CHAPTER VII
SUMMARY AND CONCLUSIONS

7.1. INTRODUCTION

The present chapter summarizes the various aspects of the present study that had been carried out on spatial suitability analysis model developed for identifying suitable locations for installing Anaerobic Digester based electrical energy production units using poultry litter in Namakkal taluk, Tamil Nadu, India. The present study had been made with a systematic methodology using the modern hi-tech capability of the geospatial techniques and presents a detailed report on the study of identifying suitable locations for electrical energy production units. The present chapter deals with the summary, findings and conclusions derived from the study, and analysis and suggestions are given in the concluding part of the chapter.

7.2. SUMMARY

Many uncertainties surround the predicted links between carbon-di-oxide in the atmosphere and global warming; the potential for serious and irreversible climate change provides an additional incentive to push ahead with a major programme of energy conservation and development of renewable energy resources. Renewable energy sources may be an efficient solution for the environmental pollution problem. Namakkal taluk has a great advantage due to its geographical location in terms of biogas energy resources available from poultry litter. The study area would generate a very clean source of renewable energy in the farm of combustible gas. The power generated from poultry litter and combustion products shall thereby, in no way, affect adversely the green house gas emissions. In fact, the organized treatment of the poultry litter ensures that noxious methane and higher organic gases are not released into the atmosphere during the natural decay process. Poultry litter is being used as fertilizer in its raw form, as in the case cattle dung. However, as in the case of cattle dung, the effectiveness and the nutrient value are enhanced by the bio-methanation stabilization process. This efficiency translates into a saving of synthetic chemical fertilizer,
thereby reducing the soil degradation and associated damage. It is well accepted that renewable energy sources may assist in overcoming the environmental problems associated with conventional energy systems. However, it became clear that renewable energy sources may have various negative environmental impacts which are mostly related to the geographical locations of renewable energy facilities. Therefore, in this thesis, a spatial decision support system for installing Anaerobic Digester site selection of biogas energy generation model is attempted through the fulfillment of the following objectives: 1. To study the spatial distribution of poultry farms in Namakkal Taluk, Tamil Nadu, India, 2. To estimate the amount of poultry litter generated from the poultry farms in the study area, 3. To estimate the amount of biogas and green energy derived from the poultry waste, and 4. To identify the suitable locations for power plants and study the viability of environmental concerns in implementing the plants.

To fulfill the objectives, the present investigation is divided into seven chapters. The first two chapters deal with the introduction and the geographical background of the study area selected for the present investigation respectively. The historical development and spatial distribution of poultry farms are presented in the third chapter. The estimation of poultry litter, biogas and green energy potential are analyzed in the fourth chapter. Identifying suitable locations for installing Anaerobic Digester based electrical energy production units through GIS techniques are discussed in the fifth chapter. The environmental implications of people’s perception were evaluated and analyzed in the sixth chapter. The final and concluding chapter summarizes all the methods, analysis and results of the study, along with suggestions for installing Anaerobic Digester based electrical energy production units using poultry litter.

7.3. FINDINGS

* The Namakkal Taluk is located in the south eastern part of Namakkal District, Tamil Nadu, India. It extends from 11° and 11° 26’ N latitudes and 78° 02’ and 78° 28’ E longitudes. The study area covers an area of 1513 km² at a mean altitude of about 300m.
The administrative headquarters of this taluk is located in Namakkal town. Namakkal Taluk consists of six blocks, namely, Erumaipatti, Kolli Hills, Mohanur, Namakkal, Puduchatram and Sendamangalam. A total of 117 revenue villages are grouped under six development blocks.

The taluk is extensively covered with a series of hilly ranges and rocks with undulatory plains. The eastern part of the study area seems to be highly rugged, whereas the western part has more of plain regions.

Well-known Kolli Hills, the garden of Namakkal taluk is spread over an area of 371 km$^2$. The slope of the terrain ranges from the mean sea level to an altitude of 1,370 m above MSL and runs along the northeast and eastern part of the taluk showing a high variation in its elevation. The Nainarmalai is located in the northern part of the taluk with an elevation of 743 m.

