Chapter–1

Farm Energy Management in India: The Transforming Economy and Ecology-The Prologue

S.K. Acharya, G.C. Mishra, Sneha Bera and Sarafat Shaik

The study of social ecology has gained a new momentum after social system theory came into operation. Extension is basically a science of knowledge system where in continuous and evolutionary interactions are occurring between knowledge and "social space". In this complex system the other components are (a) adoption and adoption period, (b) rejection, (c) Discontinuance, (d) reinvention crop and crop enterprises, (e) market and market intelligence, (f) meteorological components and cognate biological components. All these components are inextricably interacting with each other to ultimately characterize the journey of knowledge into social space. The transformation of agriculture and mellifluent, is the common nature for the new age agriculture. There is a clear showing from per hectare biological production to per hectare value generation with ecological pursuits and dimensions. Farm energy metabolism basically estimate the dynamic of energy exchange between natural ecology and social ecology, as on date, we are use to perceived of yield in terms of biological productivity expressed through quintal of wheat production per hector. Seldom think in terms of volume of energy that we have yielded or trapped from the unit volume of farms. When the entire input are assure, we are not enough sure whether we can trapped the energy efficiently, in case any farm start losing its energy balances, the factor of production must suffer. It is a local oratory that the soil is cool, it means the energy emission from the soil basically farm soil, then its trapped energy from the atmosphere in the form of photosynthesis, in addition to it the unscientific tillage operation are also responsible for energy prodigal farming. Day will come when germination of seed will be very difficult because of the downfall of latent soil energy, so a genre of extension science has to go a long way making this small and fragmented farms energy saving as well as enough productive to ensure food security.

Social ecology through its integrative and orchestration function can rationalize the expenditure after agriculture in the form of-

i. Application of agro-chemicals like fertilizers, pesticides. Handling of factor production with higher proficiency in terms of economic health

ii. Generation of values in terms of calorie values, quality contents like proteins, minerals and therapeutics and making the volume of food production affordable and accessible to people of marginal sections.

iii. The model on energy in social ecology has got three basic considerations –

iv. Flow of energy from one small niche and in between can be called social metabolism.

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v. The flow of capital into this system of entrepreneurship intensity of rotation to ultimately characterize enterprise product and outcome.

vi. Conservation of energy through considering the renewability level of different energy forms entering the system.

The energy consumption pattern in India, especially in the agro-ecosystem, followed by small and marginal farm holdings, around 85% of total 130 million farm families in India, generating 259 million tonnes of food grain that include a record production of 106 million tonnes of rice, 95 million tonnes of wheat, 22 million tonnes of maize, 17 million tonnes of pulses, about 30 million tonnes of oilseeds, 210 million tonnes of horticultural production, 180 million tonnes of milk and 8. 7 million tonnes of fish (2011-12), has got tremendous implication and need to be added against total volume of energy consumed is in a positive balance or poised with a negative balance either.

Civilization, human being used their own strength in moving and carrying loads, trapping animal, hunting for their food. In the Stone Age, man discovered the making of fire by rubbing together two pieces of wood. This revolutionary discovery was the first attempt of man to use energy from a source outside his own body. Since then he has continuously striven to minimize labour for practically everything through the use of tools and machines. The rapid advance of human progress that occurred during the historic period from the Neolithic Age to what we call the Dawn of Civilization, some 3000 or 4000 years ago, is characterized by the use of solar energy indirectly through the biological system that produce grain and animals for men's survival.

During the later Neolithic period, humans used animal power and stone tools to harness agriculture. With this step, men manage to couple his own energy – magnified through tools – with the energy resources of the Sun and renewable crops. Thus first signs of stable human communities were developed.

In the early days, the only significant energy sources were the natural ones – the power falling water and the use of wind for ships. In industry, the central energy source was fire, from the burning of wood. In addition to wood used for heating and cooking, woods became a source for charcoal for reducing ores to metals. The first fossil fuel to be exploited were surface deposits of asphalt, peat and coal, oil from surface seepage, and gas venting from underground reservoirs.

Petroleum though not extensively used at first, came into prominence in the 17^{th} century, when an oil well drilled in Modena, Italy 1640 provided fuel for street lighting. Wind as energy source for boat and ship propulsion used by men for several thousand years.

