ENERGY EFFICIENCY STUDY OF AGRICULTURE PUMP SETS IN THE STATE OF KERALA

June 2018

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DETAILED PROJECT REPORT

Year: 2018

Conducted by

Energy Management Centre – Kerala
Dept. of Power, Govt of Kerala
State Designated Agency of Bureau of Energy Efficiency,
Govt of India

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ABBREVIATIONS USED

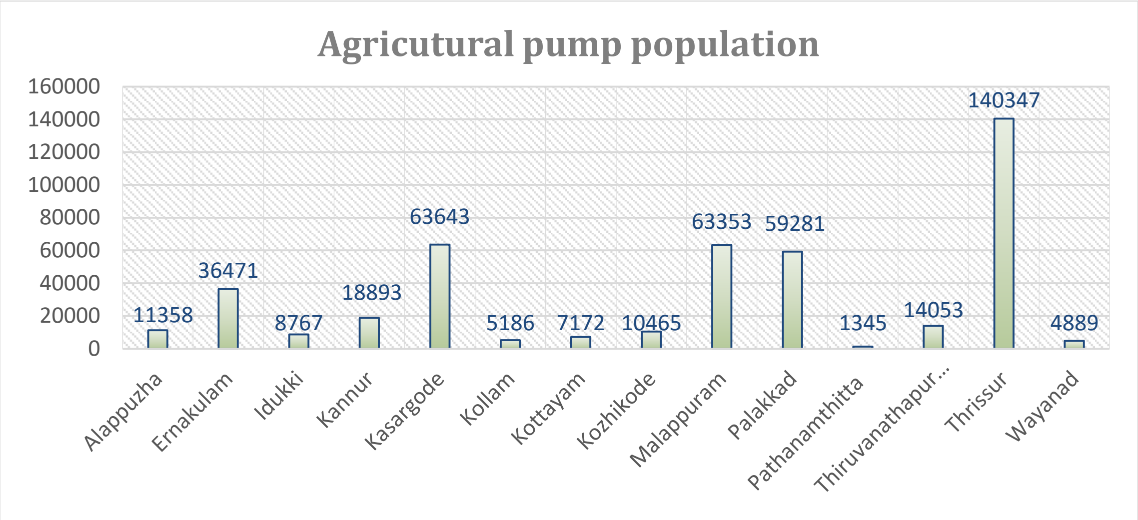
BEE	:	Bureau of Energy Efficiency
EMC	:	Energy Management Centre
KSEBL	:	Kerala State Electricity Board Limited
BCM	:	Billion Cubic Meter
GHGs	:	Green House Gases
UNIDO	:	United Nations Industrial Development Organization
DISCOMs	:	Distribution Companies
EESL	:	Energy Efficiency Services Limited
ESCOs	:	Energy Service Companies
HDPE	:	High Density Polyethylene
HVDS	:	High Voltage Distribution System
EEPS	:	Energy Efficiency Portfolio Standard
GI	:	Galvanized Iron
PVC	:	Polyvinyl Chloride
PPP	:	Public Private Partnership
MW	:	Mega Watt
KWH	:	Kilowatt Hour
MU	:	Million Units
BEP	:	Best Efficiency Point

EXECUTIVE SUMMARY

1. The study of agriculture pump sets in the state of Kerala to prepare a Detailed Project Report (DPR) for replacement of in efficient pump sets to conserve energy was undertaken by Kerala State Productivity Council (KSPC), during 2018 based on the work order received from Energy Management Center-Kerala, under the Department of Power.

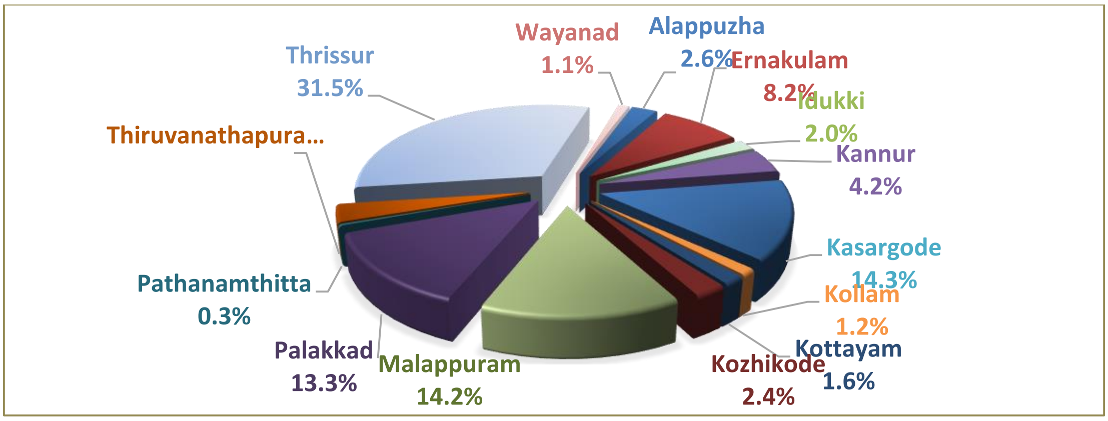
2. The study was commenced with collection of list of agriculture pump sets in the state of Kerala from Agriculture department, KSEBL, Irrigation Department, DISCOMs etc. The total number of agriculture pump sets in the state of Kerala is 4,45,223. (The soft copy of the entire list is attached in the form of CD).

3. The following figure shows the distribution of pump sets in the state of Kerala.



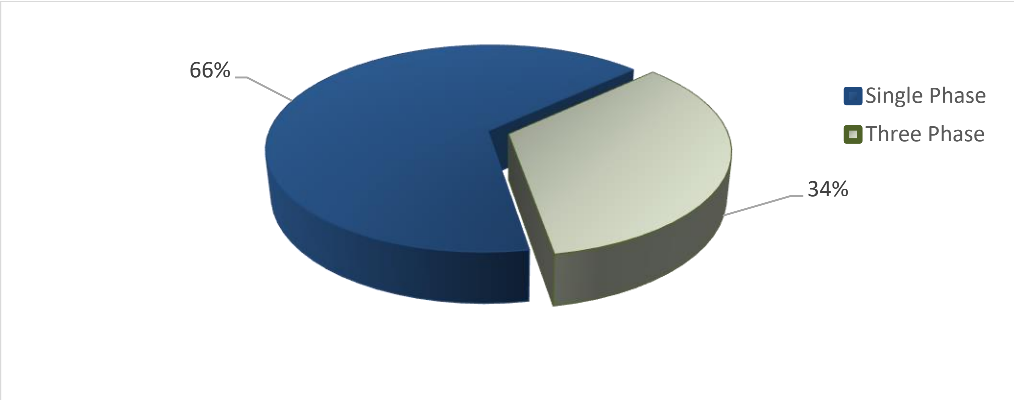
3.1 Among the total population, 31.5% of the total pump sets have been distributed in Thrissur district. The percentage distribution of the agriculture pumps in varies districts is given below:

Agriculture pump distribution district wise

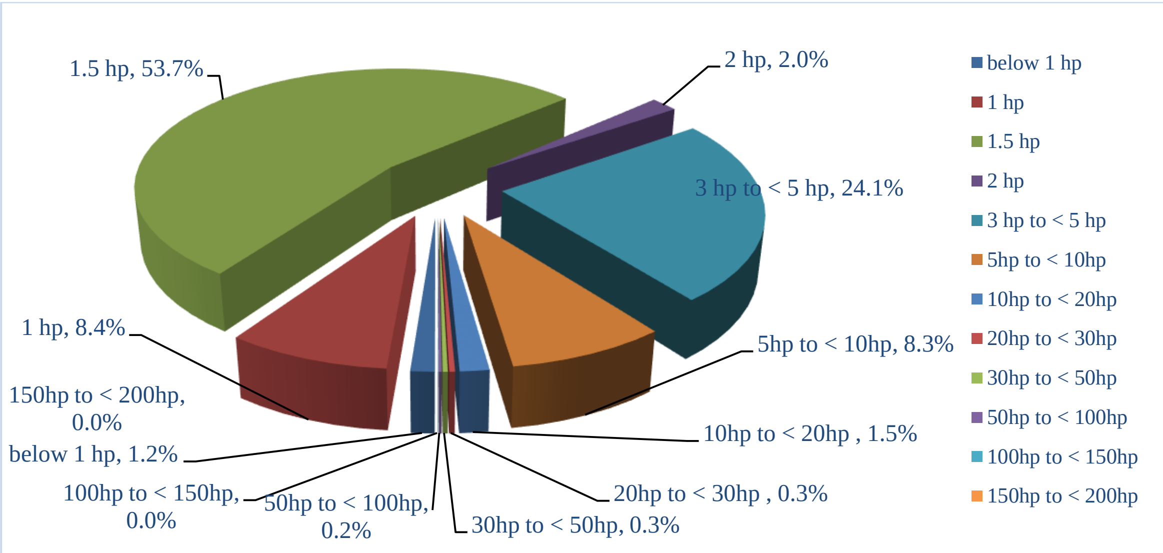


3.2 Of the total agriculture pump sets 66% were single phase and the 34 % were three phase.

Classification of pumps based on Phase (Single/Three Phase)



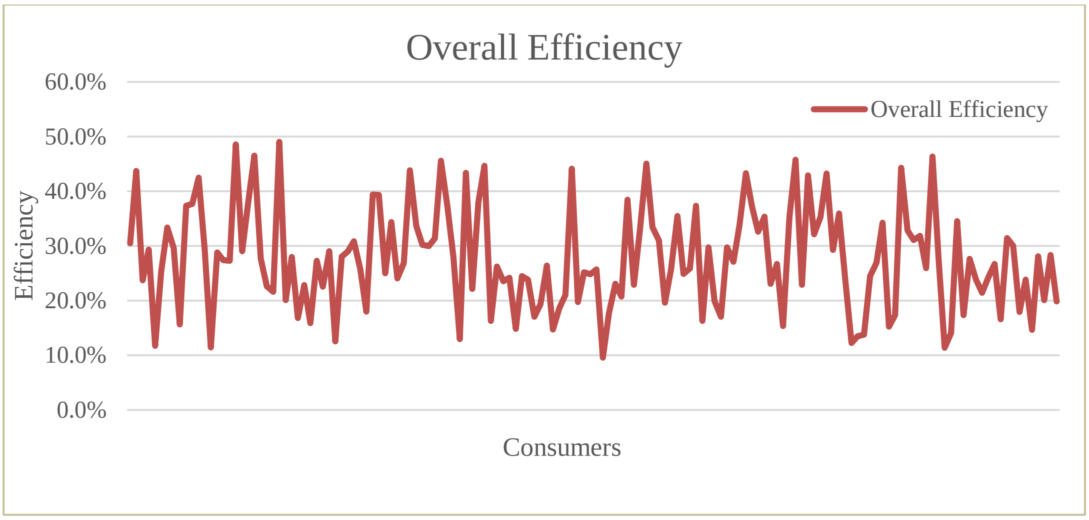
3.3 The percentage distribution of various rated pumps in the state of Kerala is graphically represented below: The 1.5 HP category pump dominates with a total number of 239303, which is 53.7% of the total agriculture pumps.



