Chapter 2

Theoretical Orientation and Concepts

2.1 Ecology: The Dynamics and Cybernetics

Ecology addresses the full scale of life, from tiny bacteria to processes that span the entire planet. Ecologists study many diverse and complex relations among species, such as predation and pollination. The diversity of life is organized into different habitats, from terrestrial (middle) to aquatic ecosystems.

Figure 2.1 Ecology

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Ecology (from Greek: οἶκος, "house"; -λογία, "study of") is the scientific study of Interactions among organisms and their environment, such as the interactions organisms have with each other and with their abiotic environment. Topics of interest to ecologists include the diversity, distribution, amount (biomass), number (population) of organisms, as well as Competition between them within and among ecosystems. Ecosystems are composed of dynamically interacting parts including organisms, the communities they make up, and the non-living components of their environment. Ecosystem processes, such as primary production, pedogenesis, nutrient cycling, and various niche construction activities, regulate the flux of ***energy and matter*** through an environment. These processes are sustained by organisms with specific life history traits, and the variety of organisms is called biodiversity. Biodiversity, which refers to the varieties of species, genes, and ecosystems, enhances certain ecosystem services.

Ecology is an interdisciplinary field that includes biology and Earth science. The word "ecology" ("Ökologie") was coined in 1866 by the **German scientist Ernst Haeckel** (1834–1919). Ancient Greek philosophers such as Hippocrates and Aristotle laid the foundations of ecology in their studies on natural history. Modern ecology transformed into a more rigorous science in the late 19th century. Evolutionary concepts on adaptation and natural selection became cornerstones of modern ecological theory. Ecology is not synonymous with environment, environmentalism, natural history, or environmental science.

It is closely related to evolutionary biology, genetics, and ethology. An understanding of how biodiversity affects ecological function is an important focus area in ecological studies.

Ecologists seek to explain:

- Life processes, interactions and adaptations
- The movement of **materials and energy through living communities**
- The successional development of ecosystems, and
- The abundance and distribution of organisms and biodiversity in the context of the environment.

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Figure 2.2 Social Ecology of Ghoshalia Village (P.C. by Kabita Mondal)

Ecology is a ***human science*** as well. There are many practical applications of ecology in conservation biology, wetland management, natural resource management (agroecology, agriculture, forestry, agroforestry, fisheries), city planning (urban ecology), community health, economics, basic and applied science, and **human social interaction (human ecology)**. Organisms and resources compose ecosystems which, in turn, maintain biophysical feedback mechanisms that moderate processes acting on living (biotic) and nonliving (abiotic) components of the planet. Ecosystems sustain life-supporting functions and produce natural capital like **biomass production (food, fuel, fiber and medicine)**, the regulation of climate, global biogeochemical cycles, water filtration, soil formation, erosion control, flood protection and many other natural features of scientific, historical, economic, or intrinsic value.

3.1.1 Biosphere: The Surroundings for Functionalities

The largest scale of ecological organization is the biosphere: the total sum of ecosystems on the planet. Ecological relationships regulate the flux of energy, nutrients, and climate all the way up to the planetary scale. For

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example, the dynamic history of the planetary atmosphere's CO_2 and O_2 composition has been affected by the biogenic flux of gases coming from respiration and photosynthesis, with levels fluctuating over time in relation to the ecology and evolution of plants and animals. Ecological theory has also been used to explain self-emergent regulatory phenomena at the planetary scale: for example, the Gaia hypothesis is an example of holism applied in ecological theory. The Gaia hypothesis states that there is an emergent feedback loop generated by the ***metabolism of living organisms*** that maintains the core temperature of the Earth and atmospheric conditions within a narrow self-regulating range of tolerance.

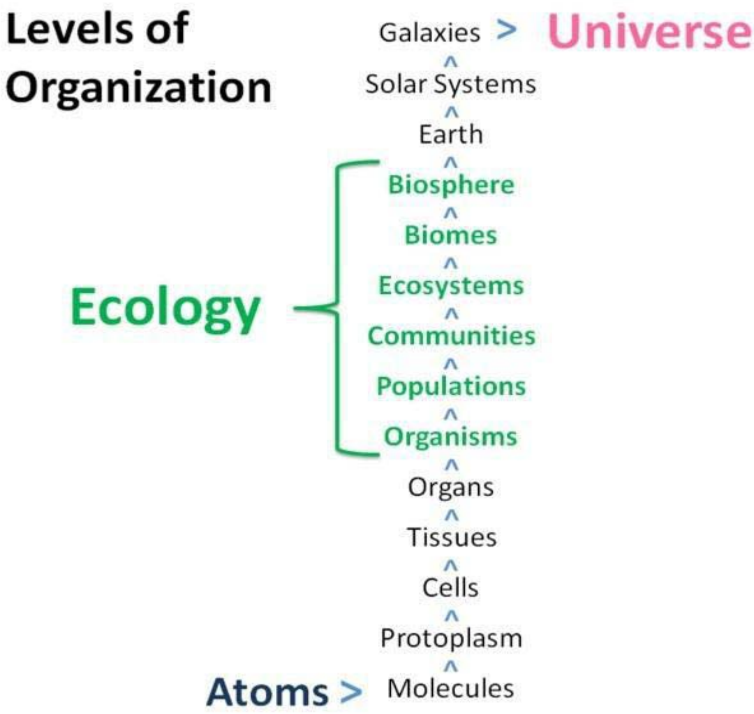

Figure 3.3 The Biosphere.
(Source: http://www.icess.ucsb.edu/)

3.1.2 Social Ecology: The Mentor for Social Function

The notion of social ecology draws from the **Aristotelian concept of eudaimonia** (often translated as flourishing), that property of one's life when

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considered in its whole. That is, the virtues of the good life go beyond any single set of norms or constructs. A modern definition of social ecology understands it as the interactions within the social, institutional, and cultural contexts of people-environment relations that make up well-being. This approach adopts an explicitly systemic approach in focusing on the interdependencies of social systems. Thus, such an approach focuses on the possibility that the foundations of ecological crises can lie in social structures, or that civil war can originate from environmental scarcity, or the multiple cause-and-effect relationships linking SES status and health. These phenomena beg for approaches that are cognizant of system complexity.

At its core, Social Ecology's motivating philosophy is a pragmatic one --the most persistent ills of society (sprawl, malnutrition, deforestation, urban violence, waterborne disease, obesity, housing insecurity, and countless others) seem to resist the prescriptions emerging from uni-disciplinary research. Social ecology often focuses on the centrality of context in understanding these phenomena --context, or place, remains despite the popular wisdom that the globalized world is now everywhere flat.

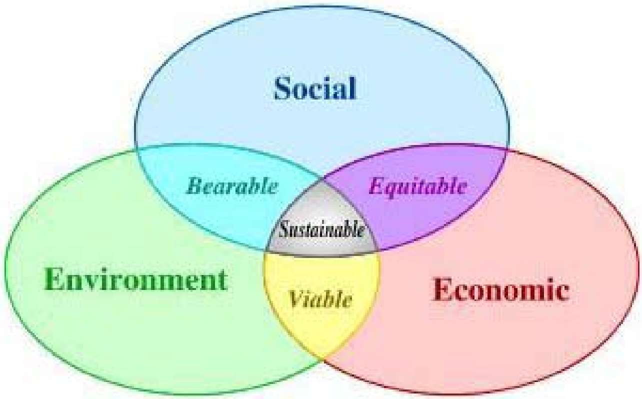

Figure 3.4 Model on Social Ecology

Is social ecology the study of everything? No, but it is a manner of studying things. Thus, it concerns how the different objects of study relate to, bump into, and change each other such that the social phenomenon cannot be attributed to any of its objects. As a noted theorist said, "one must think relationally". Without pretending to be able to model systems comprehensively, one must respect the complexity of integrated systems,

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and this requires a multiplicity of perspectives even to study relatively bounded phenomena.

In order to grasp what social ecology is, it is better to understand what it aims. The founder of social ecology is Murray Bookchin (1921-2006) whose ambition is to revive radical theory that is limited into variations of Neo-Marxism, and is frustrated by decline of feminist challenge and is curious about ecological movement. Although Bookchin strongly criticizes Marxism; both have same aim as to develop a radical social change. Strong critics of Marxism are mostly affected and shaped by Marxism itself (Bernstein 2009: 22). He is not different with his tendency to Trotsky during 1940s, transforms into anarchic-communist in later years and develops his ideas with a dialectical relation to Marxism. Bookchin is raised in red decade of 1930s within workers movement in USA as a foundry worker. Within the framework of critical theory, he tries to generate a new radical theory which is against all forms of dominations; considering not only workers but also women, poor, nature, ethnical and religious minorities, in fact all ―others.

3.1.3 Nature versus Environment: The Endless Interactions

The unique and least understood point of social ecology is the way it connects society with nature. Nature and/or environment are mostly conceptualized out of society. Hence, it is necessary to explain what nature/environment is according to social ecology.

Social ecology criticizes the human-nature duality and mastery of nature hiding patriarchy while Bauman defines the power of humans as freedom against nature (2006:162). Nature is neither a natural resource deposit nor a pastoral landscape. Nature is not environment as one of ―the others‖ of patriarchy, but it is beyond environment which is a pragmatic field of engineering applications and is a cumulative history of organic evolution of species and processes (Bookchin 1999c:48). Nature is an endless process of evolution which has a direction, tendency from simple to complex, ――a nisus exists that leads from passive reaction to active interaction, from intentionality to choice, and finally to conceptual thought and foresight‖ (Bookchin 1994:41). It has a potential towards freedom and consciousness. Deep ecologist Robyn Eckersley is against the evolutionary 17 understanding that ecocentrics believe in, i.e. letting all living things in their

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way and do not purport to know if there is a direction (Eckersley, 1992:156, cited in Dobson, 2007:48).This is a good example of anti-reason position of deep ecology that Bookchin accuses (1996b: 9). Bookchin conceptualizes nature as an objective world within causality, differentiation and actualization of the evolution process. The organic evolution of cumulative nature can be understood as neither inductive nor deductive but deductive reasoning that implies a development potential towards growth, differentiation, maturation and wholeness (Harrill 1999: 47). Bookchin conceptualizes nature within dialectic naturalism and uses a dialectical reasoning that is different from the conventional reasoning which claims A=A. Conventional reasoning is linear, mechanical and has a progressive history having independent phases. Dialectical reasoning looks for an organic nature, which has a developmental theme with consecutive periods. Although Bookchin separates his reasoning from the conventional one, Clark (2008:97) criticizes his depiction of the construction of a new revolutionary ideology and his use of conventional reasoning in the name of dialectics (Clark2008:88).

