reason some storage facility is required. The kinetic energy of wind is converted into useful shaft power by wind mills. General applications of wind mills are pumping water, fodder cutting, grain grinding, generation of power etc. In India, wind speed lies between 5 kmph-20 kmph. The high wind velocity is seasonal. The wind energy, if used for power generation, it will be uncertain to generate power. In India, wind power can be used for lifting water in rural areas for drinking and for irrigation purpose.

- **Factors affecting the wind**
  1) Latitude of the place
  2) Altitude of the place.
3) Topography of the place
4) Scale of the hour, month or year.

- **Suitable places for the erection of wind mills**
  1) Off-shore and on the sea coast: An average value on the coast is 2400 KWH/m2/year.
  2) Mountains: An average value is 1600 KWH/m2/year.
  3) Plains: An average value is 750 KWH/m2/year.

- **Places unsuitable for wind mills**
  1. Humid equatorial region- there is virtually no wind energy.
  2. Warm, windy countries, wind energy may not be usual because of the frequency of cyclones.

- **Advantages of wind energy**
  (i) It is a renewable source of energy.
  (ii) It is non-polluting and no adverse influence on the environment.
  (iii) No fuel and transportation is required.
  (iv) The cost of electricity under low production is comparatively low.

- **Disadvantages**
  (i) The available wind energy is dilute and fluctuating in nature.
  (ii) Unlike water energy, wind energy requires storage capacity because of its irregularity.
  (iii) Wind energy operating machines are noisy in operation.
  (iv) Wind power systems have a relatively high overall weight. For large systems, a weight of 110 kg/kW has been estimated.
  (v) Large areas are required for wind mill.
  (vi) The present wind mills are neither maintenance free nor practically reliable.

- **Biofuels**

  “Biofuels” are transportation fuels like ethanol and biodiesel that are made from biomass materials. These fuels are usually blended with petroleum fuels namely with gasoline and diesel fuel, but they can also be used on their own. Ethanol and biodiesel are also cleaner burning fuels, producing fewer air pollutants. It has drawn significant attention due to increasing environmental concern and diminishing petroleum reserves. Bio-diesel fuel can be made from renewable vegetable oils, animal fats or recycled cooking oils by
transesterification process. Biodiesel is the fastest growing alternative fuel in the world. Ethanol is an alcohol fuel made from the sugars found in grains such as corn, sorghum, and wheat, as well as potato skins, rice, sugarcane, sugar beets and yard clippings by fermentation.

- **Characteristics of bio-fuels**

The following are some of the characters for the efficient bio-diesel:

1. Kinematic viscosity
2. Density
3. Calorific value
4. Melt or pour point
5. Cloud point
6. Flash point
7. Acid value
8. Iodine value
9. Cetane number
10. Stability – oxidative, storage and thermal
11. Carbon residue
12. Ash percentage
13. Sulphur percentage

- **Water harvesting Structure**

There are many ways of harvesting water. All these methods basically fall under three main categories viz.:

- surface water collection
- ground water collection
- augmentation of ground water recharge

The methods which are particularly useful in augmenting drinking water availability especially in the rural areas and which can be easily adopted at a moderate cost with the Involvement of the local people are discussed in the following paras.

- **Roof top harvesting**
Rain water may be harvested in areas, having rainfall of considerable intensity, spread over the larger part of the year e.g. The Himalayan areas, northeastern states, Andaman Nicobar, Lakshadweep islands and southern parts of Kerala and Tamil Nadu. This is an ideal solution of water problem where there is inadequate groundwater supply and surface sources are either lacking or insignificant. Rain water is bacteriologically pure, free from organic matter and soft in nature. In this system, only roof top is the catchment. The roofing should be of galvanized iron sheets (g.i.), aluminum, clay tiles, asbestos or concrete. In case of thatch-roof, it may be covered with waterproof sheeting. For collection of water, a drain is provided (gutter) along the edge of the roof. It is fixed with a gentle slope towards down pipe, which is meant for free flow of water to the storage tank. This may be made up of g.i. sheet, wood, bamboo or any other locally available material. The down pipe should be at least 100 mm diameter and be provided with a 20 mesh wire screen at the inlet to prevent dry leaves and other debris from entering it.