4. Representative samples of 150 pumps from all the districts of Kerala were identified taking into consideration of type, make, size, age etc. (Please refer table 4 in the chapter 8 of the detailed report for details). The geographical identification of pumps covered under the sample study is given below:

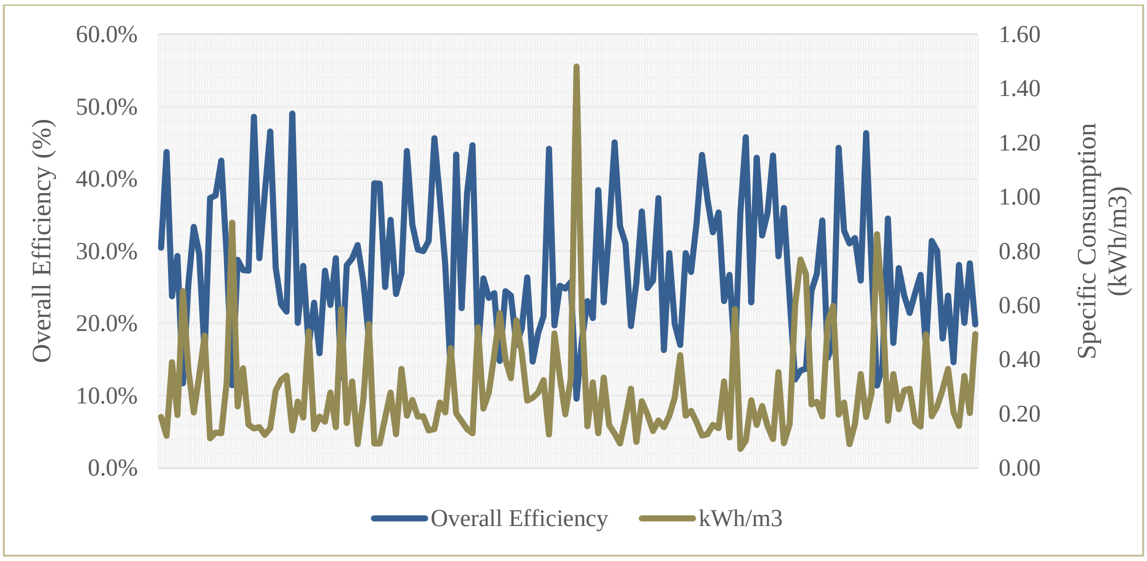
5. Our team of engineers visited each of the pump installations identified for field survey and measurements (refer Para no. 4). Power measurements, Water flow measurements, piping layout, data collection etc. (Please refer Appendix no. 3 for detailed data sheet for each installation) were carried out to arrive at operating efficiency of each installation(Please refer 8.3 in Chapter 8 for Overall approach & methodology used for the study). Details of the pump efficiency evaluation of the 150 pumps were given in para 8.12 of the detailed report.

5.1 The efficiency variation of the 150 consumers are plotted graphically and given below: From the efficiency evaluation of 150 sampled pumps, the average overall efficiency obtained is 27.6% among which maximum efficiency identified is 49.1% and the minimum efficiency is 9.6%.



5.2 The specific Power Consumption (kWh/m^3) for each pump sets were also computed and it ranges from 0.09 to 0.91 kWh/m^3. The overall efficiency and the specific Power consumption (kWh/m^3) of pumping system is plotted and given below:

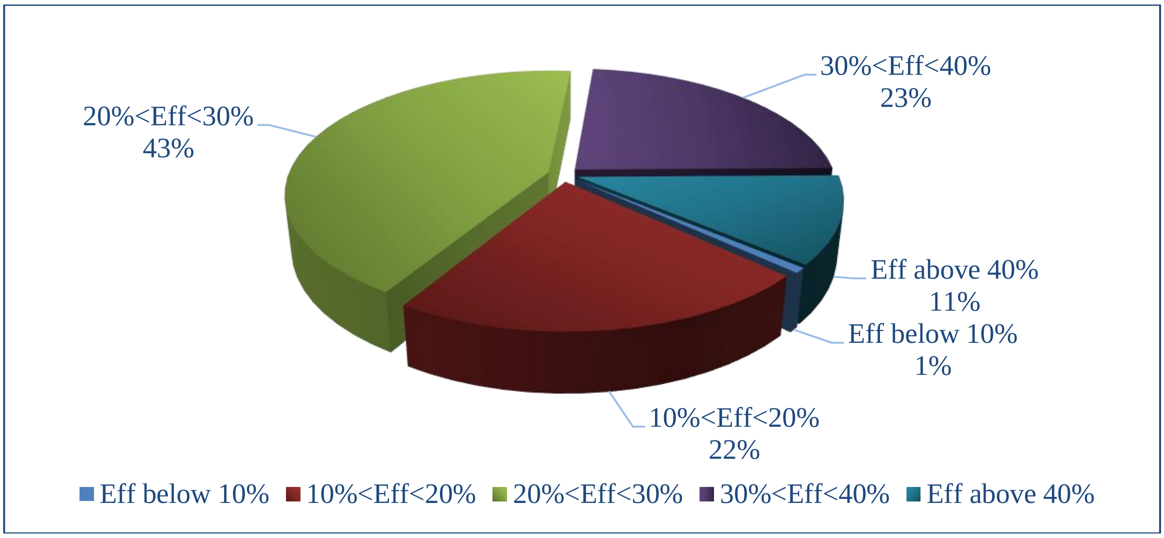
Relationship between Overall efficiency & Specific Power Consumption



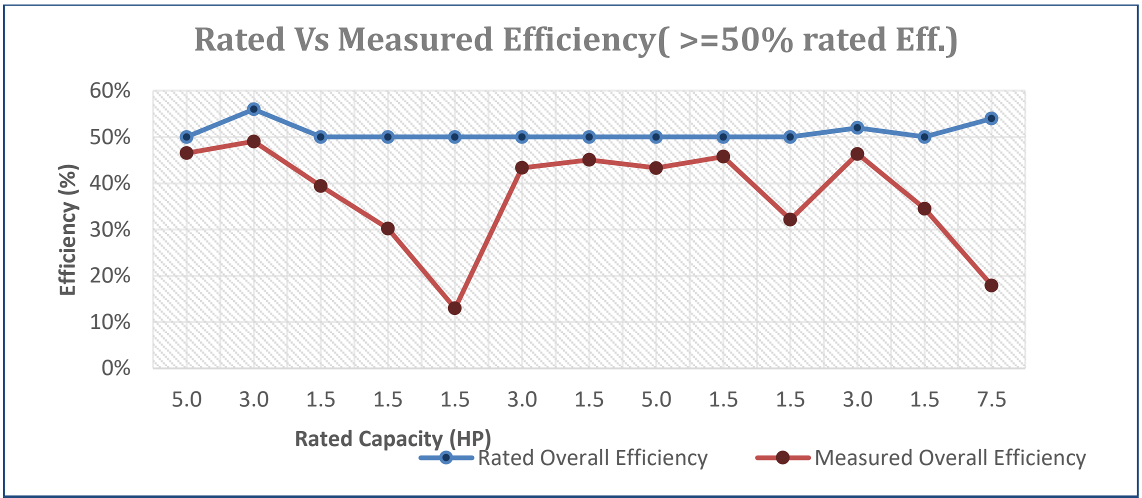
5.3 From the above, specific power consumption (kWh/m^3) has a definite bearing with the overall efficiency and is evident. (Refer para 8.20 for detailed description)

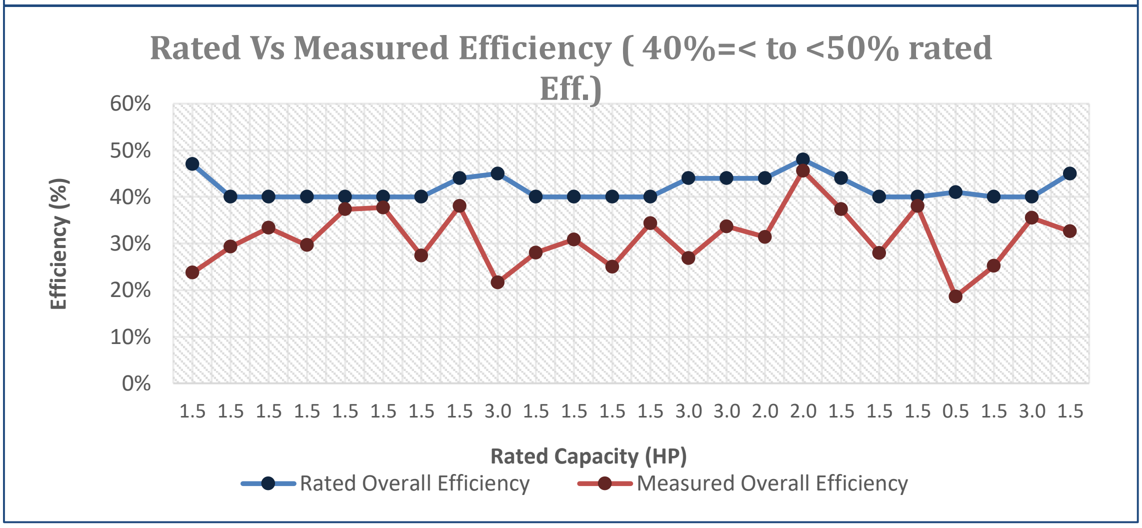
5.4 Efficiency level easily points out the poor working level of the agriculture pumping system in most of the cases. Only 11 % of the total pumps are operating above 40% of overall efficiency. The efficiency variation of the pumps are given below:

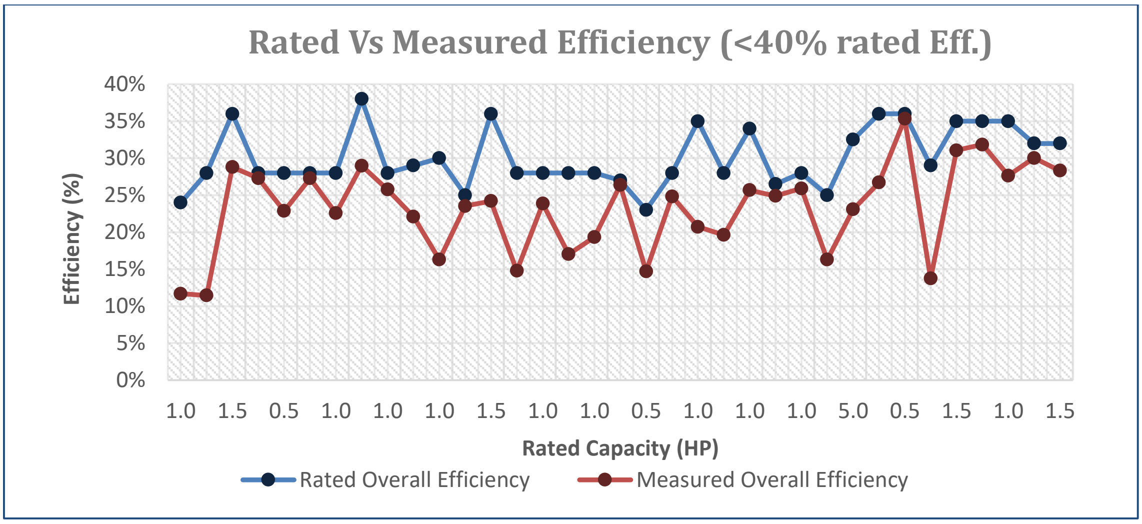
Overall efficiency variation of sampled pumps