3.1.4 Social Ecological Systems: The New Age Extension Structuralism

Finally, to summarize the main characteristics exposed below, we purpose to use the concept of social-ecological system, as a multidimensional system where natural and social spaces do not have a sharp and immobile border. We use the framework proposed by Berkes *et. al*. (1998). In this flow diagram Ecosystem, People and Technology, Local Knowledge and Property Right has been shown to have bidirectional relationship with pattern of interactions, sustainable society and knowledge and Entitlement dynamics.

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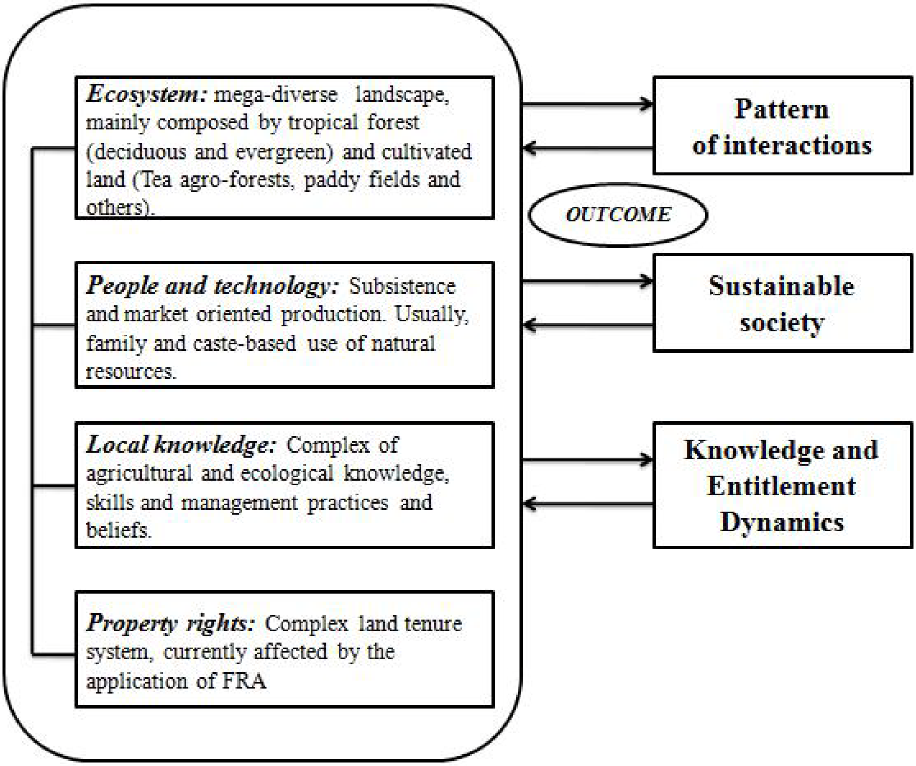

Figure 3.5: The Dynamics of Social Ecology: (Berkers, 1998)

The social ecology as a system is supported by three basic things: Physical complex, Biological complex, Social complex. While the physical complex is functionally attuned to two basic components, the matter and energy, biological complex is being characterized with basic characters viz. the genetics and metabolism. Social complex has epitomized over two complexes mentioned earlier and has been unique by two basic characters one is intelligence and other is motivation.

The social ecology (SE) has been evolved and configured through a didactic transformation of both the physical and biological complexes for example while poverty is arraying entropy to any ecology, it is being simultaneously characterized by soil fertilizers as well as availability of good seed. The other examples are access to water has become a social issue contributed by physical existence of water resources and its quality as determined by count of cumuliform.

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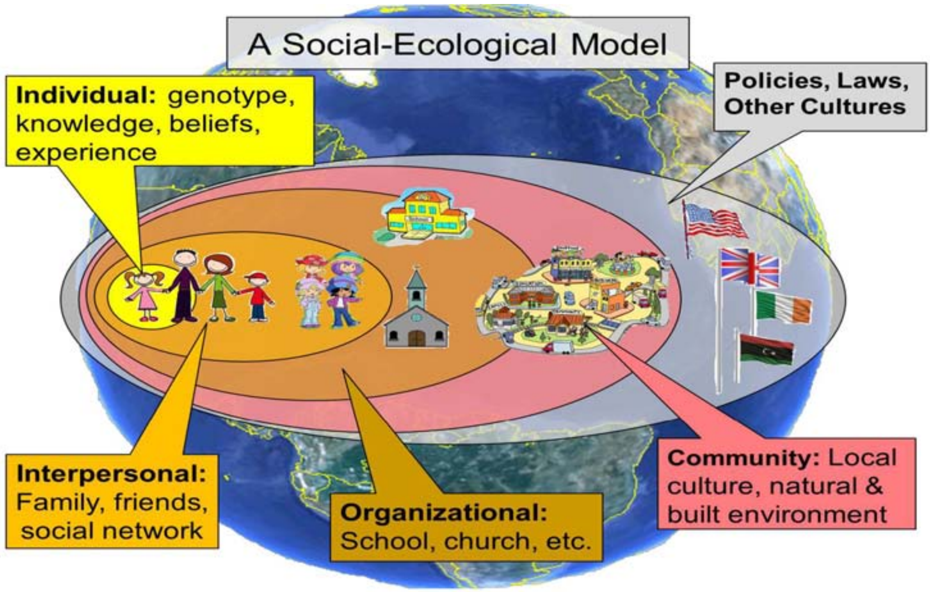

Figure 3.6: A Social-Ecological Model,
Source: Boston University, School Of Public Health

Social Ecology thus, has become an operational exposition of biodynamic as well as ***energy metabolism***. So, these two, energy metabolism and bio-dynamics i.e. flow of energy and its exponential configuration in the form of motivation and knowledge keeps nibbling along and across space of society to characterize the Social ecology and its functionality. The technology, a combination of techniques and choices to meet desires, is basically a means to organize energy metabolisms, sometimes from nature to society and at other times society to nature and vis a vis. So, the Social ecology is basically a study of interactive and inter related counts of energy and character of energy flow governed by human drive and motivation and human intelligence that begets devices and innovation, defense and aggression, pre-creation and destruction.

3.2 Energy: The Prime Mover

Energy is involved in all life cycles, and it is essential in agriculture as much as in all other productive activities. An elementary food chain already shows the need for energy: crops need energy from solar radiation to grow, harvesting needs energy from the human body in work, and cooking needs energy from biomass in a fire. The food, in its turn, provides the human body with energy.

Intensifying food production for higher output per hectare, and any other advancement in agricultural production, implies additional operations which all require energy. For instance: land preparation and cultivation, fertilizing, irrigation, transport, and processing of crops. In order to support these operations, tools and equipment are used, the production of which also requires energy (in sawmills, metallurgical processes, workshops and factories, etc.).

Major changes in agriculture, like mechanization and what is called the "green revolution", imply major changes with respect to energy. Mechanization means a change of energy sources, and often a net increase of the use of energy. The green revolution has provided us with high yield varieties. But these could also be called low residue varieties (i.e. per unit of crop). And it is exactly the residue which matters as an energy source for large groups of rural populations.

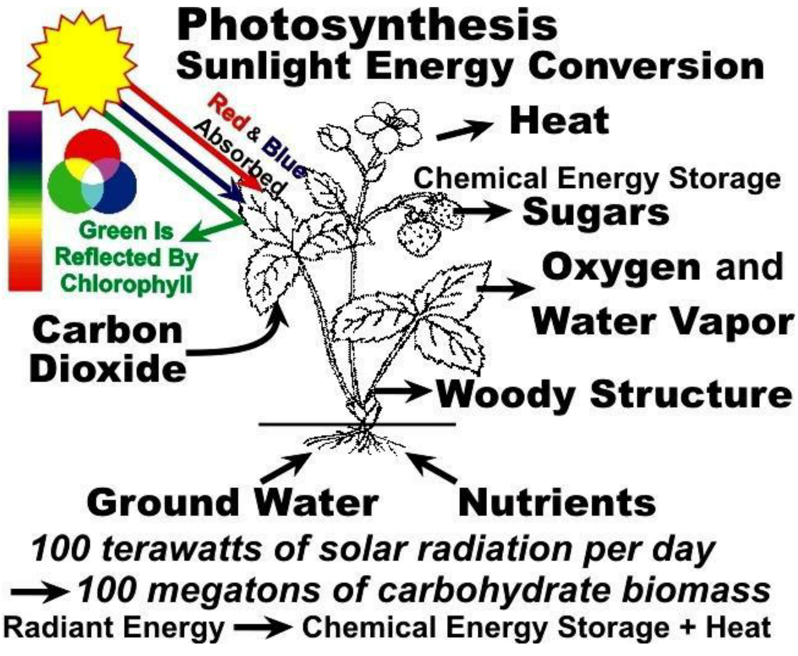

Figure 3.7: Energy conversions in plant (Source: wikipedia)

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Other sectors of rural life require energy as well. The provision of shelter, space heating, water lifting, and the construction of roads, schools and hospitals, are examples. Furthermore, social life needs energy for lighting, entertainment, communication, etc. We observe that development often implies additional energy, and also different forms of energy, like electricity.

Energy is a scarce resource, at least for some groups of people in some places and, maybe, for the world as a whole. A rational use of energy is then necessary for economic and environmental reasons. This applies to agriculture as much as to any other sector of the economy. A key to the rational use of energy is the understanding of the role of energy. The following sections aim to help understand energy in agriculture and rural development. It should help communication between agricultural planners and energy specialists.