Windmills were also widely used for flour grinding, water flow and other purposes in many parts of the world. In the 18th century steam power was developed and its refinement and proliferation in 19th century began a revolution in energy exploitation that is still continuing. The widespread use of petroleum starting from the early 20^{th} century, particularly for cars, aeroplane, industry, gave a new dimension to the revolution.

People are all intuitively conscious of the concept of energy from early childhood. In school and college we talk about having the 'energy' to run several kilo meters or to climb mountain or other physical work. This is physical energy which becomes easily defined as the capacity to do work. In the human body this energy comes from the muscles of the human system, which in turn get their energy from food and the nutrition that we imbibe. We are also conscious of other 'energy' being expended from natural forces around us in movements such the force of moving water or of wind and storms.

Today we all have some basic knowledge about the uses and application of energy.

We know that by burning petrol or diesel we get energy to run scooters, cars, trucks, etc. , and we also know that many of our homes need coal, kerosene, oil and gas for the supply for energy for cooking food and similar other domestic activities. Besides, we also need electric energy to light our house. For many of us, the awareness of energy has also come about through day-to-day inconveniences caused by power cuts, shortage of kerosene and diesel; fuel rationing, and the increasing cost of obtaining energy. For scientists, energy is in fact another form of matter and interchangeable with it. We live a world with energy all around us.

In India the concept of energy as Shakti has been almost at the focus of philosophic, scientific and metaphysical thought from time immemorial. Shakti causes the great universal movements of stars and planet, and, on our own earth, the great natural movement of wind and waters. Shakti is also at the origin of fire, heat and light, and the power to enable man, animal, plants to grow and work. Numerous references in India's ancient literature and books can be found for study and analysis of the concept of shakti which is also sometimes made synonymous with the Supreme Being. Indeed philosophically the old Indian analysis for shakti had also dealt with energy creating matter and being created from it, energy changing and appearing in different forms and energy being essentially one, with manifestations in different forms and different areas. Some similar concept of energy have been arrived at by the discoveries of modern theoretical and experimental physics, including the interchange ability of mass and energy and the unified theory for the different basic forces of nature, as known as to physics.

Energy is a basic requirement of human life, just like in agriculture, industry, transportation, communication and all other economic activities of the present civilization. So far India is concerned, agriculture constitutes foundation for the socio- economic structure, and seventy recent of the population is engaged in activities related to crop-animal-aqua production, Processing and marketing.

Man gets his energy from the food he eats, An average Indian lives on a diet of 2000 food calories(unit of food calorie = 1000 units of calorie or 1 food calorie = lkcl), and produces 60 watts of power when he works for 8 hours a day. Thus he generates energy roughly equal to 0. 5 kwh. At a rate of Rs. 5/day/man, these amounts to a cost of Rs. 10 per kwh for heaved energy. A human being is an expensive source of energy. It is better to use him to organize, manage, steer, direct and govern rather than as a energy source.

Energy is both fuel and feed stock for agriculture. Primary energy is the fuel; solar energy is the feed stock material. Both are essential in industrialized agriculture concern for the efficient and proper use of energy is evidenced from many questions, non-agricultural sources. Widely differencing proposals have been made for changes in agricultural policy in response to the energy-related concerns. Controversy exists over the correctness and feasibility of many of these proposals. It is of extreme importance, therefore, to identify the energetic relationships of agricultural systems and to be understood. We must be able to correctly identify and measure the flow of energy in the system comparing the crop and livestock production, food processing, distribution and preparation. We call such activities as agricultural *energytics*.

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Agriculture is the business of capturing solar energy in growing plants and using them for organisms sustained by that energy to produce food and fibre needed by human beings. Like most other aspects of alternative energy in agriculture, energy-efficient cropping is a long-range proposition. At least, it is for most commercial farmers.

There are short-term ways to Conserve energy in crop production, irrigation, harvesting, and crop processing. But, for the most part, this involve trade-offs. Either production is decreased for all or part of the acreage of a substantial investment, or alternative energy system is required to maintain production currently achieve by impact of purchased energy.