The hilly terrain is composed of ridge and valley complex, dominated by landforms, formed due to fluvial origin. The physiographic divisions can be divided into seven elevating stages such as low lying land, plain, foot hills, step terrain, rolling terrain, hilly plain and hilly region. Thirumanimutharu and Cauveri rivers pass through this taluk.

The geology of the study area comprises underlying rock formations and belongs to the oldest group of rocks in Archaean system and comprise of metamorphic rocks and plutonic igneous masses like granite and dyke rocks.

Namakkal taluk has a semi-arid climate. The maximum temperature ranges from 28.10°C to 37.85°C and the minimum from 20.85°C to 25.40°C.

The major seven soil series of the taluk can be grouped under three broad categories, i.e., red soil, black soil and alluvial soil.

Annual actual rainfall of the taluk is 730.5 mm. Maximum rainfall is received during the North East monsoon season followed by South West monsoon season. The cold weather and hot weather periods are dry with scanty rainfall.
Total projected population as per 2011 Census of the taluk was 5,29,343 with density being 350 persons per km². The sex ratio of the study area is 996.

The literacy rate of the study area is 71 per cent, of which male literacy rate is 55.19 per cent while female literacy rate is 44.81 per cent.

In the study area, 55 per cent of the working population is engaged in farming activities and 45 per cent of the populations are non-workers. The share of main workers is 90 per cent and marginal workers are 10 per cent.

From the 90 per cent of the main workers, 26 per cent are cultivators, 34 per cent are agricultural labourers, 3 per cent are in household industries and 37 per cent are other workers.

Of the 10 per cent of the marginal workers, 11 per cent are cultivators, 63 per cent are agricultural labourers, 6 per cent are household industries and 20 per cent are other workers.

From the IRS-ID LISS-III image supervised land use/land cover classification, the total geographical area of the taluk was classified as barren rocky, cultivable land, forest, fallow land, non-agricultural land, land with scrub and without scrub and water bodies.

In Namakkal taluk the source of irrigation is wells, canals and tanks. River Cauvery passes through this district, facilitating canal and lift irrigation. The well irrigation is the main source of irrigation covering 29,903 ha. An area of 2470.38 ha is covered by canal irrigation. There are totally 93 tanks in the taluk owned by the PWD and the Panchayats.

The groundwater potential of the Namakkal taluk is very poor. Most of the blocks come under the categories of Dark and Grey. Only Kolli Hills block is classified as white category.

Nearly 90 per cent of the cultivated area is under food crops. Paddy, cholam and maize are major food crops, followed by sugarcane, tapioca, groundnut, cotton, onion, turmeric, pulses, flowers, vegetables and fruits.
The main livestock found in the taluk are poultry, cattle, buffaloes, sheep, goats and pigs. Poultry development has been rather phenomenal in and around Namakkal. The Animal Husbandry Department has undertaken measures to improve the quality of animal wealth in the taluk.

A famous Government Veterinary College is situated in Lathuvadi, near Namakkal. Poultry industry is one of the fastest growing segments in Namakkal Taluk.

Mostly, every poultry unit has put up its own feed manufacturing unit. A few units supply poultry feed to other units also. Namakkal taluk is the major producer of egg and sends the eggs to all over the country. Hence, Namakkal is called as ‘Egg City or Poultry Town’.

Another important aspect in the taluk is the sago production. Tapioca is cultivated in Namakkal taluk in abundance. Using tapioca as raw material, about 350 factories are engaged in the production of starch and sago. There is a good market for sago and sago products in North India and are they exported to other countries.

Urbanization process in Namakkal taluk has been taking place at a high rate. The study area is well served by both rail and road transports. There has been an increase in the use of two, three and four wheeler vehicles in the taluk.

Poultry development in Namakkal Taluk has shown steady progress over the years, primarily due to research and development schemes of Government and effective management and marketing by organized private sector.

The study area covers 117 villages. Poultry farms are spread only in 64 villages and the total number of poultry farms is 431. The spatial distribution of poultry farms is seen at a higher level in 10 villages. Moderate level of spatial distribution of poultry farms is seen in 12 villages and forty-two villages are having low level of poultry farms. Most of the poultry farms are located along the transportation lines for obvious reasons.
The spatial distribution of poultry birds were analyzed using a GIS and the same constitutes the basis for the estimation and presentation of the available power potential.