3.2.1 Forms of energy

Energy can exist in various forms. Examples are:

- Radiation energy: the radiation from the sun contains energy, and also the radiation from a light or a fire. More solar energy is available when the radiation is more intense and when it is collected over a larger area. Light is the visible part of radiation;
- Chemical energy: wood and oil contain energy in a chemical form. The same is true for all other material that can burn. The content of chemical energy is larger the larger the heating value (calorific value) of the material is and, of course, the more material we have. Also animate energy (delivered by bodies of human beings and animals) is, in essence, chemical energy. Furthermore, batteries contain chemical energy;
- Potential energy: this is, for example, the energy of a water reservoir at a certain height. The water has the potential to fall, and therefore contains a certain amount of energy. More potential energy is available when there is more water and when it is at a higher height;
- Kinetic energy: this is energy of movement, as in wind or in a water stream. The faster the stream flows and the more water it has the more

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energy it can deliver. Similarly, more wind energy is available at higher wind speeds, and more of it can be tapped by bigger windmill rotors;

- Thermal energy or heat: this is indicated by temperature. The higher the temperature, the more energy is present in the form of heat. Also, a larger body contains more heat;

- Mechanical energy, or rotational energy, also called shaft power: this is the energy of *a* rotating shaft. The amount of energy available depends on the flywheel of the shaft, i.e.:. on the power which makes the shaft rotate;

- Electrical energy: a dynamo or generator and a battery can deliver electrical energy. The higher the voltage and the current, the more electrical energy is made available.

Note that sometimes by "energy form" an energy source, or even a particular fuel (like oil or coal), is meant.

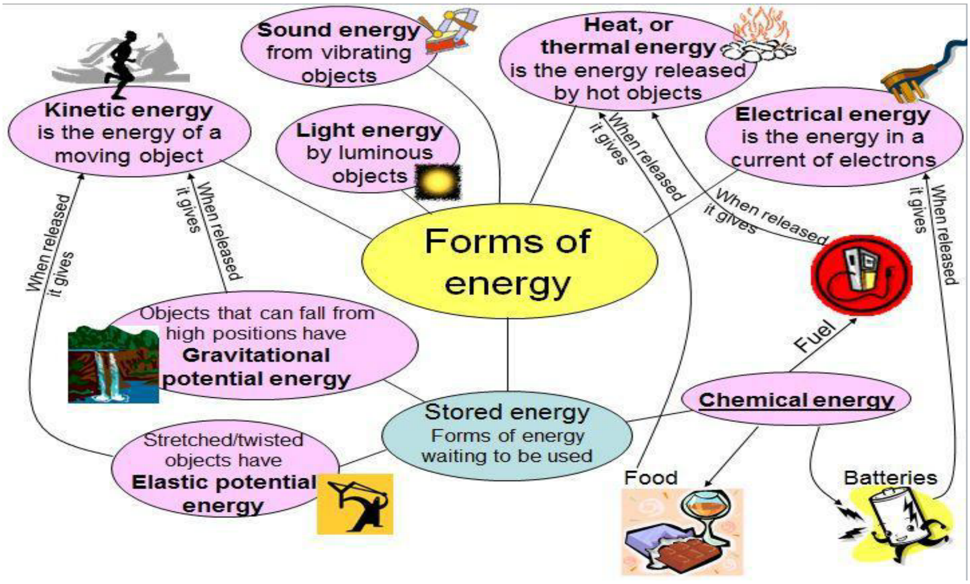

Figure 3.8: Different Forms of Energy, Source: Alessios Blog

3.2.2 Energy conversion: The Basics of Metabolism

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"Utilizing" energy always means converting energy from one form into another. For instance, in space heating, we utilize energy, that is, we convert chemical energy of wood into heat. Or, in lift irrigation, a diesel engine converts chemical energy of oil into mechanical energy for powering the shaft of a pump which, in its turn, converts shaft power into potential energy of water (i.e. bringing the water to a higher height).

"Generating" energy also means converting energy from one form into another. We can say that a diesel engine generates energy, which means that the engine converts chemical energy of oil into mechanical energy. Also, a wind turbine generates energy, which means it converts kinetic energy from wind into mechanical energy. And a solar photovoltaic cell generates energy by converting radiation energy into electricity.

The generation of energy, in fact, deals with a ***source of energy***, whereas the utilization of energy serves an end-use of energy. In between, the energy can flow through a number of conversion steps. The words "generation" and "utilization" are a little confusing because, in fact, no energy can be created or destroyed. All we can do is transform or convert energy from one form into another. In generating energy, we make energy available from a source, by converting it into another form. In utilizing energy, we also convert energy, often from some intermediate form into a useful form. In all conversions, we find that part of the energy is lost. This does not mean that it is destroyed, but rather that it is lost for our purposes, through dissipation in the form of heat or otherwise (cf. figure 1).

Table 3.1: Different forms of Energy and Its Efficiency

Energy Form	Energy Converter	Efficiency
chemical energy		
	diesel engine	30%
mechanical energy		
	Generator	80%

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Electricity		
	electric motor	80%
mechanical energy		
	water pump	60%
potential energy		
efficiency of the system = 30% x 80% x 80%x 60% = 12%		

Energy conversions can take place from any one form of energy into almost any other form of energy. (Some conversions have no practical value.) Which conversion is desired depends on our purposes. For instance, for power generation, we convert potential energy from hydro resources into mechanical energy, whereas, in water pumping for lift irrigation, we do the reverse. And, with photovoltaic cells, we convert radiation energy into electricity, whereas with light bulbs we do the reverse.

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Table 3.2 Energy Conversion Matrix

Energy Conversion Matrix

FROM ⇓ TO ⇒	Thermal	Mechanical	Acoustical	Chemical	Electrical & Magnetic	Electromagnetic Radiation	Nuclear	Elastic	Gravitational
Thermal	• Heat exchangers • Thermal conduction	• Steam turbine • Heat engines • Wind • Radiometer		• Endothermic reaction • "Cold packs"	• Thermo-electric effect • Thermionic emission	• Thermocouple • Incandescence	•Thermionic emission		• Convection • Hot air balloon • Popcorn
Mechanical	• Refrigerator • Heat pump • Brakes	• Gear box			• Wind turbine • Generator • Microphone	• X-ray tube		• Wishbone • Inflating a balloon	• Pendelum • B-ball pop fly
Chemical	• Furnace • Combustion • Exothermic reaction • "Hot packs"	• Combustion engines • Muscle action • Dynamite	• Chemical explosion	• Glycolysis • ADP to ATP • AMP to ADP	• Fuel cell • Chemical battery	• Bio - luminescence • Chemical lasers • Fireflies • Glowsticks		• Combustion expanding gas	• Rocket
Electrical & Magnetic	• Electric heater • Toaster	• Motor • Thunder		• Electrolysis • Electro-plating • Rechargeable batteries	• Transformer	• Lamp • LED • Radio broadcast		• Electrostriction • Magneto-striction	• Elevator
Electromagnetic Radiation	• Solar collector • Microwave oven	• Photoelectric effect		• Plants • Photography • Sunburn	• Solar cell	• Photo-luminescence			• Microwave popcorn
Nuclear	• Nuclear bomb • Fission reactor	• Nuclear bomb	• Nuclear bomb	• Nuclear bomb	• Nuclear bomb • Nuclear generator	• Nuclear bomb • Stars	• Nuclear bomb • Breeder reactor		• Nuclear propulsion
Elastic	• Compression of gas refrigerator	• Spring driven wristwatch • Bow & arrow			• Peizo-electric effect	• Peizo-luminescence		• Newton's cradle	• Trampoline • Toaster
Gravitational	• Contraction of a protostar	• Flowing water • Pendelum			• Hydropower		• Formation of a neutron star	• diving board	• One period of satellite orbit

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3.2.3 Energy and Power: The Input-Output Transformation

Energy and power are related but totally different concepts. A tank of petrol contains a certain amount of energy. We can combust this petrol in a certain time period, that is, we convert the energy of the petrol into mechanical energy, perhaps to power a car. The power is the energy produced per unit of time. The combustion process can be fast or slow. In the case of faster combustion, more power is produced. Obviously, the tank will be empty sooner in the case of high power production than in the case of low power production. If power is energy per time unit, then energy is power multiplied by time period. For Instance, if oxygen delivers a certain amount of power, then after a certain time period it will have delivered a certain amount of energy, i.e. the power times the time period.

$$power = \frac{energy}{time}$$

$$energy = power \times time$$

The same principle applies to all other energy conversions, whether for energy generation or for energy utilization. This implies that we characterize energy resources in units of energy (the amount of energy they contain), and energy conversion devices in units of power (the amount of power they can produce or consume).

A closer look at the list of forms of energy in section 2 reveals that some of them have actually been described in terms of power (radiation, kinetic, mechanical and electrical energy). They become energy quantities when we specify the time period during which the power is delivered, and multiply the power by this time period. Also in section 2, the quantities of chemical, potential and thermal energy become power quantities when we divide them by a time period during which the energy quantity is being converted.

3.2.4 Energy sources

Energy sources partly correspond to the energy forms of section 2, but not entirely.

The following energy sources can be relevant for rural areas.

- Biomass. We distinguish between: woody biomass (stems, branches, shrubs, hedges, twigs), non-woody biomass (stalks, leaves, grass, etc.), and crop residues (biogases, husks, stalks, shells, cobs, etc.). The energy

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is converted through combustion (burning), gasification (transformation into gas) or anaerobic digestion (biogas production). Combustion and gasification ideally require dry biomass, whereas anaerobic digestion can very well take wet biomass. Fuel preparations can include chopping, mixing, drying, carbonizing (i.e. charcoal making) and briquetting (i.e. densification of residues of crops and other biomass).

- Dung from animals, and human excreta. The energy is converted through direct combustion or through anaerobic digestion.
- Animate energy. This is the energy which can be delivered by human beings and animals by doing work.
- Solar radiation, i.e. energy from the sun. We distinguish between direct beam radiation and diffuse (reflected) radiation. Direct radiation is only collected when the collector faces the sun. Diffuse radiation is less intense, but comes from all directions, and is also present on a cloudy day. Solar energy can be converted through thermal solar devices (generating heat) or through photovoltaic cells (generating electricity). Direct beam solar devices (whether thermal or photovoltaic) would need a tracking mechanism to have the device continuously facing the sun.
- Hydro resources, i.e. energy from water reservoirs and streams. We distinguish between: lakes with storage dams, natural heads (waterfalls), weirs, and run-of-river systems. Hydro energy can be converted by waterwheels or hydro turbines.
- Wind energy, i.e. energy from wind. Wind machines can be designed either for electricity generating or for water lifting (for irrigation and drinking water).
- Fossil fuels, like coal, oil and natural gas. Unlike the previous energy sources, the fossil energy sources are non-renewable.
- Geothermal energy, that is, the energy contained in the form of heat in the earth. A distinction is made between tectonic plates (in volcanic areas) and geopressed reservoirs (could be anywhere). Geothermal energy is, strictly speaking, non-renewable, but the amount of heat in the earth is so large that for practical reasons geothermal energy is generally ranked with the renewable. Geothermal energy can only be

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tapped at places where high earth temperatures come close to the earth's surface.