Humans have found ways to secure their food from the Earth's land, beginning more than a million years ago with the hunter-gatherers. Much of the world's agriculture was -- and still is -- carried out by hand (Pimentel and Pimentel, 1996). Once fossil energy supplies became available about 200 years ago, intensive agricultural production developed. Although contemporary, energy-intensive agricultural systems are highly productive, their sustainability is questionable because : (1) rapid population growth necessitates continued increases in the use of cropland and water resources; (2) fossil energy resources that are essential for supplying fertilizers, pesticides, irrigation, and mechanization are non-renewable; and (3) the agricultural environment is being degraded by both soil erosion of cropland and pasture land and by the pollution of fresh water resources. Now, at the turn of the century, we are faced with meeting the food needs of a rapidly expanding human population. Currently, more than 3 billion people in the world are malnourished due to outright food shortages and poor distribution of some foods (WHO, 1996). In addition, shortages of cropland, fresh water, fossil energy (fertilizers and irrigation), and biological resources now plague agricultural production in many parts of the world. The supplies of various grains -- staples that make up more than 80% of world food -- have been declining since 1984 (Pimentel et al. , 1998a). Stores of fossil energy also have begun to decline; this trend will intensify after the year 2000 (Pimentel et al. , 1998a).

To meet the basic food needs of our expanding human population, a productive, sustainable agricultural system must become a major priority. From analyses of various agricultural systems, we can understand the use of all forms of energy and learn how to preserve essential land, water, and biological resources for future generations.

Agriculture in a way is an energy conversion industry. Through photosynthesis, plants transform solar and chemical energies derived from the soil into storable chemical energies as carbohydrates, proteins, fats, cellulose, dietary minerals, vitamins and phytomins, etc. To increase photosynthetic efficiency of plants, the plant breeders evolve better plant types, while other scientists develop efficient agro-techniques, hardware’s and software’s of management. Current package of practices of crop production involve various sources of energy some are locally available non- commercial while others are commercial such as, diesel and electricity, certified seeds and planting materials, fertilizers, pesticides, farm machinery, postharvest equipment and structures, cold stores as well as refrigerated carriers for perishables. Excessive use of commercial energies in Indian scenario, where 70% petroleum products are imported and where electrical power is costly and in short supply, means increased unit cost of production of agricultural products, and reduced profitability and global competitiveness. In a village eco-system, about 80% of the total energy use goes to domestic sector of which about 80% is used for cooking, mostly derived from crop and livestock residues and fuel wood. Rural electrification and socio-economic developments have provided electricity, kerosene, and biogas for resourceful rural homes. However, supply of electricity to the rural areas is not adequate; and it is not available when required most. Farmers have to wait for a long time for energisation of their irrigation pumps. Rural entrepreneurs are constrained to have stand-by power supply unit run on diesel or biomass which supply electricity at 2-3 times the cost of that obtained from grid power. Government of India has established Ministry of New and Renewable Energy, and State Governments have created corporate bodies promoting new and renewable energy sources. As a result of intensive R&D in public and private sector, a number of renewable energy applications like improved chulhas, biogas plants, solar cookers, solar water heaters, solar dryers, photovoltaic irrigation pumps and illumination systems are under massive popularization. Wind farms are generating substantial quantities of electricity for power grid and off-grid applications. Energy from biomass is also being generated on a pilot scale. Energy plantations are being taken up in a big way on reclaimed lands for biodiesel production. Blending of petrol with ethanol has started. Energy needs to be conserved, and commercial energies need to be supplemented and substituted with renewable energies to sustain rural economy and living.

Sources of energy

Fossil fuels

There are three major forms of fossil fuels: coal, oil and natural gas. All three were formed many hundreds of millions of years ago before the time of the dinosaurs – hence the name fossil fuels. The age they were formed is called the Carboniferous Period. It was part of the Palaeozoic Era. "Carboniferous" gets its name from carbon, the basic element in coal and other fossil fuels.

The Carboniferous Period occurred from about 360 to 286 million years ago. At the time, the land was covered with swamps filled with huge trees, ferns and other large leafy plants, similar to the picture above. The water and seas were filled with algae – the green stuff that forms on a stagnant pool of water. Algae are actually millions of very small plants.

Some deposits of coal can be found during the time of the dinosaurs. For example, thin carbon layers can be found during the late Cretaceous Period (65 million years ago) – the time of Tyrannosaurus Rex. But the main deposits of fossil fuels are from the Carboniferous Period.

As the trees and plants died, they sank to the bottom of the swamps of oceans. They formed layers of a spongy material called peat. Over many hundreds of years, the peat was covered by sand and clay and other minerals, which turned into a type of rock called sedimentary.

More and more rock piled on top of more rock, and it weighed more and more. It began to press down on the peat. The peat was squeezed and squeezed until the water came out of it and it eventually, over millions of years; it turned into coal, oil or petroleum, and natural gas.