During the period of no rain, dust, bird droppings etc. Accumulate on the roof. These are washed off with the first rains and enter the storage tank to contaminate the water. This can be prevented by two methods:

   a. simple diversion of foul water
b. installation of foul flush system

Under method (a), the down pipe is moved away from the inlet of the storage tank initially during the rains, until clean water flows.

Under method (b), storage provision for initial rain is kept in a pipe. These are cleaned off after each heavy rain. These are provided between down pipe and the storage tank. Filter materials such as sand, gravel or coconut/ palm/ betalnut fibre etc. are used as filter media.

Storage tank can be constructed underground or above ground. The underground tank may be masonry or R.C.C. structure suitably lined with water proofing materials. The surface tank may be of G.I. sheet, R.C.C., Plastic/ HDP or Ferro cement Tank placed at a little higher elevation on a raised platform. To facilitate cleaning of the tank, an outlet pipe may be fitted and fixed in the tank at bottom level. The size of the tank will depend upon the factors such as daily demand, duration of dry spell, catchment area and rainfall. The tank is provided with:

(i) a manhole of 0.50 m × 0.50 m size with cover
(ii) Vent pipe/ over flow pipe (with screen) of 100 mm dia.
(iii) drain pipe (100 mm dia.) at bottom

Choice of the tank depends on locally available materials and space available. When the tank is constructed underground, at least 30 cm of the tank should remain above ground. The withdrawal of water from the underground tank is made by installing hand pump on it. In case of surface tank, tap can be provided. Before the tank is put into use it should be thoroughly cleaned and disinfected with high Dosage of chlorine. Since the water shall remain stored for quite a long time, periodical disinfection of stored water is essential to prevent growth of pathogenic bacteria.

◆ TANKA/ KUND/ KUNDI

Tanka is generally circular in shape and is constructed in stone masonry in 1:3 cement-sand mortar. While small Tankas of 3 to 4.22 m diameter and about 21-59 cum capacity are built by individual households, larger ones of 6 m diameter and 200 cum capacity are built for the village communities. In both these cases the depth is kept equal to the diameter. The catchment of the Tanka is treated in a variety of ways to increase the rain water collection. The commonly used materials are murrum, coal ash, gravel, pond silt, Bentonite, soil-cement mix, lime concrete, sodium carbonate etc. Because of the constraints of availability of large open areas around the Tanka and the unit cost of treatment, a circular strip of land of 12 m width around the Tanka is usually treated, the slope of which is kept as
3% i.e. a fall of 3 cm in a length of 1 m. This provides bulk of the requisite amount of water to fill the Tanka. Remaining water is received from the natural catchment outside the treated area.

◆ **PERCOLATION TANK**

Percolation tanks are artificially created surface water bodies, submerging a land area with adequate permeability to facilitate sufficient percolation of impounded surface runoff to recharge the ground water. These have come to be recognized as a dependable mode for ground water recharge in the hard rock terrain covering two-third of the country. The hard rock areas with limited to moderate water holding and water yielding capabilities often experience water scarce situations due to inadequate recharge, indiscriminate withdrawal of ground water and mismanagement. These are quite popular in the states of Maharashtra, Andhra Pradesh, Madhya Pradesh, Tamil Nadu, Karnataka and Gujarat. The percolation tank is more or less similar to check dams or nala bund with a fairly large storage reservoir. A tank can be located either across small streams by creating low elevation check dams or in

◆ **CHECK DAMS/ CEMENT PLUG/ NALA BUNDS**

Check dams are constructed across small streams having gentle slope and are feasible both in hard rock as well as alluvial formations. The site selected for check dam should have sufficient thickness of permeable bed or weathered formation to facilitate recharge of stored water within short span of time. The water stored in these structures is mostly confined to stream course and the height is normally less than 2 m. These are designed based on stream width and excess water is allowed to flow over the wall. In order to avoid scouring from excess run off, water cushions are provided at downstream side. To harness the maximum run off in the stream, series of such check dams can be constructed to have recharge on regional scale.