This list only contains primary energy sources. These are the energy sources which are present in our natural environment. Secondary energy sources, like batteries, are not included here.

We observe that the primary energy sources are not the ultimate sources of energy. For instance, animate energy comes from biomass, whereas biomass energy ultimately comes from the sun.

Table 3.3: Transformation of Energy

Action	Energy transformation	Outcome
Sun shines on plants	Light energy from the sun is converted to chemical energy via photosynthesis	Plants store chemical energy
People eat food	Stored chemical energy is added to our bodies	People store chemical energy
Food is metabolized	Chemical energy becomes available to muscles, which convert it to kinetic energy	People can move their body parts
A person turns the stick of a wind-up	Kinetic energy gets converted into elastic energy in the rubber band	The rubber band stores potential energy, for later use
The person releases the wind-up	The elastic energy of the rubber band gets converted into kinetic energy of the wind-up	The wind-up travels across the floor
The wind-up slows down	The kinetic energy is gradually transformed into heat energy, due to friction between the wind-up, and the floor and air	The wind-up eventually stops. The floor, wind-up and surrounding air all heat up very slightly.

3.2.5 Energy flow In the System

As we have seen, generating and utilizing energy means converting energy from one form into another. Often, intermediate steps are implied. The energy flows through a number of forms, as well as conversion steps, between the source and the end-use. The costs increase accordingly. We distinguish between primary, secondary, final and useful energy.

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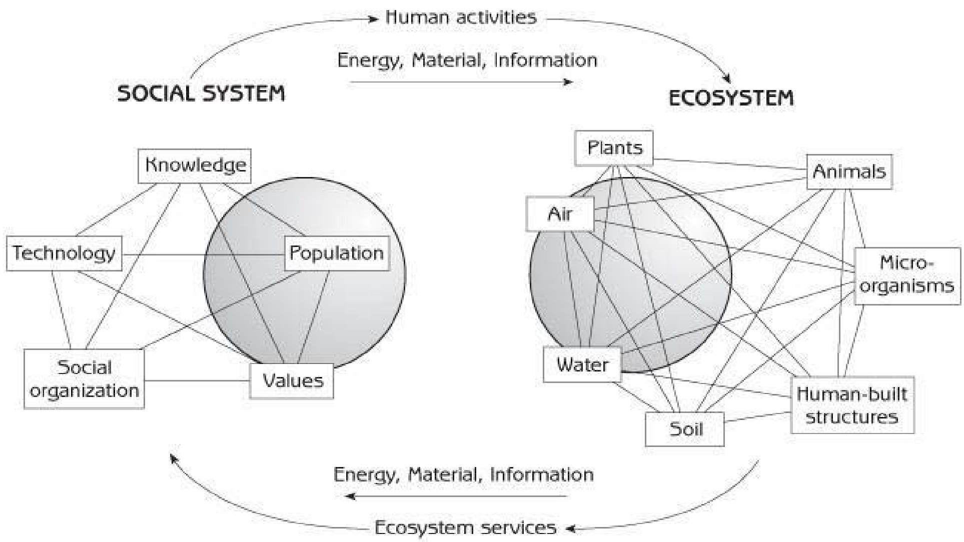

Figure 3.9: Energy Flows between Ecosystem and Social System

An example is an energy flow which is related to charcoal. Here, the primary energy form is wood. The wood is converted into charcoal in a charcoal kiln. Charcoal is the secondary form of energy, and it is transported to the consumer. What the consumer buys at the market place is charcoal, and this is called final energy. The consumer eventually converts the charcoal into heat for cooking. The heat is the useful energy.

Table 3.4: Examples of Energy Sources

Energy	**Technology**	**Examples**
Primary		coal, wood, hydro, dung, oil, etc.
	Conversion	power plant, kiln, refinery, digester
Secondary		refined oil, electricity, biogas
	transport/transmission	trucks, pipes, wires

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Final		diesel oil, charcoal, electricity, biogas
	Conversion	motors, heaters, stoves
Useful		shaft power, heat

Another example of an energy flow is: primary energy in the form of a hydro resource, secondary energy in the form of electricity at the hydro power station, final energy in the form of electricity at a saw mill, and useful energy in the form of shaft power for sawing.Energy flow is represented in the diagram in the table 4. It refers to the following terminology.

Primary energy is the energy as it is available in the natural environment, i.e. the primary source of energy.

Secondary energy is the energy ready for transport or transmission.

Final energy is the energy which the consumer buys or receives.

Useful energy is the energy which is an input in an end-use application.

3.2.6 Equivalence and Replacement of Energy Forms

In principle, the energy content of a fuel is known when the fuel Is specified. For chemical energy, the energy content is given as the calorific value, or heating value, of the fuel. The unit can be MJ/kg. And so we can compare different fuels with different energy contents. We can work out how much of one fuel is equivalent to a quantity of another fuel. For quantifying energy resources, we sometimes use coal as a reference, and the unit for comparison is then ton-of-coal-equivalent (tee). A certain amount of an energy resource is then characterized by its tee. That is, the resource has an energy content equivalent to so many tees.

Alternatively, we can express the energy equivalent of a resource in units of ton-of-oil-equivalent (toe), or in barrels-of-oil-equivalent (boe). Table 7 gives the equivalent values of some fuels.

3.2.7 Energy Balance

An energy balance of a region (or country) is a set of relationships accounting for all energy which is produced, transformed and consumed in a certain period. This basic equation of an energy balance is:

Source + Import = Export + Variation of stock + Use + Loss

Consider a primary energy balance. Sources are the local (or national) primary energy sources, like coal, hydro, biomass, animate, etc. Imports are energy sources which come from outside the region (or country). Exports go to other regions (or countries). Variations of stock are reductions of stocks (like of forests, coal, etc.), and storage. Use can be specified sectoral, or by energy form, or by end-use, etc., as required. Losses are technical losses and administrative losses:

- Technical losses are due to conversions and transport or transmission
- Administrative losses are due to non-registered consumptions.

An energy balance usually refers to a year, and can be made for consecutive years to show time variations.

Energy balances can be aggregate, or very detailed, depending on their functions. They can also be elaborate, showing all sorts of structural relationships between energy production and consumption, and specifying various Intermediate forms of energy.

An energy balance can also be set up for a village, a household, a farm, or an agricultural unit. It will show the inputs of energy in various forms, the end-use energy, and the losses. Specific for energy balances of agricultural systems is the fact that parts of the outputs of the system are, at the same time, energy Inputs into the system (agricultural residues, dung).

Energy balances have to be built up from surveys of what is actually going on. This requires energy resource surveys, and energy consumption surveys, as well as more technical energy audits. Section 12 goes into some aspects of energy auditing.

Energy balances provide overviews, which serve as tools for analyzing current and projected energy positions. The overviews can him useful for purposes of resource management, or for indicating options in energy saving, or for policies of energy redistribution, etc. However, care must be taken not to single out energy from other economic goods. That means that

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an energy balance should not be taken as our ultimate guide for action. Energy data are to be translated into economic terms, for a further analysis of options for action. And, of course, socio-cultural and environmental aspects are equally important.

3.2.8 Economics of Energy in Agriculture and Rural Development

Economics is generally defined as the study of how individuals and society choose, with or without the use of money, to employ scarce productive resources to produce goods and services over time and distribute them for consumption now and in the future among various competing ends of people and groups in society. Economics is a useful applied social science discipline for identification and analysis of the economic efficiency and income distribution trade-offs embodied in alternative solutions to important societal problems. This chapter focuses specifically on the choices related to the energy aspects in agriculture and rural development projects.

Prior to 1800, the world population was controlled primarily by famine and pestilence. Man was generally dependent on draft animals and wood for tillage, transportation and energy. Since 1800, the world population and energy use have increased dramatically. The discovery of fossil fuels and modern technology has greatly facilitated economic development. Increased energy efficiency, ease of attainment and a disregard for its finiteness made fossil fuels cheap energy sources that rapidly replaced previous biomass sources. What now seems evident is that the fossil fuel era will only be a brief period in the history of mankind - a "blip" on the scale of time.

The traditional fossil fuel energy sources are non-renewable and exhaustible, or stock resources that do not increase in physical quantity over time* Some, such as coal, are not significantly affected by natural deterioration. Others, such as oil and gas in cases of seepage and blow off, can be significantly affected by natural deterioration. However, concepts such as exhaustible and inexhaustible have meaning only in an economic context. Long before a given resource is physically used up or even appreciably diminished, it may be exhausted in

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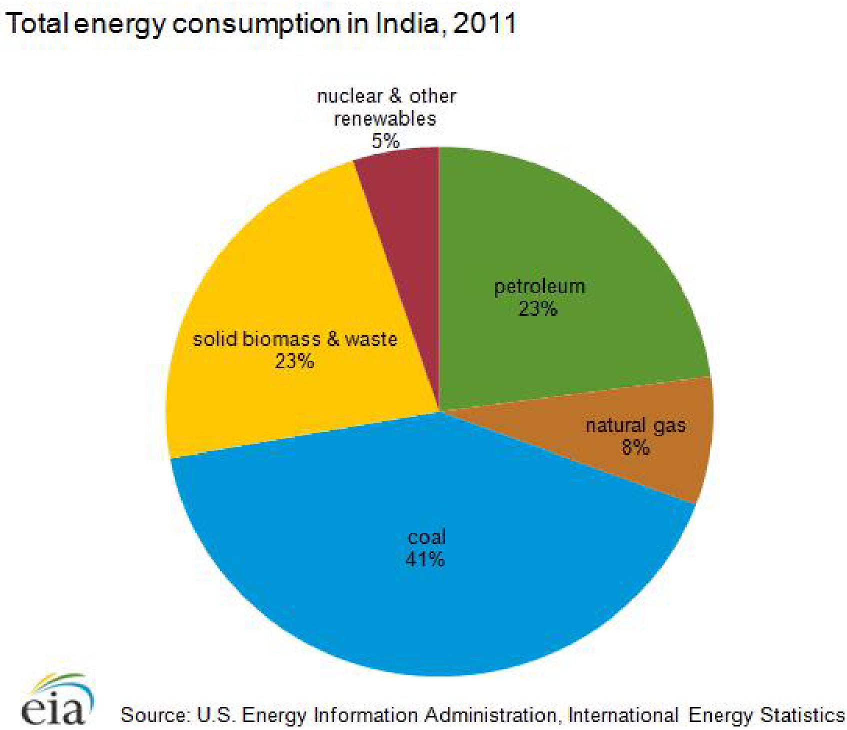

Figure 3.10 Total Energy Consumption in India

the sense that further utilization is discontinued (due to its relative price or cost) in spite of continuing human wants. Alternatively, a resource may be Inexhaustible in the sense that utilization continues indefinitely, even though it is relatively limited in physical quantity compared with other resources.