The study shows that the total number poultry birds is 1,30,23,220. The concentration of poultry birds is high in six villages. The main reason is very good environment and infrastructural facilities available there.

Nineteen villages have moderate level of poultry birds distribution and thirty-nine villages have low level of poultry birds. Most of the poultry farms are located along the transportation lines and have good connectivity.

This will help the rural formers for increasing the income from poultry farming and increase the socio-economic condition of the rural under privileged society.

India is the 5th largest egg producing country in the world with projected growth rate of 8.2 per cent, with the value of poultry products showing fourfold increase from Rs. 795 to 3,454 crores between 1981 and 1990.

The three states of Andhra Pradesh, Tamil Nadu and Punjab account for a significant fraction of the poultry farms in the country. Namakkal has over 500 hatcheries with the smallest amongst them having about 10,000 birds and the largest in excess of 5,00,000 birds.

The issue of using poultry litter as wet or dry manure on land for vegetation and arboriculture has been practiced in rural India as household recycles practice to great advantage as an environmentally sound technology.

The physical quantity of poultry litter produced per day was estimated at the village level by using the average amount of litter generated per bird. The average amount of litter generated by a bird was assumed as 90 grams per day.

Thus, the total quantity of the poultry litter generated in Namakkal taluk is about 1172 tonnes per day. The highest amount of poultry litter generated per
day was seen at two villages, namely, Marupatty and Ladduvadi, which generated 98 tonnes and 72 tonnes per day.

- The moderate amount of poultry litter was generated by twenty villages. Forty-two villages generated low level of poultry litter per day.

- Biogas is an important renewable source of energy produced from organic materials like cattle dung, human wastes and poultry litter. It is a clean and smokeless domestic fuel. The biogas plant also produced enriched good quality organic fertilizer. Energy produced from anaerobic digester, biogas is categorized as green energy.

- The processing of a range of waste streams, including source separated organic waste or poultry litter in anaerobic digesters contributes to sustainable and renewable energy.

- Biogas is a mixture of methane and carbon-di-oxide. It also has traces of hydrogen sulphide, ammonia, oxygen, hydrogen, water vapour, etc., depending upon feed materials and other conditions.

- Biogas is generated by fermentation of organic matter under anaerobic conditions. In anaerobic conditions, the methane producing bacteria become more active. Thus, the gas produced becomes rich in methane.

- Biogas is a product of anaerobic fermentation of organic matters and consists of around 60 to 70 percent methane and 30 to 40 percent carbon-dioxide and traces of nitrogen, sulphur and moisture.

- Farm wastes locally available are used for extracting biogas from poultry litter. Assuming a production of 0.1 cu.m of biogas from one kilogram of poultry litter, it is estimated that Namakkal taluk can produce biogas of 1,17,214 cu.m per day.

- Six villages are having highest amount of biogas potential and the biogas production can total more than 4200 cu.m per day. Moderate level of biogas
production is seen in nineteen villages and thirty-nine villages are having low
type of biogas potential.

♦ The estimation of green energy potential was implemented in Geographical
Information System to obtain maps showing village-wise variation of green
energy potential in the study area.

♦ Assuming that one cubic metre of biogas may produce two units of green
electricity, it is estimated that poultry litter generated in Namakkal taluk may
produce about 234 megawatt of green energy per day.

♦ The highest amount of green energy potential per day was estimated at six
villages, moderate in nineteen villages and low in thirty-nine villages.

♦ The electricity generated would be sold to the Tamil Nadu State Electricity
Board. The government of Tamil Nadu have already issued circular for of
purchase power generated from biogas energy sources at Rs. 4.50/unit.

♦ Namakkal Taluk has the potential of an income of Rs. 10,57,000 per day or
Rs. 3 crore and 17 lakhs per month.

♦ Natural gas has 75 to 98 per cent methane with small percentages of ethane,
butane and propane while biogas has about 60 per cent methane and 40 per cent
carbon-di-oxide.

♦ It is possible to improve the quality of biogas by removal of CO₂, H₂S through
scrubbing technique and enriching its methane content up to the natural gas
level.

♦ Therefore, the eco friendly enriched biogas potential is calculated and assessed
at village level. The total amount of enriched biogas potential is 70,328 cubic
metres per day in Namakkal Taluk.

