The energy forms the most important input in agricultural production particularly in paddy and banana cultivation. It requires large doses of energy in the form of different inputs as human energy; bullock energy; irrigation energy; fertilizer energy and the like. In recent years, due to modernisation and mechanisation of agriculture, the use of energy has become increased manifold. Many researchers working on energy requirements confine themselves to macro-level policy issues only. Therefore, in the present study, an attempt has been made to work on the energy use pattern in cultivation of paddy and banana at the micro level.

In Tamil Nadu, Thoothukudi is an important district for paddy and banana cultivation. This district is particularly gifted with a remarkable wealth of suitable climatic condition to augment cultivation of paddy and banana. From the district of Srivaikuntam taluk, two blocks were selected on the basis of priority consideration for paddy and banana cultivation. Five per cent of the total cultivators of paddy and banana were randomly selected for primary data collection. Total samples of 428 cultivators from areas of paddy and banana cultivation were randomly selected and then stratified into small and large farmers. The farmers holding up to five acres were grouped as small farmers and those who
have more than five acres were grouped as large farmers. The sample population was attended in person and the required data were collected with the help of a pre-tested comprehensive interview schedule.

In the foregoing chapters, the profile of the study area, characteristics of the sample farmers, cost and returns, energy utilisation, energy use efficiency, determinants of per acre output energy, substitution and complementarities between energy inputs have been discussed. The major findings along with suggestions and conclusions are presented in the final chapter.

7.1 Summary of Findings

It is observed from the characteristics of sample farmers cultivating paddy and banana that more than 40 per cent of the farmers belonged to the age group of 40-50 years. Similarly, the same proportion of farmers had primary education.

Family size of the farmers was invariably big and more number of family members was found to participate in agricultural activities in both the small and large farmers groups.

It was found that proportion of farmers with farming experience of more than five years of paddy and banana cultivation was 80 per cent and 75 per cent respectively in the case of small and large farmers. Thus, it may be concluded that participation of middle-aged farmers with better literacy and long-term association of farming activities may result in better yield and good returns.
The input structure revealed that yield per acre between paddy and banana was found to be significant. It was observed that banana reaped higher yield than paddy per acre. Inputs such as chemical fertilizer, pesticide, mechanical power and seed used for the two crops were statistically significant with output. It was observed that quantities of input application were found to be greater for banana than that of paddy.

Regarding small and large farmers producing paddy, the difference in yield was found to be significant and it was noticed that the rate of return was high in the case of large farmers. The differences in per acre input of energy - human labour, chemical fertilizer, irrigation and mechanical power, were statistically significant for the two groups of farmers. In paddy cultivation, the large farmers applied more quantity of inputs than small farmers.

The input-output structure of paddy per acre between small and large farmers was 2,639.15 kg. and that for the large farmer was 2,859.21 kg. Therefore, the third hypothesis that ‘there is no difference in yield of paddy between small and large farmers’ is disproved. Hence, there was indeed a significant difference in yield per acre between the small and the large farmers.

In the case of banana, the difference in per acre yield was statistically significant for both the groups. Per acre application of inputs was statistically significant. It was observed that large farmers have utilised more quantity of inputs than small farmers.
The input-output structure of banana cultivation per acre between small and large farmers was 11,521.61 kgs. per acre for the small farmers and 11,639.15 kgs. per acre for the large farmer. Therefore, the fourth hypothesis namely, ‘there is no difference in yield of banana between small and large farmers’ is not true. Hence, there was indeed, significant difference in yield per acre between the small and large farmers.

Regarding the cost and return structure, the analysis revealed that the large farmers received higher returns `34,310.52 than the small farmers (`31,669.80) producing paddy. The amount spent per acre was found to be higher for large farmers than for small farmers. The analysis of economics of cultivation of paddy reveals that each rupee spent resulted in an appreciable benefit for large farmers. Thus it is concluded that returns for the large farmers were higher than that for small farmers in paddy cultivation.

Regarding cost and returns structure, for banana cultivating the net income received by the large farmers was found to be higher (`1,97,865.55) than that of small farmers (`1, 95,867.37). The total cost incurred was found to be less in the case of small farmers (`31,546.40) than large farmers (`35,030.09). It was also observed that large farmers gained more (`0.85) than the small farmers (`0.74) over a rupee spent on cultivation of banana. Thus, it is concluded that in banana cultivation too, large farmers were benefited more than the small farmers.

Regarding the utilisation of different energy inputs, small farmers were found to cultivate paddy in 388.16 acres and to consume 9,35,754.38 MJ of energy
inputs. For the large farmers, the requirement was 9,55,161.90 MJ of energy inputs for cultivation in 391.21 acres. The per acre energy consumption was 2,410.74 and 2,441.56 MJ for small and large farmers respectively, producing paddy in the study area. Thus, it is observed from the analysis that large farmers consumed more energy inputs per acre than the small farmers during the period under study.

It is inferred from the analysis that the largest share in total energy utilisation was found in fertilizer energy for producing paddy, which accounted for 3,41,511.64 MJ and 3,38,851.91 MJ for small and large farmers respectively. The minimum share went to seed energy, which accounted for 6,315.15 MJ and 5,561.45 MJ for small and large farmers respectively.