In addition to supply limitations, there are some fundamental questions being raised relative to appropriate pricing of finite resources. It is argued Chat a combination of political expediency and the private market's inability to price external effects and non-renewable resources has created artificially cheap energy sources and minimal incentives for conservation, at least in some countries, leading to the substitution of high energy, capital intensive structures for labour. The failure of the "free" market to reflect full social costs from such externalities as oil spills, air pollution and congestion from automobiles, balance of payment deficits, and the potential disruptive

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economic and national security costs of an oil embargo are frequently cited reasons for higher gasoline and other energy taxes. Higher taxes on energy, particularly gasoline, may sometimes be a necessary condition, but rarely a sufficient condition for optimal energy use.

Boulding (1968) argues that the "spaceship" earth requires some revised economic principles from conventional economics, i.e. in the closed economy; throughput (production and consumption) is not a measure of success but rather something to be minimized. Economics, like biology, should evolve towards a greater consideration of the environment and understanding of the first and second laws of thermodynamics. The first law suggests that waste disposal is an integral part of production and consumption processes in energy as well as other areas. The second law supports the increased use of flow energy resources (e.g. biomass) and the development of more entropy-efficient technologies.

3.2.9 Energy Theory of Value

Substantial methodological disagreement exists between most economists and the majority of physical and biological scientists involved in analysis of energy systems. The controversy is based primarily on quite different methods of accounting for or assigning values to energy inputs and outputs. The physical and biological science approach assigns an energy value in Joules, BTUs or kilocalories to both direct and indirect energy inputs and outputs in comparing the energy efficiency of alternative systems. This methodology is predicated primarily on the concern for the finite nature of fossil fuels (upon which industrialized societies have become heavily dependent) and their rates of depletion. Ulf Renborg (1979), a Swedish agricultural economist, describes in detail the development of this methodological approach in the case of agricultural biomass. Advocates for this method of energy accounting essentially distrust the measure of relative value provided by prices formed in markets or even by legislative intervention in markets (political shadow pricing or administered prices) for that matter.

Economists may see some similarities between this "energy theory of value" and the historical labour theory of value and make the same kind of criticism as, for example. Professor Samuelson ,(1964) "that a simple labour theory of value will lead to incorrect and inefficient use of both labour and non-labour resources in even the most perfect socialist society. So long as any economic resource is limited in quantity, i.e., scarce rather than free (market economies will and) socialist planners must give it a price and charge a rent for its use".

Criticism of energy analysis based on a simple "energy theory of value" does not mean that it is without utility or that market or politically-determined economic measures of energy value are without fault. Energy analysis is useful in describing the flow of energy resources (particularly non-renewable) through a choice set of agricultural and rural development projects or of comparing the net energy balance of alternative projects. Market or even politically-determined prices for energy may understate such factors as technological externalities, national security and considerations for future generations which may require shadow pricing by the analyst[1]. However, a simple energy theory of value does not explicitly consider these factors either. In fact, it does not contain any other consumer preference than saving finite energy. Webb and Pearce (1975) point out that this "introduces the idea that energy as a constraint on economic activity is more important than any other constraint". Thus, policies or options with low energy input may have high total resource costs.

Bishop and Heberlein (1979) argue that the willingness to pay for property rights held by others may be considerably less than the minimum level of compensation that property rights holders find acceptable. Specifically, the efficiency and income distribution consequences of a given policy or programme regarding energy options are dependent on who holds the property rights of concern.

3.2.10 Environmental and Social Impact

The environmental impact statement (EIS) has been primarily associated with increased environmental pollution and awareness in many countries. The EIS is Intended as a supplement to the typical cost-benefit analysis for projects that have potential environmental impacts that cannot be easily monetized. Specific to energy conversion projects, Table 1 is a modified version of a list of potential environmental impacts developed at the East-West Centre of Hawaii.

Table 3.5: Some Environmental Impacts of Energy Conversion

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		y	**l of Life**	**tal Services**
Exploration				
Oil/gas	Accidents	-	Invasion of wilderness	- -
Production				
Coal mining	Accidents, black lung	Loss of farmland, subsidence	Use of aboriginal- Defaced landscape lands	Acid draining
Offshore oil	Accidents	-	Oil on beaches	Oil as a biocide
Hydroelectric dam	Dam collapse	Loss of farmland	Displacement wil Loss of d rivers of residents	Fish passage, wildlife breeding grounds
Micro hydro	-	-	-	-
Processing				
Oil refining	Air/disease	Air crops	Smells, visibility	Pollution of estuaries
Shale processing	Air/disease	Water consumption	Waste piles	Water pollution
Conversion				
Coal power	Air/disease	Air/crops,	Noise, visibility	Acid rain,

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plant		building		CO_2 particles/climate
Fuel wood plantation				Particulates and respiratory impacts
Biogas	-	-	Odor	-
Transportation				
Oil tanker	Fire	Fire, collision	Oil on beaches	Oil as biocide
Electrical transmission	Electrocution	Restriction on land use	Unsightly towers	
Consumption				
Automobile	Air/disease	Air/crops	Suburbanization Noise, visibility	Paved environment, heat/climate

Source: Adapted from John P. Holdren, "Energy Resources." in William W. Murdoch (ed.). Environment (Sunderland, Mass.: Sinamer Associates, 1975).

The check list type information in Table 6 is probably easier to develop for assessment of physical environmental impacts than for social impact assessment. The latter deals with impacts on such things as social infrastructure or institutions, behaviour norms, values, familial and friendship patterns, feelings of alienation, local autonomy and cultural artifacts.

It is obvious that the foregoing environmental and social impacts lack a single common denominator (similar to a monetary unit in economic analysis) for measurement. One approach has been to develop indices to scale the relative importance or uniqueness of various attributes of the natural environment and loss of community by the human population impacted by various types of projects. These and other measures of environmental and social factors become dimensions (some would say of a "social welfare function") or separate accounts in addition to financial and economic efficiency and the distribution of financial rewards to be compared by the appropriate decision-making group(s).

The important point is that there is no common denominator for the analyst to aggregate economic efficiency, income distribution, environmental and social impacts and they thus become multiple criteria for the evaluation of the energy aspects of agricultural and rural development projects. (REFERENCE * by F.J. Hitzhusen Professor The Ohio State University)

3.2.11 Comparison of Energy Alternatives for Small-scale Farming

This illustrate the overall logical framework and the specific calculating methods employed in choosing among alternative sources for rural energy supply, sizing of systems and predicting their viability under a range of prospective economic and field conditions. In showing how quite different technologies can be compared, the farm and market data have been constructed as a composite of cases. Consistency of assumptions on basic economic and environmental parameters has been checked and where necessary imposed. But it is to be stressed that conditions in any new real situation may vary widely. No general conclusions are implied by these illustrative calculations, as to the relative feasibility of the technologies examined.

The problem is to determine whether any of several energy supply technologies can be financially and/or economically viable, and to choose among them the best single- or combined-technology system for local conditions. The general approach to solution is first to examine the viability of a base case constructed under a set of conditions judged initially to be most probable. Then tests are made to see how this predicted outcome may change if natural and market conditions, or the management of the farm enterprise itself, are not as foreseen: so-called "sensitivity analysis".

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The base case is a hypothetical village of 500 persons, situated in a semi-arid area of 600 mm annual rainfall, 500 mm of which occurs during the primary crop season. The primary output to be provided is irrigation water, and windmills or small diesel pumps on individual farms would perform only this function. Village-scale central plants, either diesel or wood-fired steam, could also provide off-peak surplus energy for food processing as well as a community service center, but still no allowance is made for electrification of individual households.

For the base case, it is assumed that there is not an active hire-labor market, so that the farm size is determined by the area which can be tended under irrigation by the members of a single household. Technical, financial and economic calculations must be performed:

Technical calculations required for a new project include -

- Estimation of irrigation water requirements on the basis of local soil and climatic conditions, and the water-use physiology of crops which are marketable and/or acceptable for on-farm household consumption. Both the season total and its periodicity are needed.
- Estimation of irrigation power requirements on the basis of local surface or ground water conditions, and the water requirements.
- Plant sizing estimation on *the* basis of the power requirements, and the intensity of available solar, wind or other noncommercial energy supplies, for technologies using them.

Financial calculations correspond to the farm and project budget sheets, testing viability on the basis of purchased input costs and marketed product incomes. Economic calculations are distinguished by an attempt to include also the values of non-market costs and benefits.

3.3 System

A system is a complex whole comprising of components having integration and interaction towards achieving a system goal.

3.3.1 Types of System Based On Purpose

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There are four basic types of system depending on whether the parts and the whole can display choice, and therefore be purposeful.