◆ **Farm pond**

Farm Pond is a dug out structure with definite shape and size having proper inlet and outlet structures for collecting the surface runoff flowing from the farm area. It is one of the most important rain water harvesting structures constructed at the lowest portion of the farm area. The stored water must be used for irrigation only. Inadvertently, some people use the farm ponds as ground water recharge structures which is not correct as per the definition. For recharging the ground water, the structures require high capacity and are generally located in the soils having high infiltration rates and are called percolation tanks. Percolation tank is meant for only recharge purpose and not for irrigation. Such structures conceptually differ in
their hydrology and physical location. A farm pond must be located within a farm drawing the maximum runoff possible in a given rainfall event.

A percolation pond can be dug out in any area where the land is not utilized for agriculture. Farm ponds have a significant role in rain fed regions where annual rainfall is more than or equal to 500 mm. If average annual rainfall (AAR) varies between 500 to 750 mm, the farm ponds with capacity of 250 to 500 m³ can be constructed. If AAR is more than 750 mm, the farm ponds with capacity more than 500 m³ can be planned particularly in black soil regions without lining. It was observed from the field experience and if present rainfall pattern changes; at least two to three rainfall events producing considerable runoff are possible in a season making farm ponds an attractive proposition. In high rainfall semi-arid regions, these structures can be made as multiple use enterprises like protective/supplemental irrigation, fish culture or duck farming integrated with poultry. These structures provide localised water and food security by enhancing the crop productivity and climate resilience.

Moreover, farm ponds conserve the natural resources like soil and nutrients apart from water and acts as flood control structure by reducing peak flows in the watersheds or given area of catchment. Depending on the source of water and their location, farm ponds are grouped into four types:

1) Excavated or Dug out ponds
2) Surface ponds
3) Spring or creek fed ponds and
4) Off stream storage ponds.

◆ WATERSHED MANAGEMENT

“Watershed management is a concept which recognizes the judicious management of three basic resources of soil water and vegetation, on watershed basis, for achieving particular objective for the wellbeing of the people”. It includes treatment of land most suitable biological as well as engineering measures.

Objective of watershed management:

(i) Production of food, fodder, fuel.
(ii) Pollution control
(iii) Over exploitation of resources should be minimized
(iv) Water storage, flood control, checking sedimentation.
(v) Wild life preservation
(vi) Erosion control and prevention of soil, degradation and conservation of soil and water.
(vii) Employment generation through industrial development dairy fishery production.
(viii) Recharging of ground water to provide regular water supply for consumption and industry as well as irrigation.
(ix) Recreational facility.

- **Steps in watershed management**: Watershed management involves determination of alternative land treatment measures for, which information about problems of land, soil, water and vegetation in the watershed is essential.

In order to have a practical solution to above problem it is necessary to go through four phases for a full scale watershed management.

- **Programme**:
  1. Recognition phase.
  2. Restoration phase.
  3. Protection phase.
  4. Improvement phase.

**I Recognition Phase**: It involves following steps

1. Recognition of the problem
2. Analysis of the cause of the problem and its effect.

Necessary information is obtained from different surveys like soil survey, land capability survey, agronomic survey, forest, engineering and socio economic survey, etc. This information serves as a basis for fixing and determining the watershed problems, priorities in land treatment measures, and causes and effects of problems on land and people.

**II Restoration Phase**: It includes two main steps.

a. Selection of best solution to problems identified

b. Application of the solution to the problems of the land

As per the priorities, treatment applied initially to critical areas. After this proper measures like biological and engineering measures are applied to all types of lands.
III Protection Phase: This phase takes care of the general health of the watershed and ensures normal functioning. The protection is against all factors which may cause determined in watershed condition.