5.5 A comparative analysis has been carried out between present overall efficiency and rated efficiency of different category pumps. The details of analysis is given below:



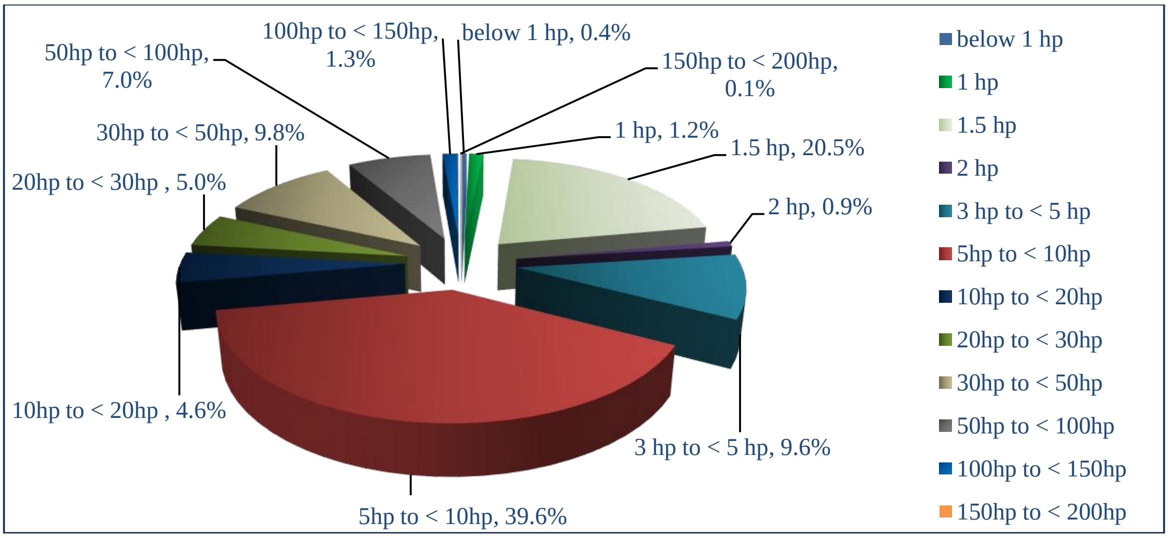




5.6 The efficiency gap (difference between rated efficiency and actual efficiency) varies from 0.6% to 37% as shown in the above graph. From the above analysis we can see that, the higher overall efficiency achieved during the survey was only for pumps with higher rated efficiency and it is also observed that some pumps with high overall efficiency are operating with lesser operating efficiency.

5.7 The energy consumption pattern of the various capacity pumps are also analysed during the study by taking the average energy consumption from the electricity bill on random basis and the percentage energy consumption distribution of each category pump is given below:

Percentage Share of consumption of varies category pumps



5.8 The category of pumps belongs to 5 hp to < 10 hp pumps have high energy consumption which accounts 39.3% of the total energy consumption. The average efficiency level of this category pumps identified is only 27.5%.

6. **Key Factors effecting the overall energy efficiency of agriculture pumps**

- Actual Pump set rating higher than name plate rating and sanctioned load
- Mismatching pump and system Head-Flow characteristic

6.1 There are various parameters that could affect the pump set efficiency performance. Parameters identified that could affect the pump performance are listed below and discussed in detail in subsequent sections. Refer Para 8.22 for detailed description

- Energy inefficient pump sets
- Improper pump selection and usage
- Undersized pipes
- Suction head variations and large discharge lengths
- Motor rewinding and low voltage profile
- Water table variations
- Other common causes

6.2 It is also observed that irrigation pumps of capacity ranging from 40kW to 150 kW are operating in LT supply resulting reduced line voltage which will affect other domestic consumers in the feeder, increased line current resulting higher energy losses and reduced motor life due to high current drawn by the motor. So it is recommended to operate the irrigation pumps through HT supply with the help of separate transformer to have better operating condition.

6.3 The overall weighted average operating efficiency for existing pump sets is arrived at 27.6% based on Energy Efficiency Calculations done for 150 pumps. However, to be on conservative side minimum overall efficiency of BEE 5 star labelled pumps (150nos) and achievable overall efficiency (in field conditions) for different category pumps considered for the up gradation is tabulated below:

Pump Category	Average Minimum efficiency of measured pumps (IS Std)	5 Star Labelled Minimum efficiency	Minimum Expected Efficiency (in field condition)
below 1 hp	23.9%	28.6%	20%
1 HP	27.6%	33.1%	25%
1.5 HP	37.8%	45.3%	35%
2 HP	38.5%	46.2%	35%
3 HP to < 5HP	44.3%	53.2%	40%
5hp to < 10 HP	50.9%	61.1%	40%

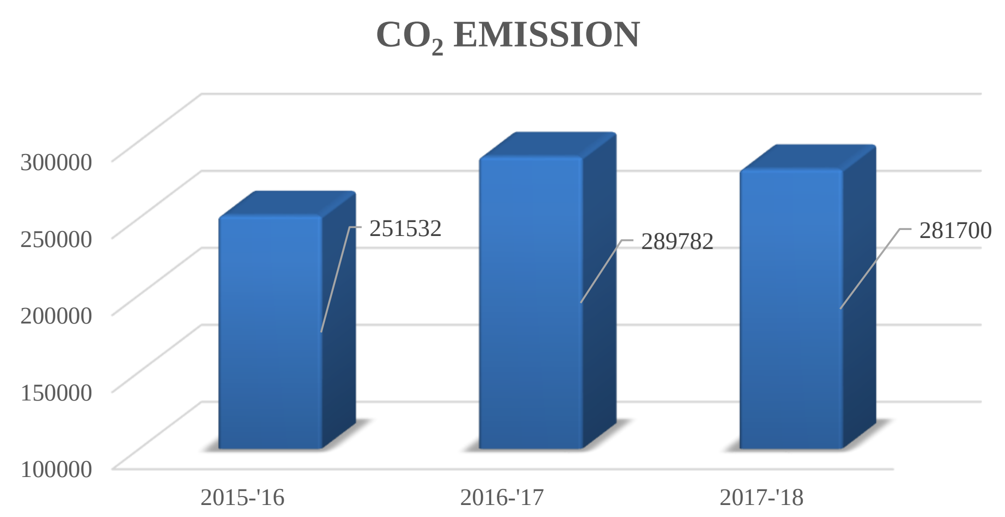
6.4 The anticipated economic benefit achieved by improving the overall average operating efficiency (field condition) of the present pumping system as per above table for the 150 pump sets is tabulated and given below:

Power Consumption of the 150 no. of pumps	=	254.4	kW
Total Consumption of 150 no of pumps	=	52776	kWh
Power Estimated at 35% overall efficiency	=	199.8	kW
Savings in the power	=	54.6	kW
Percentage Savings in Power	=	21.5%	
Estimated Consumption after improving the overall efficiency	=	36615	kWh
Total Estimated savings on consumption of 150 no of pumps	=	16161	kWh
Estimated percentage Savings	=	30.6%	

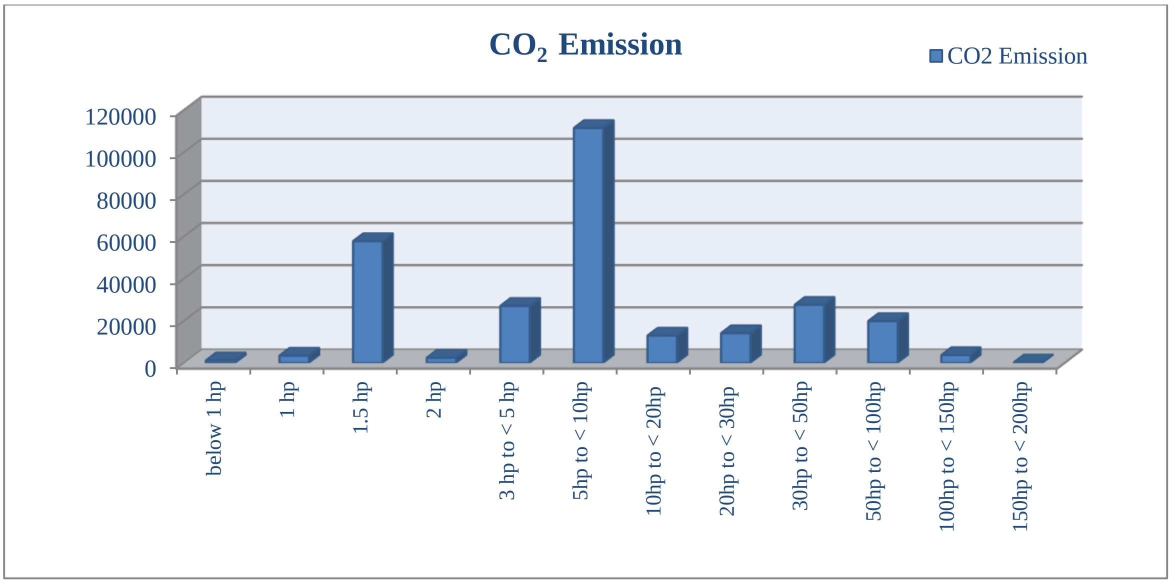
6.5 The energy saving potential is estimated only for improvement in the system efficiency due to replacement of existing pump sets with energy efficient pump sets.

7. As part of the DPR Study conducted, an analysis has been carried out to find out the existing CO_2 emission due to the energy consumption in the agriculture pumps.