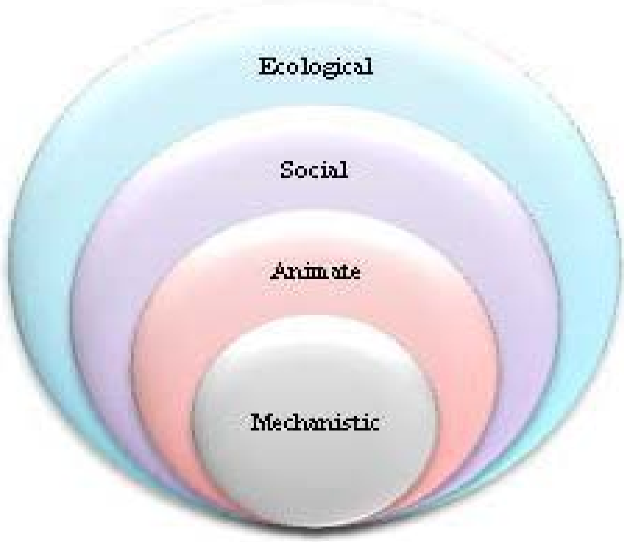

Figure 3.11 Types of system based on purpose (www.acasa.upen.edu/home2.htm)

Table 3.6: Types of System based on Purpose.

Types of System Model	Parts	Whole	Example
Mechanistic	No choice	No choice	Machines
Animate	No choice	No choice	Persons
Social	Choice	Choice	Corporation
Ecological	Choice	No Choice	Nature

These types form a hierarchy with ecological systems the highest type. All but mechanistic systems can incorporate as parts other system of the

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same or a lower type, but not a higher type; for example, social system (e.g., Society) may incorporate animate systems (People) and mechanistic system (Machines), but a mechanistic system cannot incorporate either an animate or social system. Ecological system can incorporate system of all other types. Only animate and social systems can be said to be purposeful.

Systems or their parts are purposeful if, by their choices, they can produce (a) the same outcome in different ways in the same environment and (b) different outcomes in the same and different environments.

3.3.1.1 Mechanistic System

Mechanistic systems and their parts have no purposes of their own, but their essential parts make possible the functioning of the whole. All mechanisms are mechanistic system. Plants are also. Clocks are common examples of such system; they operate with a regularity dictated by their internal structure and the causal laws of nature. Neither the whole nor the parts of a clock display choice, but they have functions. Similarly, an automobile is a mechanical system that has no purpose of its own but serves its driver"s and passenger" purpose. In addition, an automobile"s fuel pump (a mechanical system) has the function of supplying its fuel injector or carburetor with fuel, without which the automobile could not carry out its defining functions.

Mechanistic systems are either open or closed, closed if their behavior is unaffected by any external conditions or events; open if they are so affected. The universe was conceptualized by Newton as a closed (Self contained) mechanical system, with no environments like a harmonically sealed clock. On the other hand, the planet earth is seen as an open system one whose motion is influenced by other bodies in the solar system.

3.3.1.2 Animate System

These are conceptualized as purposeful systems whose parts have no purposes of their own. The principal purpose of such systems is survival. A person"s lungs have no purpose of their own; but they function to enable a person to extract oxygen from the environments in order to survive understandings these interactions in essential for understanding their properties and behavior. Animate systems are living systems "life" has been defined in many different ways. The definition now most widely accepted by biologists involves the ways concept autopoiesis.

The maintenance of units and wholeness, while components themselves are being continuosly or periodically disassembled and rebuilt, created and decimated, produced and consumed. (Zeleny, 1981, P. 5)

These definition it follows that social and ecological system are also alive. (Many biologists are unhappy about these consequences of their definition of „life.")

3.3.1.3 Social System

These are systems that (1) have purpose of their own, (2) consists of parts at least some of which are animate, hence have purposes of their own, and (3) are a part of one or more larger (Containing) system that may have purposes of their own and that may contain other social system. This, in turn, is part of or national government social system can be and usually are nested.

3.3.1.4 Ecological System

Such system contains mechanistic, animate, and social systems as parts and, therefore, containing some parts that have purposes of their own. However, these systems as a whole (3) are conceptualized as having no purpose of their own. Nature, of course, is commonly taken to be an ecological system as in our environment.

Ecological systems serve the purpose of their animate and social parts and provide necessary inputs to these and open deterministic systems. They also provide receptacles of their waste as well as their useful products. Such service and support is their function. An ecological can be affected mechanistically by the mechanical or purposeful behavior of its parts. For example, the purposeful use by people of fluoro-carbon as propellant and emissions of power plants affect the ozone layer mechanistically.

Animate and social systems are frequently confronted with situations in which their choices can affect their effectiveness, either positively or negatively. Such situations are problematic. In other words, problems are situations in which a system"s choice can make a significant difference to that system.

3.3.2 Thermodynamic system

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3.3.2.1 Energy transfer in three types of system

- **Open system:** Open systems can exchange both matter and energy with an outside system. They are portion of larger systems and in intimate contact with the larger system; our body is an open system.
- Closed system: Closed system exchanges energy but not matter with an outside system. Though they are typically a portion of larger system, they are not in complete contact. The earth is essentially a closed system; it obtains lots of energy from the sun but the exchange of matter with the outside is almost zero. A green house is an example of a closed system exchanging heat but not work with its environment.

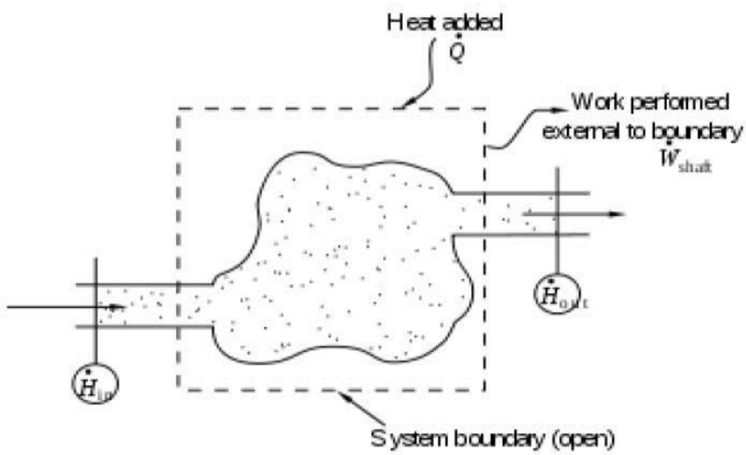

Figure 3.12: Open system

- **Isolated system:** Isolated system can exchange neither energy nor matter with an outside system. While they may be portions of larger system, they do not communicate with outside in any way. The physical universe is an isolated system; a closed thermos bottle is essentially an isolated system (though its insulation is not perfect).
- Heat can be transferred between open systems and between closed systems, but not between isolated systems. Whether a system exchanges heat, work or both is usually thought of as a property of its boundary. A boundary allowing matter exchange is called permeable.

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3.3.2.2 System Components and Properties

- **Boundary:** A system boundary is a real or imaginary two-dimensional closed surface that encloses or demarcates the volume or region that a thermodynamic system occupies, across which quantities such as heat, mass or work can flow, In short a thermodynamic boundary is a geometrical division between a system and its surroundings. Topologically, it is usually considered to be nearly a piecewise smoothly homeomorphic with a two-sphere, because a system is usually considered to be simply connected.

Boundary can also be fixed (e.g. a constant volume reactor) or moveable (e.g. a piston). For example, in a reciprocating engine, a fixed boundary mean the piston is locked at its positions. In that same engine, a moveable boundary allows the piston to move in and out. Boundaries may be real or imagery. For closed system, boundaries are real while for open system boundaries are often imaginary. For theoretical purposes, a boundary may be declared to be adiabatic, isothermal, insulating, permeable, or semi-permeable, but actually physical materials that provide such idealized properties are not always readily available.

Anything that passes across the boundary that effects a change in the internal energy needs to be accounted for in the energy balance equation. The volume can be the region surrounding a single atom resonating energy, such as Max Plank defined in 1900; it can be a body of steam or air in a steam engine, such as Sadi Carnot defined in 1824; it can be the body of a tropical cyclone, such as Kerry Emanul theorized in 1986 in the field of atmospheric thermodynamics; it could also be just one nuclide (i.e. a system of quarks) s hypothesized in quantum thermodynamics.

- **Surrounding:** The system is the part of the universe being studied while the surroundings are the remainder of the universe that lies outside the boundaries of the system. It is also known as environment, and the reservoir. Depending on the type of system, it may interact with the system by exchanging mass energy (including heat and work), momentum, electric charge, or other conserved properties. The environment is ignored in analysis of the system, except in regards to these interactions.

3.4 Family as a System

Living Systems and Reductionism:

Reductionisms: Any organized utility is composed of smaller parts and the entity can be understood by reducing it to its smallest part.

Living systems are non-reductionistic. Family systems are living systems.

Definition of Systems

"A system is defined as a whole made up of interacting parts. We cannot add their parts together and get the total system-the system is more than the sum of its parts."

"A family system is a social and or biological construction made up of a set of people related by blood or intensions."

Elements In System: Members interact in reciprocal relationships responding to one another in the content of roles.

Interaction: The interplay between members

Reciprocity: Both parties influence each other as they interact with each other

Roles: A character or function one plays.

Wholeness: To understand the family, it is necessary to look if'sin it entirely, not just at one or same parts.

Boundaries: The "lines of demarcation" that indicate who is in and who is out of a system.

Boundaries can be physical or symbolic or both.

Permeability: Ability to enter and exit the system degree to which the system is open. **Boundary Ambiguity**: Uncertainty about who is in and who is out of the system. It is very common at times of transition.

Hierarchic: Power. One up/one Down- superior/inferior "Captain first mate". Captain makes decision and first mate carries them out.

Egalitarian: Both partners maintain or attempted to maintain an equal relationship which is difficult to maintain, if focus is on total equality, in every way.

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Important concept in understanding how systems work: "Change versus stability"

Family systems are stable in their chaos and orderly in their disorder.

Families are predictable in general, unpredictable in detail.

Homeostasis: The tendency of a system to return to a state of equilibrium is known as Homeostasis.

This is counteracted by the need for change in a living system (or the national state of change in living system).