♦ There is large potential of enriched biogas and compressed bio-CNG potential
available in Namakkal Taluk to make it an alternate fuel for vehicles.
♦ Biogas can be used in automobiles after its purification. It can be used as vehicle fuel just like CNG. It has lower emission than natural gas and diesel. Biogas traffic use results in very low emissions of SO$_2$, NOx, particles and noise.

♦ The present status of the compressed bio-CNG potential is assessed and maps have been prepared in the study area. Assuming that one cu.m of enriched biogas may produce 0.714 kg of compressed biogas, it is estimated that poultry droppings generated in Namakkal Taluk may produce about 50,214 kg biogas per day.

♦ This can be bottled in bio-CNG cylinders and would be sold at an approximate rate of Rs. 30 per kg. Namakkal Taluk has the potential income of Rs. 15 lakhs per day.

♦ One carbon credit usually represents the reduction of one metric tonne of carbon-di-oxide or its equivalent in other greenhouse gases such as methane and nitrous oxide.

♦ Methane and nitrous oxide have approximately 21 times and 310 times, respectively, the heat-trapping capacity of carbon-di-oxide. Reducing methane by one tonne is equivalent to reducing carbon-di-oxide by 21 tonnes.

♦ The average amount of methane gas weight is calculated and analyzed in Namakkal Taluk. There are 0.714 kilograms in a cubic metre of methane gas. Therefore, the total amount of methane gas potential estimated in the study area is 84 tonnes per day.

♦ This methane gas potential is available to earn carbon credits. This would be at the approximate rate of Rs. 700 per tonne (10 euros for one Certified Emission Reduction). Namakkal Taluk has the potential of additional income of Rs. 58,800 per day or Rs. 17 lakhs per month. This Clean Development Mechanism helps to substantially reduce green house gas emissions and facilitates a tremendous potential to earn carbon credits.
♦ The development of organic farming, including poultry production, helps the demands of modern consumers in relation to their perceptions of food safety, animal welfare and even environmental protection.

♦ Approximately, 35 percentage of poultry litter dewatered and dried residues would be recovered daily for sale as an organic fertilizer. The process of treating poultry litter results in the generation of biogas and residue as by products of anaerobic digestion.

♦ The biogas would be utilized to generate valuable electrical energy. Furthermore, the residue following digestion, which would be rich in nutrients, will be sold as an organic fertilizer. The present status of the organic manure potential is assessed and maps have been prepared in Namakkal Taluk.

♦ The organic manure potential available in Namakkal Taluk is 410 tonnes per day. This would be sold at an approximate rate of Rs. 3,200 per tonne. Namakkal Taluk has the potential income of Rs. 13 lakhs per day. Organic manure could be used as a substitute for synthetic fertilizer, and the demand for such product is on the increase, both in the domestic and export market.

♦ A poultry litter based biogas energy system cannot be sited within a certain distance of streams, tanks, residential areas, taluk roads, National Highways, State Highways and railway line. In addition, safety concerns prevent construction such as commercial buildings, transmission lines and near power systems.

♦ Within this model, these sensitive areas are defined as “constraints” meaning they are restricted from development of poultry litter based energy systems within the area.

♦ A buffer zone is created for each of these constraints to define the minimum distances of development sites to the selected geographic feature. Different constraints correspond to different widths of buffer zones.
Sites falling within streams and a buffer zone of 100 m is avoided. Sites falling within tanks and a buffer zone of 300 m is avoided. As Namakkal city has high density residential areas, a site at distance of more than 3000 m are avoided.

Villages are having medium density residential areas and hence a radius of 500 m is maintained. Sites falling within transport line and a buffer zone of 100 m are avoided. Sites falling within National Highway-7, State Highway and railway line, a buffer zone of 500 m are avoided.

From the overlay, analysis identified the suitable location for installing Anaerobic Digester based bio-energy plants. Data processing is done in GIS environment.

To calculate individual satisfaction degrees of environmental objectives and economical feasibility criteria for each alternative location, several GIS map layers were prepared.

These layers include the boundaries of the study area, streams, tanks, river, settlement areas, transport lines, barren rocky and hilly areas integrated in a single map.