	2015-'16	2016-'17	2017-'18	
Electrical Energy Consumption	279.48	321.98	313	MU
AnnualCO_2 Emission	251532	289782	281700	Tons

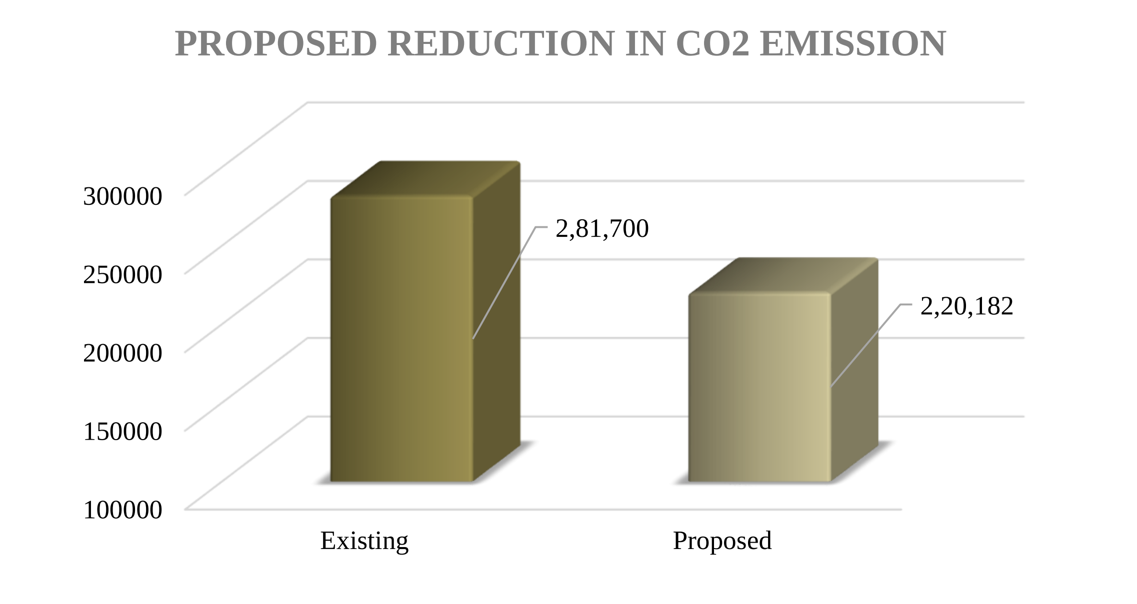


7.1 The CO_2 contribution of the different category of the pumps for the year 2017-'18 is given below:



7.2 Based on the proposed reduction in energy consumption, the reduction in the CO2 with respect to the previous year is given below:

	Existing	Proposed	
Electrical Energy Consumption	313	244.6	MU
Annual CO_2 Emission	281700	220182	Ton



8. The overall operating efficiency ranges from 9.1% to 49.1%and is because of the mainly two reasons

- Low rated efficiency of the pump sets
- Inefficient Operating Conditions

8.1 Among the 4,45,223 agriculture pump sets in Kerala, 97.8% of total pumps is falling under the category of below 10 hp capacity and its consumption is around 72.2% of the total consumption.

8.2 The overall rated efficiency of 54.8% of sampled pumps of 150 Nos is only less than 40%. From the analysis it is estimated that the present average overall efficiency of these pumps is only 23.3%.

8.3 The inferior quality pumps used in the sector is identified as one of the primary reasons for the poor operating efficiency in agriculture pumping sector. The energy efficiency improvement project in agriculture pumping system shall be implemented phase by phase.

8.4 **Phase -1 : Replacement of pump sets with overall rated efficiency less than 40% with energy efficient pump sets**

8.4.1 Based on the analysis carried out, a savings potential of about 68.4 MU per year has been identified by the replacement existing local made & low rated overall efficiency (below 40% efficiency) pumps falling under below 10 hp category. The detailed analysis is given below:

Pump Category	Total No. of pumps	Total No. of pumps below 40 % rated overall efficiency	Approx. Cost per Pump	Total Cost of the pumps (lakhs)	Percentage share of Total Energy Consumption of the pumps	Total Consumption (MU)	Savings in Energy Consumption by Pump Replacement @ 30.6%	Cost savings (lakhs)
below 1 hp	5445	2984	4500	134.3	0.4%	1.3	0.40	8.0
1 hp	37546	20575	7500	1543.1	1.2%	3.8	1.18	23.6
1.5 hp	239303	131138	8500	11146.7	20.5%	64.1	19.64	392.8
3hp to < 5hp	107293	58797	13000	7643.6	9.6%	30.0	9.19	183.8
5hp to < 10hp	36781	20156	23000	4635.9	39.6%	123.9	37.94	758.8
Total	**426368**	**233650**		**25103.6**			**68.35**	**1367.1**

8.5 Phase -2 : Efficiency improvement by matching the operating conditions with pump characteristics

8.5.1 Based on the survey conducted it was found that the rated overall efficiency of around 45.2% of the total agricultural pump sets in Kerala is above 40% efficiency of which most of the pumps are higher rated pumps but its present operating efficiency is only 27.6%. This lower operating efficiency of this pump is mainly due to the following reasons. (Detailed explanation is given in the para.8.22 of detailed report)

- Undersized pipes
- Suction head variations and large discharge lengths
- Motor rewinding and low voltage profile
- Water table variations

8.5.2 Considering the above facts and higher rating of the pumps it would be feasible to improve the operating efficiency of these pumps by improving the operational condition rather going for pump replacement. This can be implemented by adopting the following :

- A proper study should be carried out focusing on matching the existing operating point of pumps to the BEP by analyzing the flow, head, average water table on different locations, layouts, capacity analysis etc.
- The modification of the pipe layout maybe done to match the designed head-flow of the existing pumps.
- After the doing the above exercises and next phase study pumps operating with lesser efficiency may be replaced with star labeled/energy efficient pumps as next stage.

9. Business model for replacement of inefficient pump sets to conserve energy

9.1 The purpose of the exhaustive study on agricultural pumps across Kerala is to develop an implementable Detailed Project Report for replacement of inefficient pump sets to conserve energy.

9.2 To account the possible financing options, two different business models can be been developed and categorized as ESCO Mode and DISCOM Mode as described chapter 10.

9.3 Overall Project Cost: The total project cost estimated for the proposed project is about Rs. 31505 Lakh

Particulars	Value in (lakhs)
Cost of Energy Efficient Pump Sets (EEPS) (Rs.)	25103.6
Cost of dismantling existing pump sets and installing EEPS (approx.10%)(Rs.)	2510.4
Contingencies (approx.3.5%) (Rs.)	878.6
Project Management Consultancy (approx.12%) (Rs.)	3012.4
Total project cost (Rs.)	**31505.0**
Estimated Annual Savings (Rs.) @ Rs. 2/kWh –LT-V Tariff	1367.1
Simple payback period (years) @ Rs. 2/kWh –LT-V Tariff	23.0
Estimated Annual Savings (Rs.) @ Rs. 6.2/kWh –Purchase Tariff	4237.9
Simple payback period (years) @ Rs. 6.2/kWh –Purchase Tariff	7.4
Demand Savings	
Estimated annual Savings (MU)	68.35
Average annual pump operating days	250
Average daily pump operating hours (hrs)	2.75
Daily savings in energy consumption (kWh)	273413
Anticipated Demand Savings (MW)	**100**

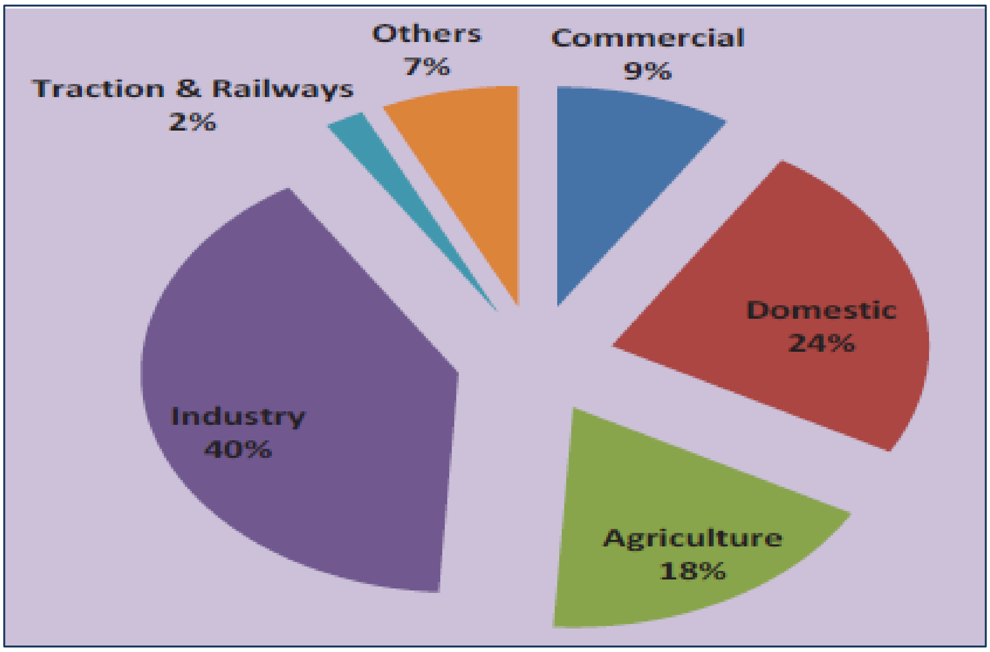
1. INTRODUCTION

1.1 India's primary energy consumption was 753.7 million tonnes oil equivalent in 2017, which is about 5.6% of the world's consumption and third highest after China and the United States. Its energy consumption is projected to grow by 4.2% annually, faster than all major economies in the world. Indian economy faces significant challenges in meeting energy needs in the coming decades.

1.2 The Agriculture is the one of the most important sector of Indian Economy. There are more than 20 million irrigation structures used in the India. That is four times the number of irrigation structures in China, Iran, Mexico, Pakistan, and the United States Combined.

1.3 The agriculture sector consumes approx. 18% of the total electricity consumption, and its power consumption is expected to rise by an estimated figure of 54% between 2015 and 2022.

Figure 1 Electricity Consumption by Sectors in India during 2016-17



Source: Energy Statics 2018, Central Statistics Office

1.4 The power consumption pattern in agriculture consumption is increased up by 10% from 1970. The high rate of growth in agriculture electricity consumption results from aggressive rural electrification coupled with a policy of below cost pricing to farmers. The result "a high share of total electricity used for irrigation pumping and very low revenue generation on agricultural sales" has created an increasingly unsustainable situation. The inefficient power user in India provides immense opportunity to save energy through better Demand Side Management techniques.

1.5 The problem is further compounded by the fact that out of the total water used in India, 25 billion cubic meter (bcm) i.e. 83% goes for irrigation and of this amount half comes from the exploitation of the ground water resources. This not only creates stress on the water table but also is highly energy intensive. Energy intensity of pumping is increasing further because of falling water table.

1.6 This has implication for the sustainable development and its impact on the persons below the poverty line. This is because even today more than 60% of the work force in India is employed in farming activity and almost 70-80% of the poor in the country are either marginal farmers or the land-less laborers.

1.7 Besides the above, the inefficient water pumping in the agriculture sector also has its impact on global warming and climate change. The inefficient pumps operation results in higher power consumption resulting into higher GHG emission at the power plants. In India, burning of coal in power plants emits nearly 50%of the total carbon emissions. This has both global as well as local implications.