In the case of banana, small farmers grew crop in 411.65 acres and utilised 11,31,970.60 MJ of energy inputs while the large farmers used 12,50,872.73 MJ of energy input for cultivation in 466.45 acres. Per acre energy consumption was 2,749.83 MJ and 2,681.70 MJ for small and large farmers respectively.

Thus, it is concluded that large farmers consumed more energy per acre than the small farmers per acre in the study area. The maximum energy consumption per acre was found in respect of fertilizer energy for both small and large farmers cultivating banana.

It is observed that per acre output energy of paddy was 2,864.34 MJ and 2,976.01 MJ for small and large farmers respectively. Producing banana was 3,316.16 MJ and 3,261.65 MJ for small and large farmers respectively. Thus it is
inferred from the analysis that large farmers in the case of paddy and small 
farmers in the case of banana reaped higher benefits in terms of per acre output 
energy than other energy sources.

The analysis of input-output energy ratio revealed that the ratio was higher 
for the small farmers than for the large farmers in both crops.

Thus, it is observed that more energy inputs were more effectively and 
efficiently used by small farmers than by large farmers.

The analysis of energy equivalence in MJ joules in terms of rupee value 
revealed that a rupee spent on bullock energy earned the higher of 0.92 MJ while 
seed energy earned the lowest of 0.06 MJ in the case of small and large farmers 
producing paddy. Further, it is inferred that the highest amount was spent for one 
MJ joules of seed energy (15.47). The least cost was 1.09 and 1.23 for bullock 
energy for both the small and large farmers.

In the case of banana a rupee spent on seed energy was observed to earn the 
least value of 0.06 MJ while bullock energy earned the highest value of 1.04 MJ 
and 0.78 MJ for both small and large farmers.

Further it is observed that the amount required for 1MJ joules was 
maximum for seed energy and minimum for bullock energy.

The analysis of the determinants of per acre output energy of paddy and 
banana revealed that fertilizer energy followed by the human energy had a greater 
influence on the determination of per acre output energy for small farmers 
producing paddy than for large farmers. In the case of large farmers among the
significant energy inputs, human energy had greater influence on determination of
per acre output energy followed by mechanical energy.

Chow's test revealed that there existed structural differences between small
and large farmers producing paddy. The computed F-value was found to be about
3.61 which was higher than 1.95, the table value. Therefore, the fifth hypothesis
namely ‘There is no difference in amount spent for inputs between small and large
farmers producing paddy’ is invalid. Hence, it is concluded that there was
structural difference between small and large farmers producing the paddy. It was
observed that nature of technical change was neutral for both the groups of
farmers.

The structural change was due to the variable mechanical energy in the
study area. It is understood that one per cent increase in this variable will result in
output energy increase by 0.0817 per cent and 0.0616 per cent for small and large
farmers respectively.

The fitted multiple linear regression model results for banana showed that
human energy played a greater role in per acre output energy for both small and
large farmers. The Chow's test adopted to find out the structural difference that
existed between small and large farmers producing banana. The table value of the
F-test (1.95), the computed value (1.66) was found to be less and statistically
significant at one per cent level. Therefore the sixth hypothesis that, ‘there is no
difference in amount spent for inputs between small and large farmers producing
banana’ is accepted. The results of the Chow's test showed that there was no structural difference between small and large farmers producing banana.

In order to test the hypothesis that there was no structural difference between cost and output of paddy and banana, Chow's test was adopted. The results indicated that there existed structural differences between the two crops. The difference between the two crops existed only at the slope level. It indicated that the nature of technical change was neutral and the difference was caused by the variable, bullock energy.

The analysis of resource use efficiency of different energy inputs showed that human energy, fertilizer energy and irrigation energy were utilised in paddy production for both the groups of farmers in the study area. In the case of banana, human energy, fertilizer energy and irrigation energy were under utilised in both the groups of farmers. Mechanical energy was found to be better utilised for large farmers producing both varieties. Thus it may be concluded that there was scope for increasing use of resource inputs for both paddy and banana to maximise their return.

The analysis of substitution and complementarities between energy inputs reveals that human and mechanical energy were substitutes in the case of small farmers producing paddy. It was also observed the existence of complementarities between fertilizer energy and pesticide energy. In the case of large farmers producing paddy, complementarities between mechanical and fertilizer energy was observed.
The estimated results of Allen Elasticity of Substitution indicated that substitution between human energy - mechanical energy, bullock energy - mechanical energy, and pesticide energy - fertilizer energy was established in the case of small farmers. Elasticity of substitution between human energy - mechanical energy, and bullock energy - mechanical energy was found to be significant. Complementarities were found between human energy and fertilizer energy in the case of large farmers.

The estimated results of 'own and cross price elasticity of demand' revealed that own price elasticity of human energy was less than unity indicating the necessity of human energy in all operations in the case of small farmers producing paddy. The cross price elasticity showed that there was positive price elasticity of demand between human and mechanical energies and human and fertilizer energies.