A binary grid was created for each of the eight constraints, with pixels that fall within the buffer zone of constraints assigned ‘‘0’’ and the rest ‘‘1’’. To evaluate environmental and economical constraints, various analyses need to be conducted, using spatial data.

Only the cells that have an ‘‘1’’ in each input layer will have a non-zero value in the final result. This is indicating suitable locations for installing Anaerobic Digester potential of biogas based electrical energy production units.

Location allocation is a combinational optimization problem. Traditional exact method cannot solve location allocation problem efficiently. This problem does not limit itself to a small spectrum.
The general objective of location-allocation problems is to place an optimal number of sites for installing anaerobic digester for producing biogas based green electricity in Namakkal Taluk.

Identifying the geographic centre or the centre of location for a set of features calculations, based on either Euclidean or Manhattan distance which require projected data to accurately measure distances.

The mean centre is a point constructed from the average x- and y-values for the input feature centroids. If a case field is specified, the input features are grouped according to case field values, and a mean centre is calculated from the average x- and y-values for the centroids in each group.

A biogas based power plant is located in Sarkar Uduppan village in Namakkal Taluk. Based on this existing biogas based electricity production unit, it is observed that a power plant needs nearly hundred tonnes of poultry litter per day for green electricity generation.

The total quantity of poultry available in Namakkal Taluk is 1172 tonnes. Using the ArcGIS software, the villages which produce nearly hundred tonnes of poultry litter are grouped.

There are eleven grouped villages available in the study area. These grouped villages are involved for mean centre analysis. From the 64 poultry litter producing villages, only 56 poultry villages are included for centrographic analysis.

Eight villages are not grouped in this analysis, because, these villages are producing minimum amount of poultry litter and are located far away from the adjacent village location.

A poultry litter collecting vehicle is needed to travel long distance to these villages. Therefore, these villages are excluded from the grouping and mean centre analysis.
Using each grouped village’s location in ArcGIS software, the mean centre is identified for installing Anaerobic Digester potential of biogas based electrical energy production unit.

In total, eleven optimal sites were identified and overlaid on suitable land use analysis map. All the power plants are well located in suitable lands. These sites are suitable for installing Anaerobic Digester potential of biogas based energy systems using poultry litter as the feedstock in Namakkal Taluk.

The eleven optimal sites were verified with Global Positioning System. All the sites are located either around the agricultural land or adjacent to the agricultural land.

There is no new construction established around these selected sites. All the places are well suited for constructing poultry litter based electrical energy production units in the study area.

Around the sites, the sampling survey has been conducted with 300 respondents from poultry owners, agricultural farmers, agricultural labourers, poultry related workers local administrators and environmental activists.

The respondents were visited with a set of questionnaire related to energy consumption, green energy production, green house gas emission reduction in atmosphere, energy conservation, environment conservation, renewable energy, land use, crops, manure type, type of irrigation, industrial development, poultry litter, methane gas, usage of boienergy, pollution, global warming and climatic change.

This primary survey has been used to judge the levels of people’s awareness regarding poultry industry development, green electrical energy production and environmental conservation.

From the questionnaire analysis it was found that all the respondents are used electric lights and television. 85 respondents used for fan, 78 per cent respondents had mixie and 62 per cent of the respondents used grinder.
This primary survey is clearly showing that most of the respondents used all electrical appliances in their homes and need energy. Nearly 59 per cent respondents were using LPG in the houses for the purpose of cooking as the main source.

But in recent times the use of LPG is highly increasing in Namakkal Taluk. It is obvious from this survey that use of LPG is on the rise in the household areas and firewood and kerosene are declining.

Nearly 90 per cent of the cultivated area is under food crops. During the primary survey, 42 per cent of the respondents replied that poultry manure is a major nutrient for their agricultural crops.

Nearly 72 per cent of the respondents replied that the poultry industries did not make any impact on human health. It is clearly observed from the respondents that poultry industries are helping their health and wealth.

According to interview schedule, nearly 62 percent of the respondents replied that they do not have awareness about methane gas. The people in the study area need awareness about methane gas and demonstrate effective and innovative use of bioenergy systems for household, community, institutional and industrial applications.