1.8 The irrigation pump sets used are generally very inefficient with operating efficiency level of 30% or less is common. The pump sets are more often oversized so as to pump more water from increasingly declining depths and also to withstand large voltage fluctuations. The energy consumption is high mainly due to

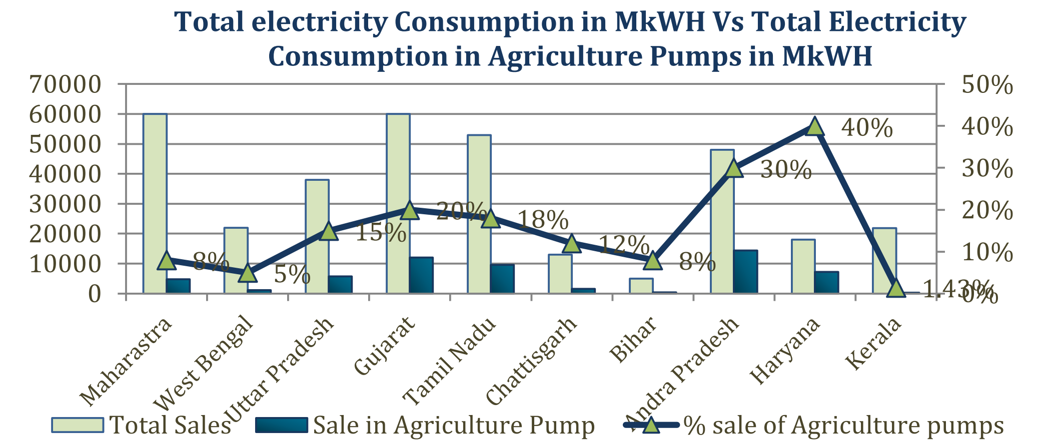
a. Improper selection and installation,

b. Use of high-friction piping, and

c. Lack of proper maintenance.

1.9 The electrical energy consumption of agriculture pump for various states in India were analysed and is given below:

State	Total Sales (mu)	% sales of Agriculture pumps (%)	Sale in Agriculture Pump (mu)
Maharastra	60000	8%	4800
West Bengal	22000	5%	1100
Uttar Pradesh	38000	15%	5700
Gujarat	60000	20%	12000
Tamil Nadu	53000	18%	9540
Chattisgarh	13000	12%	1560
Bihar	5000	8%	400
Andra Pradesh	48000	30%	14400
Haryana	18000	40%	7200
Kerala	21900	1.43%	313



1.10 Experience in India has established that the electric energy required to deliver a given quantity of water can be reduced by about 35% to 40% simply by replacing the inefficient pump set with more efficient, right-sized pump set.

1.11 National wide agriculture DSM schemes are organized to improve the efficiency of the agriculture pumping sector.

1.12 Agricultural Demand Side Management (DSM) by Bureau of Energy Efficiency

1.12.1 The objective of the program is to reduce the energy intensity of agriculture pumping sector by carrying out efficiency up gradation of agricultural pump sets. It is estimated that there are about 19 million pump sets, and 2.5 to 5 lakh new pump sets are being added every year. These pump sets are inefficient, largely because farmers have no incentive to invest in higher cost, higher efficiency pump sets due to low electricity tariffs for agriculture consumers.

1.12.2 This has resulted in increased annual subsidy burden on State governments which has grown to more than Rs. 65,000 crore per annum. Studies reveal that about 30%-40%

energy savings is possible in agriculture sector by adoption of Energy Efficient Star Labelled Pump Sets

1.13 AgDSM programs by BEE

1.13.1 **First AgDSM pilot project in Solapur, Maharstra**:-The first pilot Ag-DSM project is being implemented in Mangalwedha Sub-division of Solapur District in Maharashtra. Under this project, total 2209 pumpsets is replaced with energy efficient star rated pumpsets reflecting annual energy savings of 6.1 million units.

1.13.2 **Pilot AgDSM project in HESCOM, Karnataka** :-Replacement of old in-efficient 590 nos. of agriculture pumps with new star rated energy efficient pumps in phase one in Nippani and Byadgi circles of HSECOM, has been completed successfully. Energy savings of 37% has been achieved.

1.14 AgDSM programs by EESL

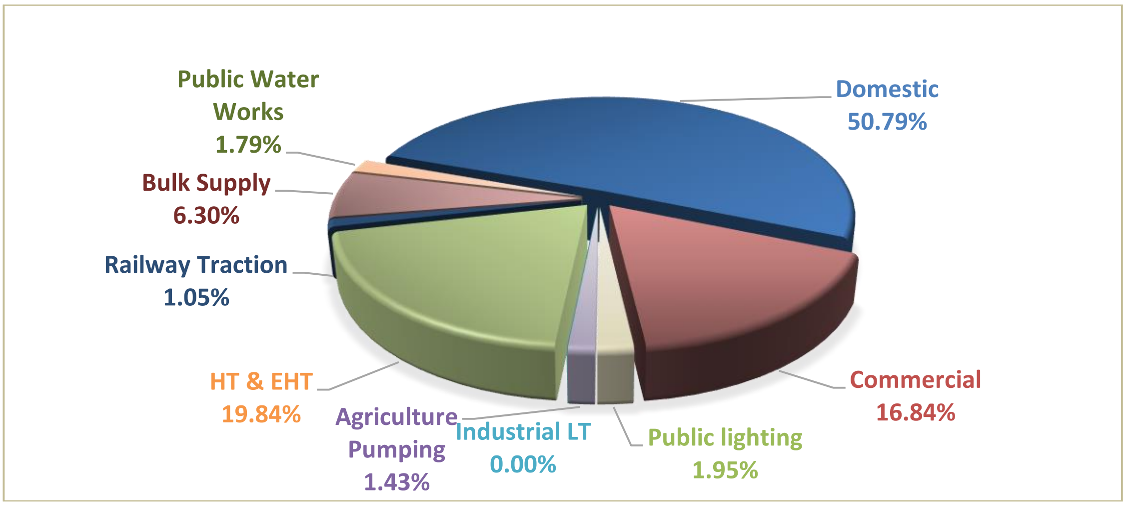
1.14.1 Replaced 1,337 pump sets in Mandya district under the Chamundeshwari Electricity Supply Corporation Limited (CESC), Karnataka.

1.14.2 Currently, EESL is undertaken replacement of 2,496 pump sets at Rajanagaram Mandal in the East Godavari district under the Eastern Power Distribution Company of AP Limited, Andhra Pradesh.

1.15 Agriculture Pumping Scenario in Kerala

1.15.1 Kerala has electricity consumer strength of more than 1.19 Cr dominated by the domestic sector, which accounts approximately 50.79% of the total energy consumption. The Energy consumption pattern of Kerala state for the year 2017- 18 is given below:

Figure 2 Power Consumption Pattern of the Kerala state



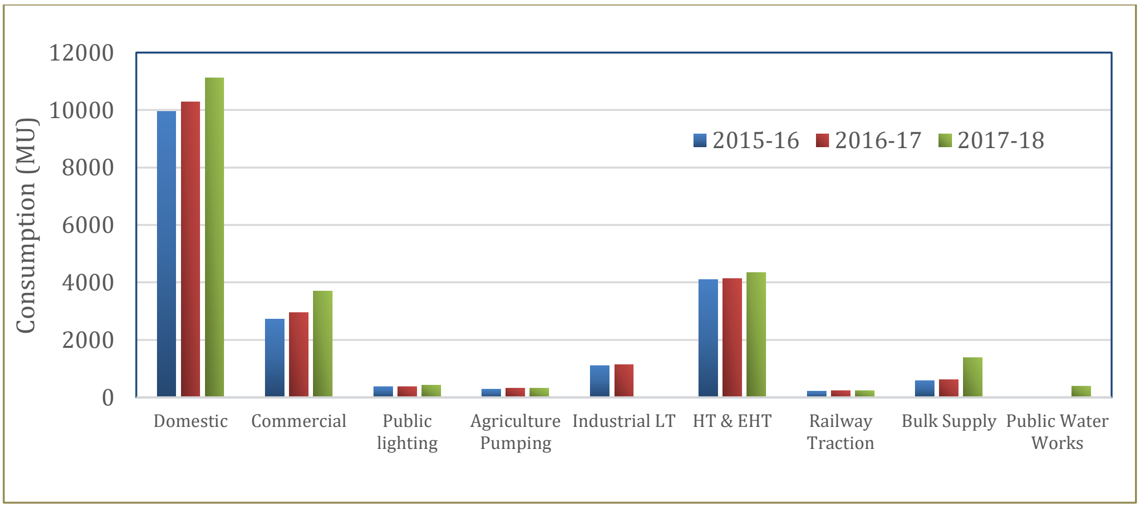
Source: 19th Electric Power Survey by Central Electricity Authority

1.15.2 The agriculture pumping consists of 3.73% of the total consumers which consumes 1.43% of the total electrical energy consumption. The total electrical energy consumption of the agriculture pumping system for the year 2017-18is about 313million units.

1.15.3 The energy consumption of the agriculture pumping system in Kerala for the year 2015-'16& 2016-'17 were 279.48 mu & 321.98 mu respectively, an increment of 15% were recorded for the successive year. The energy consumption for the year 2017-18 was 313 mu.

1.15.4 The pattern of the energy consumption of agriculture pumping of the Kerala for the year 2015-'16, 2016-'17& 2017-'18 were plotted and given below:

Figure 3 Power Consumption Pattern



Economic Review by state planning board

1.15.5 Based on the 19th Electric Power Survey by Central Electricity Authority, the energy consumption of the state for the next 10 years were projected for each particulars and details were tabulated below:

Figure 4 Projected Power Consumption

Particulars	2017-18 (MU)	2020-21 (MU)	2023-24 (MU)	2026-27 (MU)	Increase over 2017-18 (%)
Domestic	11,123	13,098	15,293	17,805	60
Commercial	3,689	4,497	5,399	6,414	74
Industrial	4,344	4,715	5,086	5,450	25
Agricultural Pumping	313	339	365	391	25
Bulk Supply	1,380	1,601	1,839	2,086	51
Public lighting	428	513	605	703	64
Public Water Works	392	437	484	534	36
Railway Traction	231	260	292	335	45
Total	21,900	25,460	29,363	33,718	54
Source: 19th Electric Power Survey by Central Electricity Authority					

1.15.6 To enhance the productivity and productive capacity of the sector, the departments have deployed various action plans, in which the farmers are directly beneficiary. The schemes developed are to augment even the bottom most point of the sector.

1.15.7 The free electricity connection to the agriculture pumps is one of the revolutionary plot among them. This scheme provides the farmers to have free electricity to the agriculture pumps, which are owned to meet the water requirement for the irrigation purpose.

1.16 Project Overview

1.16.1 The Energy Management Center-Kerala invited proposal for conducting a study of agriculture pump sets in the state of Kerala so as to prepare an implementable Detailed Project Report (DPR) for replacement of inefficient pump sets to conserve energy via letter No, EMC/EED/17/04/SAgp dated 07/04/2018 & 18/04/2018.

1.16.2 Kerala State Productivity Council (KSPC), Kalamassery submitted their offer vide letter No. KSPC/E-1/7000 dated 19th April 2018. EMC has awarded the work of conducting the study of agriculture pump sets in the state of Kerala vide WO no. EMC/EED/17/04/SAgp/WO dated 30th April 2018.