In the case of large farmers producing paddy the highest own price elasticity was found for mechanical energy in the study area. Own price elasticity of demand was found less than unity in all energy inputs. High cross price elasticity was found for human and fertilizer energy, mechanical and human energy, and mechanical and bullock energy.

In the pooled category, mechanical energy had a greater impact on the cost of cultivation of paddy in the study area. There was also a positive relationship found between cost and output. Therefore the first hypothesis that ‘There is positive relationship between cost and output of paddy in the study area’ is proved.
In the case of banana energy demand except human energy, from all other energy inputs was price elastic. The highest own price elasticity was observed for mechanical energy in the case of small farmers. The significant cross price elasticity was found between human – mechanical energy and bullock – mechanical energy. It indicated that an increase in price of human and bullock energy led to an increase in demand for mechanical energy. Thus it confirmed the substitutability between human – mechanical energy and bullock – mechanical energy.

In the case of pooled category, three out of five price variables namely human energy, fertilizer energy and mechanical energy were statistically significant and positively related to the cost of cultivation of banana in the study area. Price of mechanical energy had a greater impact on cost of cultivation. Hence, a positive relationship was observed between cost and output. Therefore the second hypothesis that ‘There is positive relationship between cost and output of banana in the study area’ is proved.

In the case of large farmers, the negative own price elasticity indicated high price elastic. The estimated results of cross price elasticity of human energy and mechanical energy indicated the substitutability between human and mechanical energy.
7.3 Suggestions

To increase productivity and sustain soil health, it is essential to adopt improved agronomic practices. This calls for timely sowing, appropriate spacing depending on the variety of hybrids, adequate irrigation during the critical stage, and the balanced use of fertilizers according to soil requirements. Organic manures such as farmyard manure, green manure, crop residue and recyclable waste are good sources of nutrients.

Selection of high yielding varieties or hybrids based on soil and agro-climatic condition and seed treatment will also give the desired yield.

There is inequality in the distribution of net energy among the farmers in the study area. To eradicate this, the farmers may be instructed regularly to use the recommended input energy. The Government may take steps to provide good quality of seed, fertilizer and pesticide at subsidised prices. In order to avoid the farmer's loss in cultivating paddy and banana, procurement centres may be effectively set up by the Government.

Liberal financial assistance may be made available to the cultivators as crop loans through commercial banks and co-operative societies.

7.2 Conclusion

Agriculture in India, the principal sector of the economy, is the source of livelihood of almost two thirds of the workforce in the country. The contribution of agriculture and allied activities to India's economic growth in recent years has
been no less significant than that of industry and services. The importance of agriculture to the country is best summed up by renowned economists by this statement: "If agriculture survives, India survives".

The early years of Independence witnessed emphasis on the development of infrastructure for scientific agriculture. The steps taken were the establishment of fertilizer and pesticide factories, construction of large multi-purpose irrigation-cum-power projects, organization of community development and national extension programmes and above all, the starting of agricultural research institutions in the country. However, the growth in food production was insufficient to meet the consumption needs of the growing population which necessitated food imports.

In fact, Indian agriculture still continues to face internal and external challenges in many parts of the country. The aspects such as monsoon dependency, fragmented land-holding, poor energy management tactics, outdated agronomic practices, lack of technology application and poor rural infrastructure are some of the key internal constraints that discourage a healthy growth of agricultural productivity.

Agricultural energy management has a critical role in issues like higher agricultural production and rural employment generation. Periodic assessment of energy use and need through surveys, operations research and liaison with the line departments, private, public and non-governmental organizations, farmers and
other interest groups should be carried out for finding timely solutions for such issues.

There are thrust areas for improving practical agriculture. The development of precise energy use methods, machinery and strategies for carrying out timely and efficient agricultural operations in irrigated and rain-fed conditions will be of much use. Increasing energy efficiency by employing an integrated pattern of human use, animal and mechanical energy systems and by reducing the occupational hazards in agricultural operations may be planned. Further, energy management and utilization of conventional and non-conventional energy sources in agricultural production and processing activities should be encouraged.

Thus, enhancement in agricultural productivity becomes essential to meet the ever increasing food demand despite shrinking natural resources and impending climate change. Indeed, the objective of every policy should be helpful to make Indian agriculture globally competitive by producing globally acceptable quality crops at globally comparable cost.

It is concluded from the above analysis that the largest share in the production of paddy and banana was recorded by the fertilizer energy and the least share went to seed energy. It is understood that there is a need to improve paddy and banana cultivation technology in order to increase the efficiency of energy inputs, used in the study area. Further, there is a scope for increasing the use of energy inputs so as to earn the maximum returns. Energy use efficiency can also
be improved by practicing good husbandry, as there is scope for increasing yield through the use of higher inputs efficiently.

7.3 Scope for Further Research

This study gives scope for further research in energy use pattern in agricultural sector.

This study opens up further avenues of research in the context of a comparative study on energy use pattern in paddy and cotton.

Further, research study on the energy requirement and energy efficiency for production of major agricultural crops.