3.4 Flow of Energy through the Body - A Brief Overview

Food that is ingested contains energy - the maximum amount being reflected in the heat that is measured after complete combustion to carbon dioxide (CO_2) and water in a bomb calorimeter. This energy is referred to as ingested energy (IE) or gross energy (GE). Incomplete digestion of food in the small intestine, in some cases accompanied by fermentation of unabsorbed carbohydrate in the colon, results in losses of energy as faecal energy (FE) and so-called gaseous energy (GaE) in the form of combustible gases (e.g. hydrogen and methane). Short-chain (volatile) fatty acids are also formed in the process, some of which are absorbed and available as energy. Most of the energy that is absorbed is available to human metabolism, but some is lost as urinary energy (UE), mainly in the form of nitrogenous waste compounds derived from incomplete catabolism of protein. A small amount of energy is also lost from the body surface (surface energy [SE]). The energy that remains after accounting for the important losses is known as "metabolizable energy" (ME) (see Figure 3.1).

Not all metabolizable energy is available for the production of ATP. Some energy is utilized during the metabolic processes associated with digestion, absorption and intermediary metabolism of food and can be measured as heat production; this is referred to as dietary-induced thermogenesis (DIT), or thermic effect of food, and varies with the type of food ingested. This can be considered an obligatory energy expenditure and, theoretically, it can be related to the energy factors assigned to foods. When the energy lost to microbial fermentation and obligatory thermogenesis are subtracted from ME, the result is an expression of the energy content of food, which is referred to as net metabolizable energy (NME).

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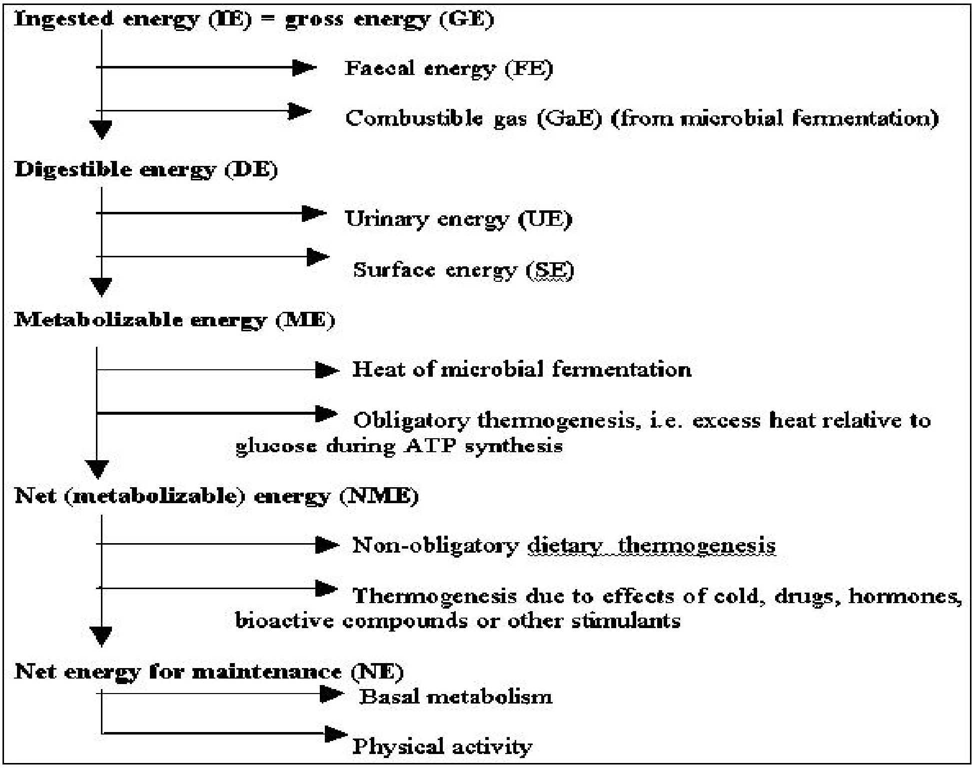

Figure 3.13: Overview of food energy flow through the body for maintenance of energy balance

Additional energy is needed for gains of body tissue, any increase in energy stores, and growth of the foetus during pregnancy, production of milk during lactation, and energy losses associated with synthesis/ deposition of new tissue or milk.(*Source:* Adapted from Warwick and Baines (2000) and Livesey (in press [a]).

Some energy is also lost as the heat produced by metabolic processes associated with other forms of thermogenesis, such as the effects of cold, hormones, certain drugs, bioactive compounds and stimulants. In none of these cases is the amount of heat produced dependent on the type of food ingested alone; consequently, these energy losses have generally not been taken into consideration when assigning energy factors to foods. The energy that remains after subtracting these heat losses from NME is referred to as net energy for maintenance (NE), which is the energy that can be used by

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the human to support basal metabolism, physical activity and the energy needed for growth, pregnancy and lactation.

3.4.1 Conceptual Differences between Metabolizable Energy and Net Metabolizable Energy

ME has traditionally been defined as “food energy available for heat production (= energy expenditure) and body gains” (Atwater and Bryant, 1900), and more recently as “the amount of energy available for total (whole body) heat production at nitrogen and energy balance” (Livesey, 2001). By contrast, net metabolizable energy (NME) is based on the ATP-producing capacity of foods and their components, rather than on the total heat-producing capacity of foods. It can be thought of as the “food energy available for body functions that require ATP”. The theoretical appeal of NME for the derivation of energy conversion factors rests on the following: substrates are known to differ in the efficiency with which they are converted to ATP, and hence in their ability to fuel energy needs of the body. These differences in efficiency are reflected in the differences between heat production from each substrate and that from glucose; they can be determined sociometrically and can be measured. Furthermore, foods replace each other as energy sources in the diet and in intermediary metabolism on the basis of their ATP equivalence (which is reflected in NME), rather than on their ability to produce equal amounts of heat (which is reflected in ME). For more of the derivations of and differences between ME and NME see the detailed discussions of Warwick and Baines (2000) and Livesey (2001).

3.5 Social Metabolism in Social Ecology

Fisher-Kowalsky and Haberle 1994, described Social metabolism as “the particular form in which societies establish and maintain their input from and output to nature; the mode in which they organize the exchange of matter and energy with their natural environment”. However, among early sociologist the concept of social metabolism was widely adopted. At that time it was used to describe the same process: the exchange and the transformation of matter, energy, labour and knowledge carried out between the social system and the environmental system. But it did have various different meanings. For some authors it was one concrete way in which society was embedded in cosmic evolution, which simultaneously offered

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models to help understand how the social system functioned; for others it was a way of describing the exchange of energy and matter between society and nature, that which permitted the reproduction of the social system and of the social environment needed for human advancement; for others again, social metabolism was one way in which society could renew its *elite*. It was assumed that this concept was the product of sociological organicism and when sociology became more rationalist and individualist, it lost this perspective which linked society with its environment.

3.5.1 Material and Symbolic Metabolism

Analogical thought, and early reflections on the relation between living organisms (Biological and Social) and the environment laid the foundations for the discovery of the phenomenon termed “Social Metabolism”. For the sociologists of the time, the fact that a living organism depended on its environment posited a problem of the way in which the exchange of matter and energy between the organism and its environment took place. Obviously, in their explanations, they drew heavily on both biology and anatomy both of which, as we have seen, had for some time been trying to discern the nature of the relation between living things and their environment. However, once they began to consider the social organism, not only did the scale of the phenomena being studied” change, but also the quality. Above a certain size threshold, quantity took on an entirely different, often inexplicable, qualitative meaning.

Spencer‟s work based on close analogies between natural and social organisms, offers an important demonstration of the way in which society and nature are related. A society, Spencer argued, lives by appropriating matter from the Earth. It appropriates the mineral matter transformed from vegetal matter raised on its surface for food and clothing and the animal matter transformed from vegetal matter. The very process of social metabolism became clear when Spencer said that the lowest social stratum is the one through which such matter are taken up and delivered to agents who pass them into the general current of commodities” (Spencer, 1876). The process of exchange and transformation reveals the true nature of “Social Metabolism”.

But in Spencer there was other unusual kind of metabolism: when nature becomes a mirror of society. A mirror which reflected the ways in

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which society and nature became cognitive and symbolic Nature offered to sociologists the geological structure to survey the workings of society. The functional rationality of Spencer had glimpsed within the natural organization of biological organisms, and which had burst forth freely from the evolutionary dynamic of such organisms, was soon applied to the analysis of society as a system. Thus, we can speak of cultural or symbolic metabolism.

Unlike Comte, Spencer did not really consider nature and living organisms as the counterpart of society rather, he saw them as a reflection of social organization. Thus the social construction of the image of nature was fundamental. For Spencer, society had to go through the same evolutionary process; society would have reached a new level, unlike the animal level wherein the integration of the whole was subordinated to the autonomy and freedom of the parts. Thus society would become a super-organism.

For Spencer, the key concept was that of *evolution.* Evolution corresponded to the process of increasing differentiation (that is of functional specialization) and to integration (or rather, of the mutual) interdependence of the structurally differentiated parts and the co-ordination of their functions). Furthermore, within a group, evolution was linked to the distribution of quantities of materials and movement; "evolution under its simplest and most general aspect is the integration of matter and the concomitant disintegration of matter" (Spencer, 1900). The tension between evolution and dissolution was, in Spencer‟s view, Visible everywhere and even as one process triumphed, so would the other triumph in its turn. In ecological terms one could say that Spencer had already identified the process that cybernetics has called "the increase and decrease of negative entropy", the dialectical relation between order and chaos.

Lastly, the process of evolution is linked to another curious phenomenon that Spencer identified quite clearly; he argued that *heterogeneity* was, in Spencer‟s view, an almost universal fact. At the time when the *Principles of Biology* was published, this conviction was still without any empirical foundations but, curiously enough, it fits perfectly with what ecologists have recently discovered: ecological communities that contain a large number of interdependent species are very stable, while those with only a few species are subject to violent fluctuations and the population itself may even become extinct.

In Spencer"s view society mirrored living organisms in organizational and functional aspects. He argued that social and biological organisms are similar in terms of the system by means of which they are sustained (metabolism): the system of distribution (the vascular and circular system in an organism is similar to the arteries, paths, taken by trade and commerce in a society) and also, the system which regulates the organism (the nervous system of an organism) is analogous to the system with which a society is governed.