1.16.3 KSPC has commenced the above study in the month of June 2018 by collecting the list of Agriculture Pump Sets falling under the above criteria from varies sources like Agriculture department, KSEBL, Irrigation Department, DISCOMs etc.

1.17 Various types of measuring instruments were also used for carrying out necessary onsite tests for evaluation of overall energy efficiency of agriculture pumps

- Portable Load Manager (ALM 30, Krykard)
- Portable Load Manager (ALM 31, Krykard)
- Clamp on meter (MECO 4500)
- Pressure Gauge
- Ultrasonic Flow meter (UFM 6720)

1.18 About Energy Management Centre

1.18.1 Energy Management Centre (EMC) – Kerala under Department of Power, Government of Kerala, is working towards attaining energy efficiency in all sectors of economy. EMC is formulating and implementing energy conservation projects and programmes. In compliance with the Energy Conservation Act - 2001, Government of Kerala has designated EMC as the State Designated Agency (SDA) to enforce, regulate and co-ordinate the activities of Energy Conservation Act in the State. Bureau of Energy Efficiency (BEE), Ministry of Power, Government of India the coordinating agency to implement the Act in the country has identified thrust areas for reducing the energy consumption.

1.18.2 EMC is working very closely with Bureau of Energy Efficiency, Government of India and all the stake holders in initiating and implementing energy efficiency measures in the State. EMC has been bestowed with the best SDA Award in 2008, 2010, 2012, 2013 and 2014 by Government of India.

1.18.3 The Energy Management Centre, Kerala is also promoting Small Hydro Power developments in the State. The United Nations Industrial Development Organization (UNIDO) opened its first Regional Centre for Small Hydro Power is in Energy

Management Centre in April 2003. The SHP Cell of Department of Power, Government of Kerala is also functioning in EMC.

1.19 About Kerala State Productivity Council

1.19.1 The Kerala State Productivity Council (KSPC) was established in 1959 as an autonomous tripartite organization with representation from Government, Management and Labor. The Council is affiliated to the National Productivity Council, New Delhi and Asian Productivity Organization, Tokyo, Japan. The basic mission of KSPC is to enhance productivity, through its promotion activities, in all walks of human endeavor. It considers productivity as a grass-root, level movement essential to nation building. The Council is now one of the premier productivity organizations in the country for imparting Training in Productivity Techniques and providing Consultancy Services.

1.19.2 KSPC is accredited energy audit firm with Bureau of Energy Efficiency (BEE), Ministry of Power, Govt. of India and empanelled energy audit firm with Energy Management Centre, Department of Power, Govt. of Kerala.

2. ABOUT AGRICULTURE SECTOR

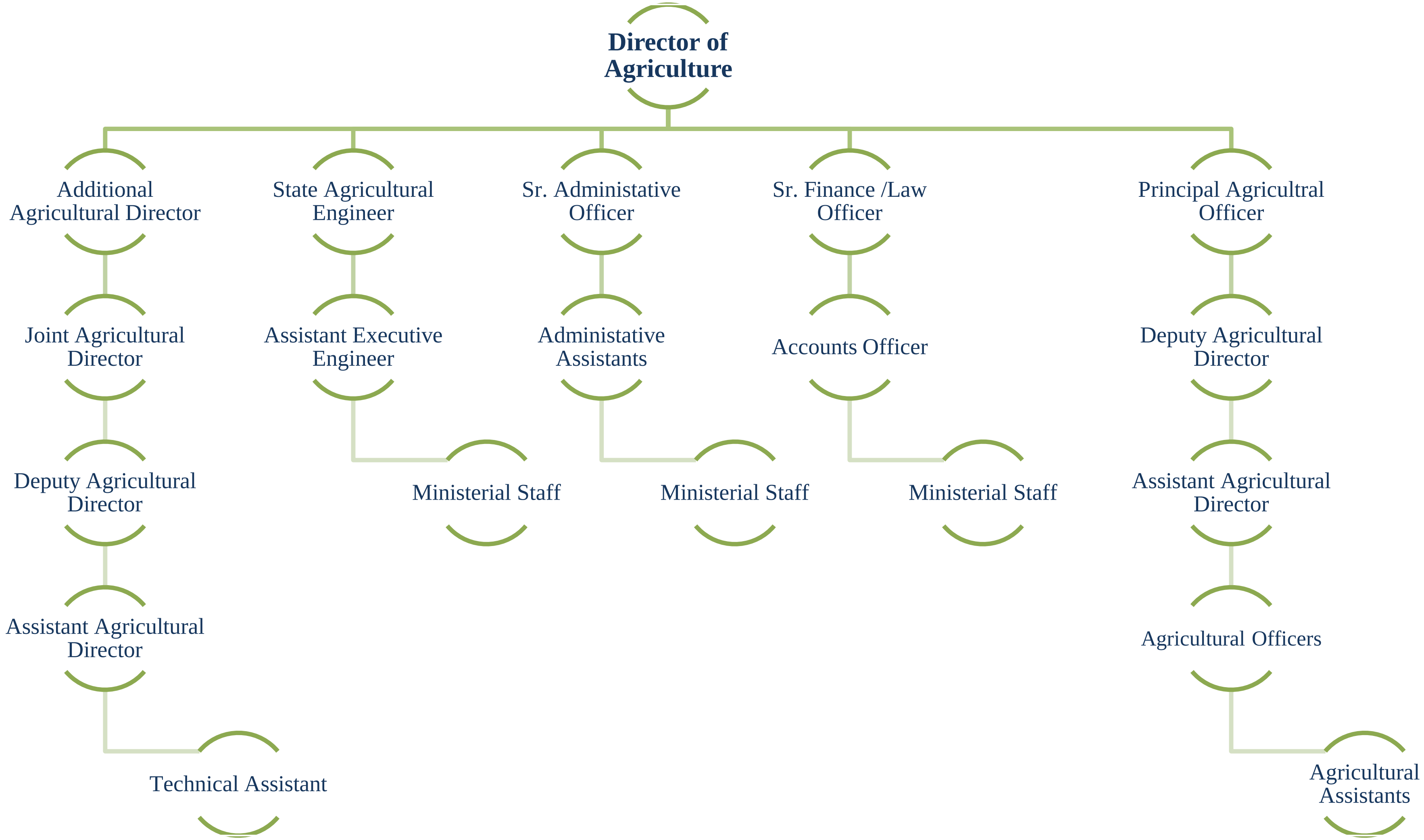
2.1 The agricultural department Kerala was formed in 1908 May 27 as a visionary to improve the production and productivity of the agricultural sector in Kerala. The state structure was limited to the growth of agricultural land area, due to the rapid increase in population density and tertiary sector. Department plays a vital role in the improvement of the sector through various schemes and action plans.

2.2 This department deals with the formulation and implementation of various programs to augment production of both food crops and cash crops in the State. It undertakes activities among farmers to promote scientific methods of cultivation plant protection etc. and also arranges the supply of high yielding varieties of seeds, seedlings, planting materials and plant protection chemicals to farmers. The department also formulates policies and programs relating to provision of credit to farmers. Agricultural Research, Education and Extension are three important functions of the department. It runs agricultural farms and also has an engineering wing.

2.3 ORGANIZATION STRUCTURE

2.3.1 The Director of Agriculture is the head of the Department. The department has offices at the regional, district and Panchayat levels. It has presence in all the village panchayat through Krishi Bhavans. There is a directorate of soil conservation, which has a soil conservation wing and soil survey wing. They undertake investigation preparation, and execution of all the soil conservation work. Agriculture Production Commissioner heads the Agriculture department and under him there is Secretary Agriculture and Secretary Animal Husbandry and Dairy Development. There are separate field departments for Animal Husbandry and Dairy Development

Structural illustration of the department



2.3.2 The Mechanizing activities of the agricultural sector are coordinating by the agricultural engineers. There are two offices functioning throughout the state based on the zone under the State Agricultural Engineer. The northern zone office is functioning in Kozhikode and the Southern zone office is functioning in the Alappuzha.

2.3.3 The state level department activities are governed by the Principal Agricultural Officer (Joint Director Rank). Central Government Schemes are coordinated by the Project Directors.

2.3.4 There are 1076 krishi bhavans throughout Kerala spread over the 14 districts. The district wise list of the same is given below.

SL No.	District	Krishi Bhavan
1	Trivandrum	89
2	Kollam	78
3	Pathanamthitta	57
4	Alappuzha	78
5	Kottayam	79
6	Idukki	53
7	Ernakulam	97
8	Thrissur	105
9	Palakkad	95
10	Malappuram	108
11	Kozhikode	81
12	Wayanad	26
13	Kannur	89
14	Kasaragod	41
Total		**1076**

3. OBJECTIVE & SCOPE OF THE STUDY

3.1 In agriculture sector, most of the irrigation pump-sets operate at poor efficiency. There are many other parameters such as water table variation, irregular maintenance, poor supply voltage, use of non-standard pumps, improper pump sizing etc., which could affect the efficiency of the pump-sets.

3.2 The broad objective of this study is to study the impact of those external parameters on overall average operating efficiency and to estimate the energy saving potential. The study involves survey and measuring the present operating efficiency of sampled lot of 150 Nos of total agriculture pumps in Kerala.

3.3 The detailed objectives of this study are provided below,

- Identifying operating efficiency of all the pumps considered in sample study.
- Identify the major causes of low operating efficiency and recommend improvements / better operating practices,
- Study external parameters that could affect the efficiency and their impact on operating efficiency,
- Cost benefit analysis for various options for saved energy due to pump set replacement

3.4 Scope of Work

The detailed scope of work for the above study will be as follows

- Listing out the population of agricultural pumping system in the State and preparation of the data base with respect to age, type, size, make, rating, purpose, usage, water use, energy consumption, geographic/spatial deployment etc.
- Identify a representative sample of about 150 pumping system from the above data base for detailed energy efficiency evaluation study.
- Conduct the energy efficiency evaluation of the sampled lot of about 150 nos. of pumping system. This included piping lay out, pipes and fillings, control, water utilization and technical efficiency of motor-pump system.
- List out projects for energy efficiency enhancement with techno economics analyses; this shall include operation and maintenance activities, retrofit options, modifications, and replacement options.

- Preparation of implementable Detailed Project Reports (DPRs) for replacement of inefficient pump sets to conserve energy.
- Project the State wise energy saving plan with saving potential and investment in the State’s agricultural pumping system.
- Review the existing policies, rules and regulations and suggest effective interventions for energy efficiency enhancement of the State’s agricultural pumping system.

4. APPROACH AND METHODOLOGY

4.1 The projects follow a basic methodology, which is structured for maximum efficiency and flexibility. The study process follows a three pronged strategy of extracting data from

- Preliminary Stage.
- Secondary Stage.
- Tertiary Stage

4.2 Data collection methods involved multidisciplinary approach and integrated qualitative and quantitative data collection and analysis such as surveys, focus group discussion, key informant interviews, and secondary data collection.