Around the proposed sites, the sampling survey has been conducted from poultry owners, agricultural farmers, agricultural labourers, poultry related workers local administrators and environmental activists.

According to the questionnaire survey, about 74 percent of the respondents replied that they strongly supported construction of biogas based power plants in their village.

During the questionnaire survey with the local people, it became clear that renewable energy investments, particularly, those for biogas energy are expected to increase in the near future.
However, to the researcher’s knowledge, there is no decision support system that can provide guidance to the authorities in evaluating the renewable energy sources applications.

The proposed decision support tool may provide useful guidance both for the investors and the authorities in identifying suitable locations for renewable energy sources, with respect to environmental and economical aspects.

7.4. CONCLUSION

The requirement of electricity in Namakkal taluk is 216 MW per day. The supply of electricity from Tamil Nadu Electricity Board and private sector is 166 MW per day. The shortage of electricity in Namakkal taluk is 50 MW per day. Biogas energy is a clean, pollution free and renewable source of energy. The method of generating electricity from biogas resources is one of the most effective ways to reduce global warming emissions. Poultry litter being generated continuously in Namakkal taluk may be profitably used, as it has a potential of generating about 234 megawatt of power per day. Namakkal taluk possesses great biogas energy potential and opportunities are open.

Indian government has laid a strong foundation and infrastructure for supporting and promoting the use of renewable energy and energy conservation especially in the form of necessary legislations and support funds. However, despite several financial incentives, the dissemination rate of the use of biogas energy technologies is still unsatisfactory due to institutional, policy, technical, financial and information barriers. Efforts have been made to try to remove some barriers such as government organization reform aiming to improve line of commands and coordination among organizations in the energy sector. More emphasis should have been given to the promotion of renewable energy technologies particularly biogas energy.

The society of energy engineers and managers is one such organization of professional, engaged in the task of enhancing the knowledge of common citizens and industry professionals alike in the areas of energy efficiency, renewable energy usage
and productivity consciousness. It plays a very crucial role in bridging the information gap between firms and government agencies, which is essential for achieving the targets outlined in the various action plans.

While the state government needs to be involved in any such programme, the discretionary power given to it to recommend projects has led to a lot of grievances about the questionable methods adopted by it in picking and choosing projects to be recommended. Any new programme has its teething problems. There will be difficulties. But the approach should be one of revisiting the guidelines in the light of the experience that is gained. In order to create a sustained interest within the investor community, Ministry of New and Renewable Energy proposes to support viable business models:-

♦ To create awareness and demonstrate effective and innovative use of bioenergy systems for household, community, institutional and industrial applications,

♦ To create among masses awareness about the importance, benefits and methods of conserving petroleum products, environment conservation, clean environment, energy security and sustainable development,

♦ To promote research, development and deployment efforts for adoption and dissemination of fuel efficient technologies and substitution of petroleum products with alternate fuels and renewables,

♦ To encourage innovation in addressing market needs and promoting sustainable business models, and

♦ To encourage replacement of kerosene and diesel, wherever possible.

Although energy policies adopted by the government are in the right direction, the pace of implementation is slow. A clear policy and a strong signal from the government are needed to disseminate information through public campaign, and encourage discussion and debate among various stakeholders so as to build a strong foundation and public confidence on renewable energy technologies. These policies and signals must be clear and strong enough for the private sectors to be confident
and actively participate in the renewable energy projects. The exploitation of biogas, as a source of renewable energy, not only provides a steady flow of income to the association but also demonstrates its willingness to reduce the impact of our modern way of life on the environment. This policy is supported by an information campaign directed towards the different age groups and contributes to improving public acceptance of the solutions provided. Support from the Indian Government as well as the purchase price applied to electricity generated from renewable energy sources are a guarantee of long-term viability and profitability for such projects.

Overall, the study revealed that, green energy production, biogas enrichment and compression system is a profitable venture for rural areas due to availability of large quantity of poultry litter. Highest biogas based power potential available in the study area makes it attractive for renewable energy investors. The system is recommended to establish rural entrepreneurship for the effective utilization of local resources for production of biogas energy in a decentralized manner, leading to sustainable rural development, reducing Green House Gas emissions, enhancing energy security and employment generation in the study area.