Thus Spencer, if he is read carefully offers a mine of observation, concepts, theories and explanations concerning the relation between society and nature and the way in which society and nature can reciprocally influence each other.

3.5.2 Social Metabolism as Exchange of Matter and Labour

Organicism thought that evolution was the permanent process of an organism"s adaptation to an environment. The organism"s life is dependent on maintaining this equilibrium. If the environment were to change suddenly, the organism risked death, if changes took place slowly and gradually, the organism would find its place in a new and well balanced state. Thus organisms should be seen as being part of a dynamic process, within which they show phenomena of unceasing differentiation and integration of both structures and functions.

The same happens within human society. This can only improve if the process of adjustment is both unceasing and dynamic. If the process of transformation is blocked, or goes too fast, as for example during a revolution, there is a risk that society will collapse. Human society, like any other organism cannot adapt to incessant variations in the environment. It must adapt not only to natural environmental changes in climate, food and vegetation, but also to the new conditions produced by economic and social activities. Activities of social nature create an artificial environment, different from but linked to the natural environment. This mechanism of differentiation of the environment outside of society was, like for the natural environment, called social metabolism.

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A fairly clear description of social metabolism was offered by the German sociologist Adam Schaffle. He sociologist was one of the best at interpreting the process which allowed society to reproduce itself. In Schaffle‟s opinion, the pre-condition for every activity, from those of the smallest, least important parts, to the activities of the largest parts of the social body too requires an exchange of materials, which simultaneously penetrates every part of the social body: production, circulation, distribution, intermediary exchanges, use and elimination of the materials necessary for maintaining both the person and institutions of the social unit.

Indeed, continued Schaffle, every day an immense mass of the materials and the energy of nature are, through work activity, appropriated by the social body, only to be adapted to its needs, through production activity and then distributed to the various parts through circulation; transformed into the social fabric by means of absorption of goods and bodily forces. Thus Schaffle clearly outlined the mechanism of that social metabolism by means of which the energy and the matter existing in nature enables the social body to maintain itself.

Furthermore, the exchange of materials does not only serve as a means of conserving the bio-organic substratum of society, that is conserves biological bodies, it is also indispensable for maintaining the extra-organic parts of the social body: the functions of social life, the spiritual, religious ideas, culture and symbolic aspects which cannot exists without an exchange of materials. Even though it is still elementary, Schaffle recognised and described, very clearly, the ecological interdependence of society and nature.

The economic and physiological exchange of material does not entail the destruction of the material and energy but, rather, it entails their re-organization into sources of energy and into institutions which make their social use possible. Basically, Schaffle applied thermodynamic principles to social exchanges. According to these principles energy and matter are not destroyed but are only transformed, dis-organised and then reorganised for other uses. An efficient mechanism of social metabolism can neither allow any energy to be lost not permit increasing entropy, the result would be crisis within the social organism itself.

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Schaffle distinguished between a progressive and a regressive exchange of materials or matter. The former corresponds to production and manipulation of raw materials; the second to the consumption and elimination of used materials (waste/rubbish/garbage). This distinction renders the social exchange of material that is carried out by the human community unique, different from that of animals and plants. Even though the organic process of transformation of materials is similar in humans and in other animals at the bodily level, Schaffle quite rightly argued, that the social economics of the exchange of materials was very different from the natural economy of exchange as practiced by other organisms.

Economic regulation of social metabolism depended on the conscious needs and reasons developed by society. According to Schaffle, socially manipulated goods, other than raw materials, contained a quid of uniqueness, spiritually, rationality, work and social techiniques that made them completely different from the goods required for animal life. Traces of Marxian thought seem to hover around these words. Work makes the social exchange of materials possible and this work is, at a high level, conscious, spiritual, guided by rationality. The rational activity of intelligence, feeling, will makes the energy and the matter in nature available to humans, modifying, dis-organising and re-organising both energy and matter in order to meet humanity's specific needs. Thanks to agriculture and animal husbandry, the same process for the production of food rationality dominates the whole organic kingdom of nature: nutrition becomes both rational agriculture and culinary art.

3.5.3 Concepts of Schaffle's Social Metabolism

First concept is *nature*, which meant as a “font or spring” and as the “place of dejection or evacuation” for the exchange of matter. Nature was one of three factors of production identified by Schaffle, which could be associated to labour and capital (the influence of Marx). Nature demonstrated two contrasting aspects in its relation with society without this help having to be group of “free goods”, (*res communes*) which have recently been defined as being “service supplied free of charge by the ecological systems of society” for the good functioning of the support system for life on Earth” (Costanza, 1997).

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Second concept was that of *scarcity*. For Schaffle quantitative scarcity and the qualitative lack of natural resources was the basis of all need, hence of the social economy of exchange which was effectively a complex of means for satisfying needs. Here he seems to be reasoning along the lines of the classical economists, except, one should remember, he was writing in 1874.

Third concept was that of labour, in the broadest physical maning of the word: every effort made by living forces, every use of this living force. According to Schaffle, both the labour of every person and every service (utility) supplied by a thing, every service and every personal use was labour. This definition is quite close to Lilienfeld, for whom labour is the combination of the physiological forces of natural organism with the forces of human bodies or, to use other formula, the combination of matter and force.

3.5.4 Forms of Motion of Matter

- **Physical form of motion**: The mechanical motion of objects in space and their motion relative to one another is the most primitive kind of motion of matter. Thermal process, chaotic movements of molecules, sound and electromagnetic process etc. are more complicated type of motion.
- **Chemical form of motion:** The motion of atoms in molecules, the joining together of atoms and molecules is called chemical form of motion.
- **Biological form of motion:** It is taken to mean the life of organic (live) nature, physiological process in plants and animals, the evolution of species etc.
- **Social form of motion:** Man‟s social life, the development of material production, economic relation between men, cognitive process etc. is a most complex form of motion.

A profound understanding of forms of motion of matter of their interrelationship and mutual transitions leads to an understanding of the basic classification of scientific knowledge. If one cognizes real processes, one‟s knowledge is the reflection of the process. Thus different sciences corresponds to different forms of motions of matter, with the mechanical form studied by mechanics, the physical and chemical forms by physics and chemistry, the biological forms by biology and social form by social sciences.

The known processes of motion of matter do not exist independently, or in isolation, from one another, they are interrelated. The chaotic movement of molecules generate heat process. Heat processes can cause chemical transformations and light phenomena. At a certain stage of development, chemical processes lead to the formation of protein bodies and on this basis to the emergence of life i.e. to the biological form of motion of matter. It follows that some forms of motion of matter can turn into other forms; in particular, this is reflected in the law of conservation and transformation of energy and matter. Yet each stage in the development of matter corresponds to a form of motion, which differs qualitatively, and the highest forms of motion of matter cannot be reduced to the lowest. For example physiological process, which includes mechanical as well as physical and chemical motion are not reduced to and are not exclusively brought about by the mechanical, physical, and chemical motion of these elements, molecules and atoms. It follows that social life, the highest form of motion of matter, cannot be explained through biological process, the way idealist do. They claim that same laws are in effect in society and in animal life, the strongest survive. The rich and poor are claimed to exist because some are stronger and other weaker but in actual fact a strong man can be poor if he has no property and lives a society based on exploitation and enslavement.

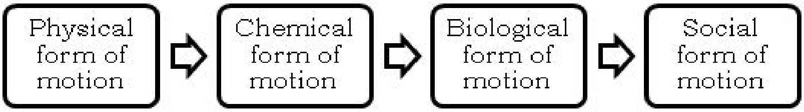

Figure 3.14: Forms of motion and matter

In the figure 14. Model of social metabolism has been shown to illustrate the basics of social metabolism. The same carbon, hydrogen, nitrogen, oxygen, sulfer, and potash, which are in the lowest level of energy

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configuration, form in the physical system characterized with matter and energy, attains the highest level of energy configuration in a social system with the help of motivation and intelligence via biological system, which is furthur characterized with metabolism and genetics.

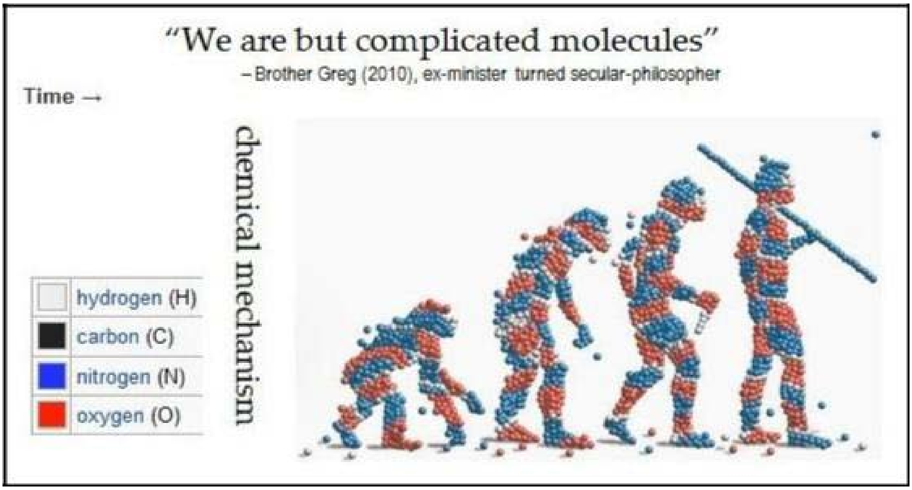

Figure 3.15: Human as complicated molecules

The figure 3.15 shows that humans, which are composed of complex protein molecule, are also a product of nature and are a medium of flow of molecules in nature.

The figure 3.15 shows evolution of social system from hunting age to the most advanced and modernized and industrialized form. The system has evolved through conflict in various stages. In the first phase, social system was in primitive stage, when human fulfilled their basic needs of food through hunting in natural system and there was no concept of economy. There was conflict with nature and there was no need to accumulate wealth, therefore, there was no surplus. Primitive humans were not worried about future because there was immense stock of natural resources to meet there biological, physical and social needs. Therefore, in the primitive commune society conflict was lowest among people. In the second phase humans were more organized and form a social system known as feudal system. In this system, society form on the basis of divison of labour and some of them became land lord and some became their serf. In this system conflict was higher than the primitive commune society.

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