4.3 Preliminary Stage

- Various rounds of discussions (both personal and telephonic) were conducted with the concerned officials at EMC, EESL, KSEBL, Agricultural Department(s), DISCOMs, Irrigation Department and Pump Manufactures. Based on the inputs received from these organizations, a questionnaire was prepared to collect the data regarding Pump size, Capacity, Location, Age, Type etc. and a database to suit the defined functions of the project has been created.

4.4 Secondary Stage

- The secondary stage consists of identifying sample of about 150 pumping system from the data base for detailed energy efficiency evaluation study.
- A template was created to collect the data during field study of the selected agricultural pumps for efficiency evaluation.
- Carried out Field tests, trials and measurements of the 150 selected pumps to evaluate the overall efficiency.
- Interacted with pump OEMs/stakeholders and necessary information’s were collected regarding energy efficiency in agricultural pumps.
- Reviewed the rules and regulations related to the agriculture pumping system in Kerala to enhance the energy efficiency in the sector.
- Identified Energy efficiency and conservation measures with techno-economics analysis.

4.5 Tertiary Stage

- Detailed discussions were held with the pump manufacturers/ESCOS/other agencies and draft report has been prepared based on the comments/suggestions.
- Presentation of the draft report with EMC/Power Department/ Other Concerned Departments.
- Preparation of the Final Report based on the feedback from the presentation of the draft report and submission.

5. CHALLENGES FACED

5.1 The data collection for this project activity was rather straightforward, requiring interaction at state level with key governmental agencies (mainly State Electricity board, Agricultural Department, Irrigation Department, DISCOMs &self-government). The challenges faced in this data collection was the varying level of organization of the data, lack of formal procedure for reporting, assimilating, archiving and sharing this data, lack of ownership and responsibility for documentation of this data and generally the limited understanding of the importance of this task in the context of larger national opportunity for improving energy availability through more efficient utilization of the same.

5.2 While the project team was able to overcome these challenges through sustained interactions and support from Energy Management Centre, KSEBL, agricultural Department, Irrigation Department, ESCOS, DISCOMs, local self-government etc.

5.3 As the agricultural consumers were less concerned about the importance of the context of the study their approach towards the field study was not convivial.

5.4 The challenges faced in collection of the data present an opportunity in developing normative procedures for comprehensive documentation, information management, and analysis of data in a routine manner.

6. ABOUT AGRICULTURE PUMPING SCHEME

6.1 The scheme is applicable for the farmers under the krishi bhavan limits who have availed the agricultural electricity connection.

6.2 The agriculture electricity connection is applicable for the farmers under the krishi bavan limit who have equipped with 25 Cents of agricultural land area, either a well or pond, pump set and a pump house.

6.3 The famer should submit the application through a corresponded form along with the land tax receipt to the krishi bhavan for both the agricultural electricity connection and for the free electricity connection. There is no separate fee for the application.

6.4 The pump set can be selected by the applicant either with the aid of the krishi bhavans or by themselves. krishi bhavans are providing directions to the farmers regarding the choice. Pump set can be purchased directly through the manufactures or through some subsidy schemes available by the department.

6.5 Meanwhile applicant will be constructing a pump house and acquire the building number through corresponding principal bodies. The application consists of the pump rating, land area, crop details and the pump house building no. and is submitted before the agricultural officer along with the land tax receipt, in some cases the land area and the pump house photos will also be enclosed along with the application.

6.6 Based on the site verification report agricultural officer will be issuing the certificate to the applicant. Applicant should take necessary arrangement to have separate agricultural electrical connection to the pump set through KSEB.

6.7 The certificate for the agricultural electricity connection should be issued by the agricultural officer within 5 days.

6.8 The free connection is authorized by the assistant agricultural director and is forwarded to the corresponding electrical section through the agricultural officer. Based on this department will be paying the consumption amount to the KSEB

6.9 The KSEB charges for the agricultural connection is provided below:

Table 1 KSEBL charge

SL No.	Tariff Structure		Description	Rate /Charge
1	LT- V - AGRICULTURE	LT - V (A)	Fixed charges (Rs / kW/ month)	8
2			Energy Charge (Rs/ kWh)	2
3		LT - V (B)	Fixed charges (Rs / kW/ month)	8
4			Energy Charge (Rs/ kWh)	2.5

6.10 The details recorded by the krishi bhavan about the applicant are summarized below.

Primary Information	Applicant Name Address
Agricultural Details	Land details (area, Survey no. etc.) Crop details (type area etc.)
The details recorded about the pump set	Motor Rating, Consumer no. Initial consumption amount, KSEB Section

7. AGRICULTURAL PUMP DATA BASE

7.1 As the population of the agriculture pump sets in the state was not readily available from a single source, we contacted various agencies like Agricultural department, KSEBL, Irrigation Department, DISCOMS etc. for the preparation of data base.

7.2 The total number of pumps with necessary details in each district/section offices KSEBL was collected from KSEBL/Agricultural departments/Irrigation Departments/DISCOMs with the help of questionnaire prepared with specific pump information.

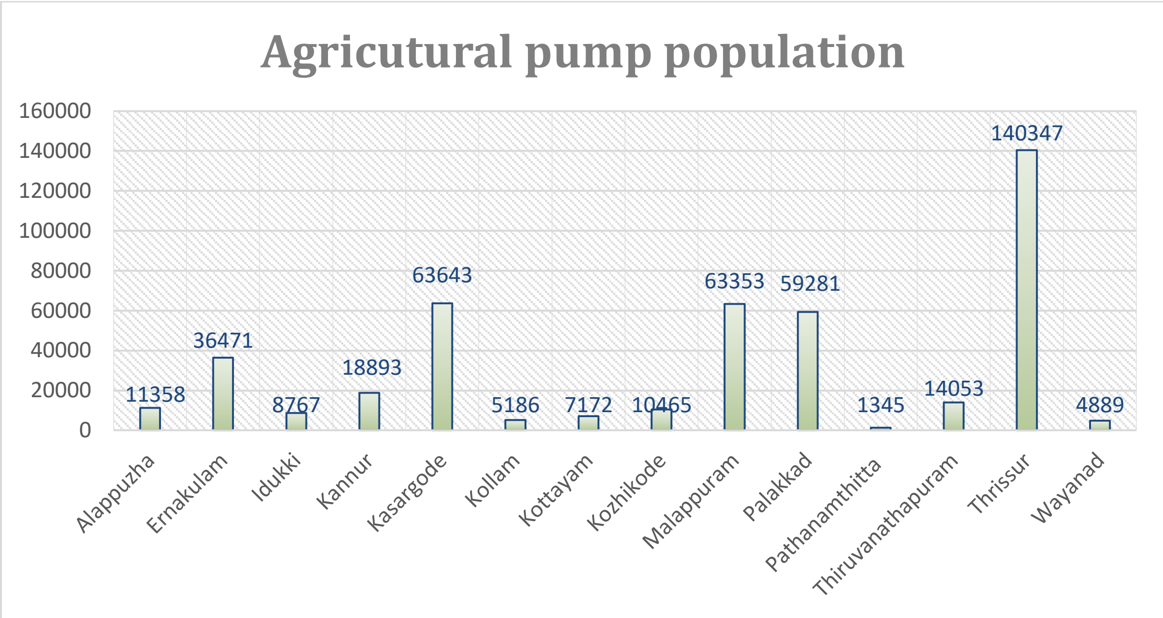
7.3 Intent meetings with department heads were also conducted to analyze the present agriculture pumping scenario in the state. Also as part of study, the prominence of the energy conservation was nourished to the people during the discussions/meetings/survey.

7.4 The list of agricultural pumping population in the state was summarized and the district wise details of agriculture pumps is given below:

Table 2 List of agricultural pump population

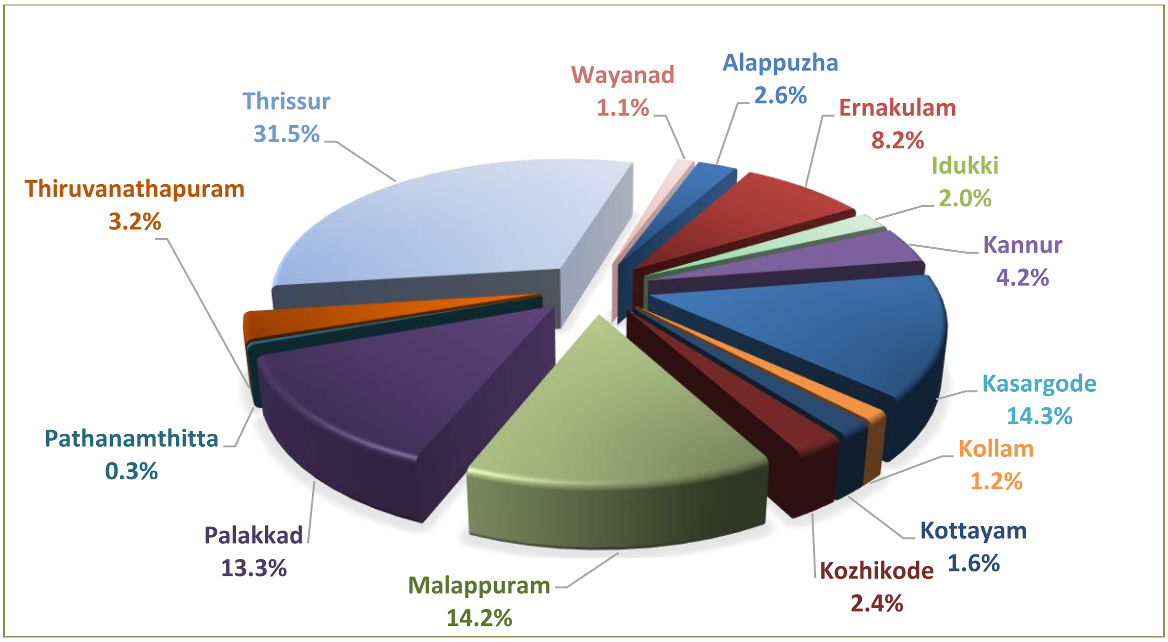
SL No.	District	Single Phase	Three Phase	Total no. of agriculture Consumers
1	Alappuzha	9906	1452	11358
2	Ernakulam	16505	19966	36471
3	Idukki	5169	3598	8767
4	Kannur	15652	3241	18893
5	Kasargode	47510	16133	63643
6	Kollam	4590	596	5186
7	Kottayam	4183	2989	7172
8	Kozhikode	8751	1714	10465
9	Malappuram	53684	9669	63353
10	Palakkad	28677	30604	59281
11	Pathanamthitta	957	388	1345
12	Thiruvanathapuram	10590	3463	14053
13	Thrissur	85613	54734	140347
14	Wayanad	1433	3456	4889
TOTAL		**293220**	**152003**	**445223**