Coal

Coal is a hard, black colored rock-like substance. It is made up of carbon, hydrogen, oxygen, nitrogen and varying amounts of sulphur. There are three main types of coal – anthracite, bituminous and lignite. Anthracite coal is the hardest and has more carbon, which gives it higher energy content. Lignite is the softest and is low in carbon but high in hydrogen and oxygen content. Bituminous is in between. Today, the precursor to coal—peat—is still found in many countries and is also used as an energy source.

Oil or Petroleum

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Oil is another fossil fuel. It was also formed more than 300 million years ago. Some scientists say that tiny diatoms are the source of oil. Diatoms are sea creatures the size of a pin head. They do one thing just like plants; they can convert sunlight directly into stored energy. As the diatoms died they fell to the sea floor. They were buried under sediment and other rock. The rock squeezed the diatoms and the energy in their bodies could not escape. The carbon eventually turned into oil under great pressure and heat. As the earth changed and moved and folded pockets where oil and natural gas can be found were formed.

Natural gas

Natural gas is lighter than air. Natural gas is mostly made up of a gas called methane. Methane is a simple chemical compound that is made up of carbon and hydrogen atoms. It's chemical formula is $CH4$ – one atom of carbon along with four atoms hydrogen. This gas is highly flammable. Natural gas is usually found near petroleum underground. It is pumped from below ground and travels in pipelines to storage areas.

Biomass energy

Biomass is matter usually thought of as garbage. Some of it is just stuff lying around - - dead trees, tree branches, yard clippings, left-over crops, wood chips (like in the picture to the right), and bark and sawdust from lumber mills. It can even include used tires and livestock manure. The waste wood, tree branches and other scraps are gathered together in big trucks. The trucks bring the waste from factories and from farms to a biomass power plant. Here the biomass is dumped into huge hoppers. This is then fed into a furnace where it is burned. The heat is used to boil water in the boiler, and the energy in the steam is used to turn turbines and generators

Geothermal energy

Geothermal Energy has been around for as long as the Earth has existed. "Geo" means earth, and "thermal" means heat. So, geothermal means earth-heat. Below the crust of the earth, the top layer of the mantle is a hot liquid rock called magma. The crust of the earth floats on this liquid magma mantle. When magma breaks through the surface of the earth in a volcano, it is called lava. For every 100 meters you go below ground, the temperature of the rock increases about 3 degrees Celsius. Or for every 328 feet below ground, the temperature increases 5. 4 degrees Fahrenheit. So, if you went about 10,000 feet below ground, the temperature of the rock would be hot enough to boil water.

Deep under the surface, water sometimes makes its way close to the hot rock and turns into boiling hot water or into steam. The hot water can reach temperatures of more than 300 degrees Fahrenheit (148 degrees Celsius). This is hotter than boiling water (212 degrees F / 100 degrees C). It doesn't turn into steam because it is not in contact with the air. When this hot water comes up through a crack in the earth, we call it a hot spring. Or, it sometimes explodes into the air as a geyser.

Hydro

When it rains in hills and mountains, the water becomes streams and rivers that run down to the ocean. The moving or falling water can be used to do work. Energy, you'll remember is the ability to do work. So moving water, which has kinetic energy, can be used to make electricity.

Nuclear energy

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Another major form of energy is nuclear energy, the energy that is trapped inside each atom. One of the laws of the universe is that matter and energy can't be created nor destroyed. But they can be changed in form.

Nuclear fission

An atom's nucleus can be split apart. When this is done, a tremendous amount of energy is released. The energy is both heat and light energy. Einstein said that a very small amount of matter contains a very LARGE amount of energy. This energy, when let out slowly, can be harnessed to generate electricity.

Nuclear fusion

Another form of nuclear energy is called fusion. Fusion means joining smaller nuclei (the plural of nucleus) to make a larger nucleus. The sun uses nuclear fusion of hydrogen atoms into helium atoms. This gives off heat and light and other radiation.

Ocean energy

There are three basic ways to tap the ocean for its energy. We can use the ocean's waves, we can use the ocean's high and low tides, or we can use temperature differences in the water.

Wave energy

Kinetic energy (movement) exists in the moving waves of the ocean. That energy can be used to power a turbine. In this simple example, to the right, the wave rises into a chamber. The rising water forces the air out of the chamber. The moving air spins a turbine which can turn a generator.