IV Improvement Phase: This phase deals with overall improvement in the watershed and all land is covered. Attention is paid to agriculture and forest management and production, forage production and pasture management, socio economic conditions to achieve the objectives of watershed management. Health, family planning, improving cattle, poultry, etc. are taken depending upon intensity.

◆ Agro processing

Agro processing could be defined as set of techno economic activities carried out for conservation and handling of agricultural produce and to make it usable as food, feed, fibre, fuel or industrial raw material. Hence, the scope of the agro-processing industry encompasses all operations from the stage of harvest till the material reaches the end users in the desired form, packaging, quantity, quality and price. Ancient Indian scriptures contain vivid account of the post-harvest and processing practices for preservation and processing of agricultural produce for food and medicinal uses. Inadequate attention to the agro-processing sector in the past put both the producer and the consumer at a disadvantage and it also hurt the economy of the Country. Agro-processing is now regarded as the sunrise sector of the Indian economy in view of its large potential for growth and likely socio economic impact specifically on employment and income generation. Some estimates suggest that in developed countries, up to 14 per cent of the total work force is engaged in agro-processing sector directly or indirectly. However, in India, only about 4 per cent of the work force finds employment in this sector revealing its underdeveloped state and vast untapped potential for employment. Properly developed, agro-processing sector can make India a major player at the global level for marketing and supply of processed food, feed and a wide range of other plant and animal products.

- Modified and Controlled Atmospheres for the Storage

Modified atmosphere (MA) and controlled atmosphere (CA) technologies have great potential in a wide range of applications. The increasingly global nature of food production and the increased emphasis on reducing chemical preservatives and pesticides have put the spotlight on these centuries-old technologies. Yet until now, there have been very few current resources available, and none have covered all aspects.

- Modified and Controlled Atmospheres for the Storage, Transportation, and Packaging of Horticultural Commodities
Explores the science and application of the modified atmosphere (MA) and the controlled atmosphere (CA). It covers all technological applications, including storage, transport, and packaging for all fruits, vegetables, and ornamentals of temperate, subtropical, and tropical origin. Tracing the historical developments of these technologies, it provides information on the ideal conditions to be used for many horticultural commodities. It also outlines the effects of MA and CA on the physiology and biochemistry of these commodities as well as on their flavour and quality.

Providing the most comprehensive resource on all basic and applied aspects of these technologies, the text also reviews the vast amount of literature already written on this topic. This extensive work captures, for the first time, the entire subject of MA and CA, presenting a complete review of the technological aspects of this important development in food safety and preservation.

The controlled atmospheric storage in higher CO2 and lesser O2 are maintained is most significant contribution in storage technology. If storage done with refrigeration, it gives growth to respiratory activity and delay softening, yellowish, quality change, etc. The important factor of storage is tolerance susceptibility to injured vegetables increasing CO2 and decreasing O2.

- **Advantages of Controlled Atmosphere Storage:**
  1. Control all types of micro-organisms.
  2. Chilling injury and other physiological disorders.
  3. Black heart in potato
  4. Cost of equipment and operation
  5. This is less popular in India.

- **Perishable food storage**

Cold storages are meant to preserve the perishable commodities of food items for a longer period with retention of the original colour, flavour and taste. However, each commodity or item has certain life and they cannot be stored even in a cold storage for indefinite period. Storage beyond certain period may not be economical as well since payment of rent of cold storage increases the cost of the item. Hence, cold storages are used for high value items or when prices crash down due to bumper crop or for such items which are grown during the season but there is a demand round the year or for products like meat, fish or milk products which are quickly perishable.

- **PRODUCT**
Cold storages are being used for preservation of many food products since long. Their location has to be strategic and they should have easy access. Cold storages have demand all over the country. This note primarily looks into the prospects in Assam. Assam grows many varieties of fruits and vegetables. Consumption of meat, fish, chicken etc. is also on the higher side. Hence, a cold storage unit seems to have good scope.