When the wave goes down, air flows through the turbine and back into the chamber through doors that are normally closed.

This is only one type of wave-energy system. Others actually use the up and down motion of the wave to power a piston that moves up and down inside a cylinder. That piston can also turn a generator.

Most wave-energy systems are very small. But, they can be used to power a warning buoy or a small light house.

Tidal energy

Another form of ocean energy is called tidal energy. When tides come into the shore, they can be trapped in reservoirs behind dams. Then when the tide drops, the water behind the dam can be let out just like in a regular hydroelectric power plant.

Ocean thermal energy conversion

The idea is not new. Using the temperature of water to make energy actually dates back to 1881 when a French Engineer by the name of Jacques D'Arsonval first thought of OTEC. The final ocean energy idea uses temperature differences in the ocean. Power plants can be built that use this difference in temperature to make energy. A difference of at least 38 degrees Fahrenheit is needed between the warmer surface water and the colder deep ocean water.

Wind energy

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Wind can be used to do work. The kinetic energy of the wind can be changed into other forms of energy, either mechanical energy or electrical energy.

Renewable vs non renewable energy:-Environment and air quality

Fossil fuels are not renewable, they can't be made again. Once they are gone, they're gone. But there's no shortage of renewable energy from the sun, wind and water and even stuff usually thought of as garbage — dead trees, tree branches, yard clippings, left-over crops, sawdust, even livestock manure, can produce electricity and fuels — resources collectively called "biomass. "

Clean energy sources can be harnessed to produce electricity, process heat, fuel and valuable chemicals with less impact on the environment.

In contrast, emissions from cars fuelled by gasoline and factories and other facilities that burn oil affect the atmosphere. Foul air results in so-called greenhouse gases.

Renewable energy resource development will result in new jobs for people and less oil we have to buy from foreign countries. If we fully develop self-renewing resources, we will keep the money at home to help the economy.

Continued research has made renewable energy more affordable today than 25 years ago. The cost of wind energy has declined from 40 cents per kilowatt-hour to less than 5 cents. The cost of electricity from the sun, through photovoltaic’s (literally meaning "light- electricity") has dropped from more than $1/kilowatt-hour in 1980 to nearly 20cents/kilowatt-hour today. And ethanol fuel costs have plummeted from $4 per gallon in the early 1980s to $1. 20 today.

But there are also drawbacks to renewable energy development. Solar thermal energy involving the collection of solar rays through collectors (often times huge mirrors) need large tracts of land as a collection site. This impacts the natural habitat, meaning the plants and animals that live there. The environment is also impacted when the buildings, roads, transmission lines and transformers are built. The fluid most often used with solar thermal electric generation is very toxic and spills can happen.

Solar or PV cells use the same technologies as the production of silicon chips for computers. The manufacturing process uses toxic chemicals. Toxic chemicals are also used in making batteries to store solar electricity through the night and on cloudy days. . Manufacturing this equipment has environmental impacts.

Also, even if we wanted to switch to solar energy right away, we still have a big problem. All the solar production facilities in the entire world only make enough solar cells to produce about 350 megawatts, about enough for a city of 300,000 people.

That’s a drop in the bucket compared to our needs. And the cost of producing that much electricity would be about four times more expensive than a regular natural gas- fired power plant. So, even though the renewable power plant doesn't release air pollution or use precious fossil fuels, it still has an impact on the environment.

Wind power development too, has its downside, mostly involving land use. The average wind farm requires 17 acres of land to produce one megawatt of electricity, about enough electricity for 750 to 1,000 homes. However, farms and cattle grazing can use the same land under the wind turbines.

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Producing geothermal electricity from the earth's crust tends to be localized. That means facilities have to be built where geothermal energy is abundant. In the course of geothermal production, steam coming from the ground becomes very caustic at times, causing pipes to corrode and fall apart. Geothermal power plants sometimes cost a little bit more than a gas-fired power plant because they have to include the cost to drill.

Environmental concerns are associated with dams to produce hydroelectric power.

People are displaced and prime farmland and forests are lost in the flooded areas above dams. Downstream, dams change the chemical, physical and biological characteristics of the river and land.

Unlike fossil fuels, which dirties the atmosphere, renewable energy has less impact on the environment Renewable energy production has some drawbacks, mainly associated with the use of large of tracts of land that affects animal habitats and outdoor scenery. Renewable energy development will result in jobs and less oil imported from foreign countries.

Agro ecosystem and energy

Agro ecosystem an assembly of mutually interacting organisms and their environment in which materials related to crop production are interchanged in a largely cyclical manner. An ecosystem has physical, chemical, and biological components along with energy sources and pathways of energy and materials interchange. The interactions between these three components exert considerable influence on a particular ecosystem. In agro ecosystem, besides the natural components, some plants are introduced to get benefit for humans and their livestock.

An agricultural system functions with all its inputs and outputs. Inputs include all materials such as fertilizer, irrigation, pesticides etc for proper functioning of the economic production system and outputs are the gains from the system in any form such as grains, leaves, stems, roots etc. For the sustainability of the production system, agro ecosystem research considers all aspects of biology of an agricultural system. This broader approach to agricultural systems becomes more useful as production methods, developed through experimental methods, begin to approach the limits of the biological processes. As these limits are approached, it becomes more important to know how biological processes determine yield and to learn how these processes act in determining the biological limits to yields. Cycling of the nutrients through biogeochemical processes must also be considered in order to determine whether these cycles are able to sustain the high yields of intensive agricultural production that is based on the use of chemicals.

Agro ecosystem research uses the methods of ecosystem analysis to measure the material and energy entering plant and animal populations and to explain how these inputs affect the physiological processes determining growth and maintenance. Green plants harvest the solar energy and store within their bodies in the form of organic compounds. The accumulated organic carbon of the compounds can be divided into three categories: (i) course materials, such as fodder eaten by livestock; (ii) grains, fruits, vegetables and other edible portions, eaten by humans and livestock; and (iii) dense stems and leaves which may be used for fuel, shelters or utensils. The paths of energy and material flow between plants and the consumers follow simple consistent patterns that are more or less similar in most agricultural systems. Agro ecosystems have relatively simple cycle compared to other ecosystems that form complex food webs.

Energy used in agriculture

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Since the 1940s, agricultural productivity has increased dramatically, due largely to the increased use of energy-intensive mechanization, fertilizers and pesticides. The vast majority of this energy input comes from fossil fuel sources. Between the 1960– 65 measuring cycle and the cycle from 1986 to 1990, the Green Revolution transformed agriculture around the globe, with world grain production increasing significantly (between 70% and 390% for wheat and 60% to 150% for rice, depending on geographic area)as world population doubled. Modern agriculture's heavy reliance on petrochemicals and mechanization has raised concerns that oil shortages could increase costs and reduce agricultural output, causing food shortages.

Modern or industrialized agriculture is dependent on fossil fuels in two fundamental ways: 1) direct consumption on the farm and 2) indirect consumption to manufacture inputs used on the farm. Direct consumption includes the use of lubricants and fuels to operate farm vehicles and machinery; and use of gas, liquid propane, and electricity to power dryers, pumps, lights, heaters, and coolers.

Indirect consumption is mainly oil and natural gas used to manufacture fertilizers and pesticides. The natural gas and coal consumed by the production of nitrogen fertilizer can account for over half of the agricultural energy usage. China utilizes mostly coal in the production of nitrogen fertilizer, while most of Europe uses large amounts of natural gas and small amounts of coal. According to a 2010 report published by The Royal Society, agriculture is increasingly dependent on the direct and indirect input of fossil fuels.

The country inherited a stagnant agriculture at the time of Independence. The traditional tools and implements relied mostly on human and animal power and used a negligible amount of commercial energy. However, successive governments realized the importance of agriculture and initiatives were taken for the growth of this sector.

Increased investment in irrigation infrastructure, expansion of credit, marketing, and processing facilities

(http://planningcommission. nic. in/plans/planrel/fiveyr/10th/volume2/v2_ch5_1. pdf), therefore, led to a significant increase in the use of modern inputs.

Till the 1950s, use of tractors for agriculture was very limited. Tractor manufacturing in India started in 1961 with aggregate capacity to manufacture 11 000 tractors. Joint efforts made by the government and private sector have led to steady increase in the level of mechanization over the years.