◆ MARKET POTENTIAL

Demand and Supply Location is a very critical aspect for the success of cold storage. It should be in close proximity of growing area as well as market and at the same time should be easily accessible for heavy vehicles round the year. Uninterrupted power supply is yet another prerequisite.

Marketing Strategy Many fruits and vegetables like pineapples, apples, plums, oranges, potatoes, brinjals, cauliflowers etc. are grown in Assam. Likewise, consumption of meat, chicken, fish etc. is also substantial. Hence, there is a good scope for a cold storage unit. A possibility of storing some milk products may also be explored. Different items are stored during different times requiring different temperatures. Hence, there is a need to divide total storage space in different temperature zones depending upon local needs.

◆ MANUFACTURING PROCESS

A proper market analysis would throw light on storage needs and accordingly tentative plan for the whole year has to be drawn. Compressors suitable for using ammonia have to be selected as ammonia is cheap, easily available and is of high latent heat of evaporation, but it is highly toxic in nature if mixed with oil containing high carbon percentage. Hence, handling and maintenance has to be very careful. Rooms with different temperature requirements must be properly insulated and protected from moisture. On outside walls, one coating of foam with vapour proof material is advisable. Temperature and humidity is maintained according to the items stored. Use of skewed door arrangements, proper insulation and required circulation of cool air inside the storage area would make operations economical and improve profitability.

- Silos
A **silo** ("pit for holding grain") is a structure for storing bulk materials. Silos are used in agriculture to store grain (see grain elevators) or fermented feed known as silage. Silos are more commonly used for bulk storage of grain, coal, cement, carbon black, woodchips, food products and sawdust. Three types of silos are in widespread use today: tower silos, bunker silos, and bag silos.

- **Tower Silos**

  Storage silos are cylindrical structures, typically 10 to 90 ft (3 to 27 m) in diameter and 30 to 275 ft (10 to 90 m) in height with the slip form and Jump from concrete silos being the larger diameter and taller silos. They can be made of many materials. Wood staves, concrete staves, cast concrete, and steel panels have all been used, and have varying cost, durability, and airtightness trade-offs. Silos storing grain, cement and woodchips are typically unloaded with air slides or augers. Silos can be unloaded into rail cars, trucks or conveyors.

  Tower silos containing silage are usually unloaded from the top of the pile, originally by hand using a silage fork, which has many more times than the common pitchfork, 12 vs 4, in modern times using mechanical unloaders. Bottom silo unloaders are utilized at times but have problems with difficulty of repair.

- **Bunker Silos**

  Bunker silos are trenches, usually with concrete walls, that are filled and packed with tractors and loaders. The filled trench is covered with a plastic tarp to make it airtight. These silos are usually unloaded with a tractor and loader. They are inexpensive and especially well-suited to very large operations.

- **Bag Silos**

  Bag silos are heavy plastic tubes, usually around 8 to 12 ft (2.4 to 3.6 m) in diameter, and of variable length as required for the amount of material to be stored. They are packed using a machine made for the purpose, and sealed on both ends. They are unloaded using a tractor and loader or skid-steer loader. The bag is discarded in sections as it is torn off. Bag silos require little capital investment. They can be used as a temporary measure when growth or harvest conditions require more space, though some farms use them every year.
- Bins

A bin is typically much shorter than a silo, and is typically used for holding dry matter such as concrete or grain. Grain is often dried in a grain dryer before being stored in the bin. Bins may be round or square, but round bins tend to empty more easily due to a lack of corners for the stored material to become wedged and encrusted.

The stored material may be powdered, as seed kernels, or as cob corn. Due to the dry nature of the stored material, it tends to be lighter than silage and can be more easily handled by under-floor grain unloaders. To facilitate drying after harvesting, some grain bins contain a hollow perforated or screened central shaft to permit easier air infiltration into the stored grain.