Connected load in the agriculture sector in 2004 was estimated to be 51. 84 GW, the number of consumers being 12. 8 million. The electricity consumption in agriculture during 2003/04 was 87 089 GWh (second highest), 24. 13% of the total electricity consumption. There was an increase of 3. 08% in the electricity sales to the agriculture sector in 2003/04 over 2002/03 (CEA 2005). Electricity consumption in agriculture sector has been increasing mainly because of greater irrigation demand for new crop varieties and subsidized electricity to this sector. Moreover, due importance is not given to proper selection, installation, operation, and maintenance of pumping sets, as a result of which they do not operate at the desired level of efficiency, leading to huge waste of energy.

Agriculture (plantation/food) consumed 7 123 thousand tonnes of HSD (high-speed diesel) in 2003/04, accounting for 19. 2% of the total HSD consumption during the year. Consumption of LDO (light diesel oil) and furnace oil for plantation in 2003/04 was 44 000 and 243 000 tonnes, respectively, accounting for 2. 7% of the total LDO and 2. 9% of the total furnace oil consumed in

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the country. Consumption of furnace oil for transport (agriculture retail trade) in the agriculture sector was 94 thousand tonnes (Ministry of Power and Natural Gas 2004). However, it is difficult to assess the total diesel consumption for agriculture from the available data.

Fertilizer consumption in India has increased significantly in the last three decades.

Total NPK (N, P2O5 and K2O) consumption increased nine-fold (from 2 million to 18 million tonnes) between 1969/1970 and 1999/2000. Per-hectare NPK consumption increased from 11 to 95 kg in the same period. After reaching a record level in 1999/2000, fertilizer consumption in India has been irregular. It has fluctuated around 17 million tonnes since 2000/01

Classification of energy

On the basis of source, the energy can be classified as direct and indirect energy.

Direct source of energy

The direct sources of energy are those that release the energy directly-like man power, bullocks, stationary and mobile mechanical or electric power units, viz. , diesel engines, electric motor, power tiller and tractors. The direct energy may be further classified as renewable and non-renewable sources of energy depending upon their Replenishment. Renewable direct sources of energy: In this category, the energy sources, which are direct in natural but can be subsequently replenished, are grouped. The energies which may fall in this group are human beings, animals, solar and wind energy, fuel wood, agricultural wastes9o etc.

Non-renewable direct sources of energy: In this category, direct energy sources which are not renewable (at least in near further say next 100 years) are classified. Coal and fossil fuels exemplify non-renewable direct sources of energy.

Indirect source of energy

The indirect sources of energy are those which do not release energy directly but release it by conversion process. Some energy is invested in producing indirect sources of energy. Seeds, manures (farmyard and poultry), chemicals, fertilizers and machinery can be classified under indirect sources of energy. Again, on the basis of their replenishment, these can be further classified into renewable and non-renewable indirect source of energy. Renewable indirect source of energy: Seeds and manures can be termed as renewable indirect source of energy as they can be replenished in due course of time. Non-renewable indirect source of energy: The energy sources that are not replenished come under non-renewable indirect sources of energy. Chemicals, fertilizers and machinery manufacturing are the non-renewable indirect sources of energy.

On the basis of comparative economic value the energy may be classified as commercial and non-commercial.

Commercial energy

The energy sources like petroleum products (diesel, petrol and kerosene oil) and electricity, which are capital intensive, exemplify commercial sources of energy.

Considering the fact that most of the commercial sources are also non-renewable and to some extent are imported to India, efforts are made to conserve such sources of energy.

Non-commercial energy

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Each and every energy source has some economic value. Some energy sources are available comparatively at low cost whereas others are capital intensive. The energy sources which are available cheaply are called non-commercial sources of energy whereas the ones which are capital intensive are called commercial energy sources.

Human labour a of power directly. The commonly available and less expensive materials like fuel wood, twigs, leaves agro-wastes and animal dung, etc. are also classified as non- commercial sources of energy.

Energy input from various sources

Direct sources

The energy input of human labour and a pair of large bullocks (having a body weight of 450 kg) may be assumed to be 1. 96 MJ / man-hr and 14. 05 MJ / pair-hr, respectively. The specific fuel consumption of the mechanical power source (obtained from the test report) can be used to find energy inputs.

Indirect sources

The energy requirement in producing seeds, fertilizers, pesticides, weedicides, etc Energy and Farm Management Agriculture is the most important sector in Indian economy and agriculture is basically an energy conversion industry. The energy use pattern for unit production of crop has varied under different agro climatic zones. The use of energy in crop production depends on the availability of energy sources in particular region and also on the capacity of the farmers. It is therefore, essential to carry out energy analysis of crop production system and to establish optimum energy input at different levels of productivity. Agricultural productivity is proportional to energy input in the form of improved seed, fertilizers, chemicals, irrigation and mechanization including management practices (Dhavan and Mittal,1989; Moulik et al. 1992).

Marathwada being a dryland region, Kharif sorghum, soybean, cotton and rabi sorghum are taken as a major crop in the seasons. Out of these, Kharif and Rabi Sorghum are major crops and is the staple food cultivated on a large scale for food and fodder purpose. The appropriate use of energy input to this crop production could originate from several types of conservation practices. The reduction, elimination or combination of machinery operations will reduce energy input and also may reduce the uses of labour and time (Ozkan et al. 1981). The increase in area under high yielding varieties of various crops has put heavy demand on limited non-renewable energy sources. The energy use for raising various crops has increased significantly (Surendra Singh and Mittal. , 1989).

In development process of mankind energy is playing as key role. Energy is one of the most valuable inputs in production agriculture. It is invested in various forms such as mechanical (farm machines, human labour, animal draft), chemical fertilizer nd bullocks exemplify the category of non-commercial source of energy. Human labour and animals are readily available and can be used as a source (pesticides, herbicides), electrical, etc. The amount of energy used in agricultural production, processing and distribution should be significantly high in order to feed the expanding population and to meet other social and economic goals. Sufficient availability of the right energy and its effective and efficient use are prerequisites for improved agricultural production. It was realized that crop yields and food supplies are directly linked to energy (Stout, 1990). In the developed countries, increase in the crop yields was mainly due to increase in the commercial energy inputs in addition to improved crop varieties (Faidley, 1992).

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Particularly in developing countries, the primary objectives of mechanizing crop production are to reduce human drudgery and to raise the output of farm by either increasing the crop yield or increasing the area under cultivation (Jekayinfa, 2006).

These can only be done by supplementing the traditional energy input i. e. Human labour with substantial investments in farm machinery, irrigation equipment, fertilizers, soil and water conservation practices, weed management practices, etc.

These inputs and methods represent various energies that need to be evaluated so as to ascertain their effectiveness and to know how to conserve them. Energy analysis, therefore, is necessary for efficient management of scarce resources for improved agricultural production. It would identify production practices that are economical and effective. Other benefits of energy analysis are to determine the energy invested in every step of the production process (hence identifying the steps that require least energy inputs), to provide a basis for conservation and to aid in making sound management and policy decisions (Bebendra & Bora, 2008) Human and animal energy is predominately used in most of the farming operations in Vidarbha region, starting from land preparation to harvesting of the crops. Due to much involvement of labour in different farm operations, the cost of production of most of the crops in our country is quite high as compared to developed countries.

Also the unavailability of human power due to migration towards town in peak period accounts more expenditure with less productivity. Human energy account Rs. 125 to 156 for produce the 1 kWh of energy of and for draught animal it is estimated as Rs. 29. 32 per kWh and for the mechanical it is in the range of Rs. 3 to 10. 71 per kWh (Srivastava 2006).

Energy is a critical aspect of a national development process. It is expended in agricultural operation in food processing and transportation, in the production of fertilizers, pesticides, and farm equipments. It is necessary for industrial operations that provide jobs. It is required for cooking, for household lighting and heating, and for the construction and operation of the infrastructure needed for schools, health centres and water supply.

To obtain an understanding of energy matters, it is essential to convert energy rapidly to a common equivalent. The tonne of coal equivalent (t. c. e.) are such a unit and has been adopted by the United Nations (UN) bodies. Since the chemical composition of coal is not a fixed quantity, it is necessary to assume a representative figure. A commonly used value for the t. c. e. is 2. 9 × 109 J or 29 GJ. Electricity is normally quoted in terms of kilowatt hours or units. It is helpful to know that a tonne of coal per year is approximately equivalent to an average power of 1 kW or 1 t. c. e. per year - 1kW.

OBJECTIVES

1. To develop and operationalize the concept of rural development and energy metabolism.
2. To study the farm energy metabolism, as a composite consequent variable, against a set of exogenous causal variables, consisting of socio economic, techno managerial and ecological characters.
3. To study the intra and inter level of relationship and interaction in order to estimate the farm energy metabolism, that has been contributed by a set of exogenous and causal variable.
4. To generate a kind of operational model for creating micro level farm energy policy towards achieving a sustainable rural development.

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