7.5 The details of the pump population is provided in the appendix no.1



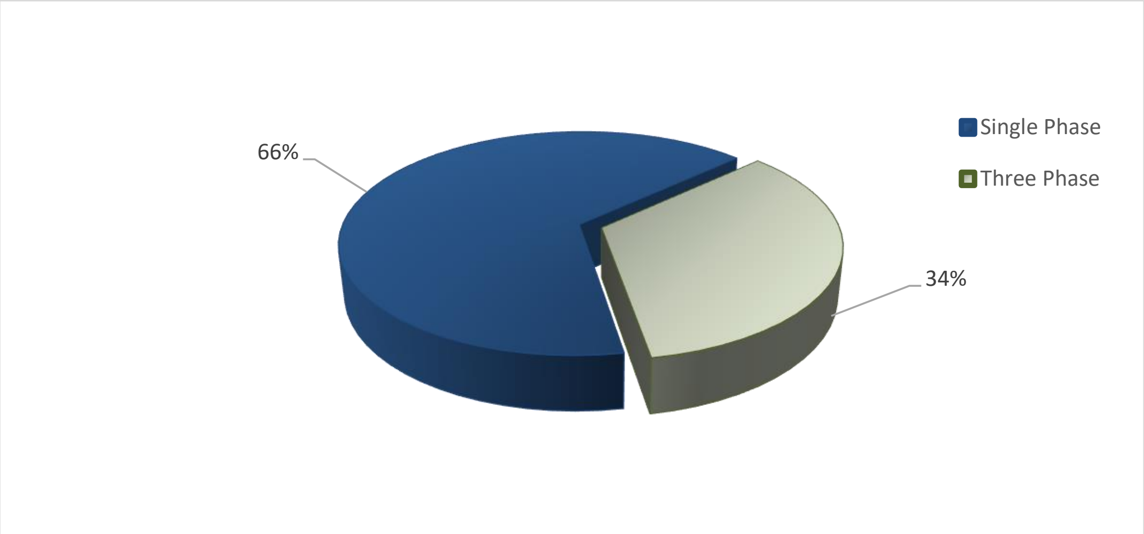
7.6 The total number of the agricultural pump consumers is 4,45,223 Nos. among which the Thrissur district contributes the highest which is 31.5% of the total consumers. The percentage distribution of the agricultural pump list is given below:

Figure 5 Agricultural pump distribution district wise



7.7 The above list can be classified by the single and three phase consumers. The 66% of the total consumers were of single phase and the rest 34 % is three phase. The contribution is given below:

Figure 6 Pump Classification based on phase



7.8 The agricultural pump population was categorized based on the pump capacity at different districts and the details of which is given below:

Figure 7 Classification of Pump Population

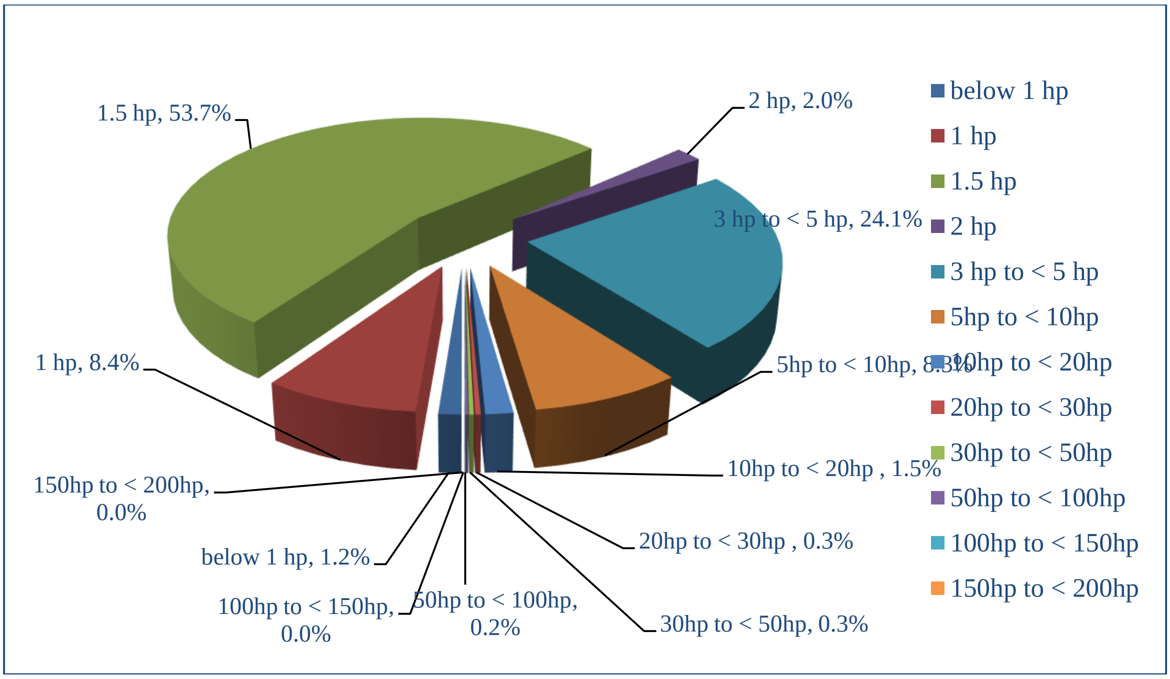
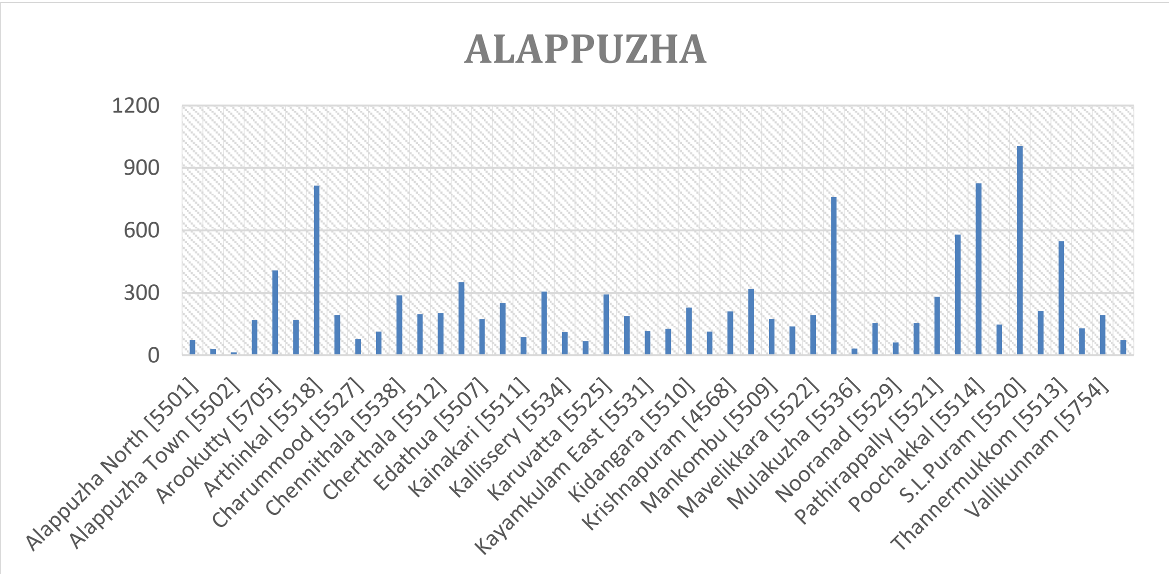


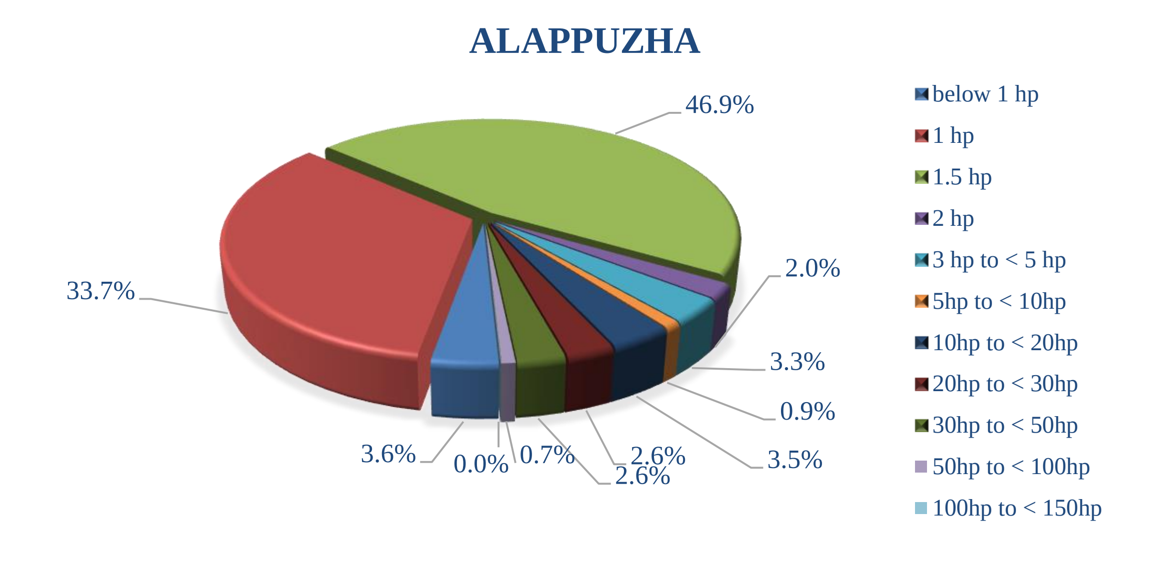
Table 3 Pump Classification

District	Alappuzha	Ernakulam	Idukki	Kannur	Kasargod	Kollam	Kottayam	Kozhikode	Malappuram	Palakkad	Pathanamthitta	Thiruvanathapuram	Thrissur	Wayanad	TOTAL
Below 1 hp	412	248	204	761	599	537	219	997	472	164	62	541	199	30	**5445**
1 hp	3832	1418	1167	7931	6851	2820	1560	3011	3339	377	522	3727	849	142	**37546**
1.5 hp	5329	13911	2854	6433	38987	1081	2099	4022	48668	26636	306	5260	82728	989	**239303**
2 hp	227	789	778	464	876	115	226	648	947	1330	52	750	1458	255	**8915**
3hp to<5hp	373	15114	1159	1808	10262	478	1416	1147	7922	13174	175	3150	50514	601	**107293**
5hp to <10hp	105	4311	1568	1198	5599	105	638	493	1458	15840	70	538	3151	1707	**36781**
10hp to <20hp	393	393	808	275	453	26	354	134	430	1596	76	60	737	977	**6712**
20hp to <30hp	299	102	194	10	12	11	179	5	31	84	35	16	199	135	**1312**
30hp to<50hp	300	74	30	2	1	8	230	6	30	38	37	4	348	34	**1142**
50hp to<100hp	85	76	5	4	1	5	249	2	39	33	10	7	140	15	**671**
100hpto<150hp	3	32		7	2		2		16	8			23	4	**97**
150hpto<200hp		3							1	1			1		**6**
	11358	**36471**	**8767**	**18893**	**63643**	**5186**	**7172**	**10465**	**63353**	**59281**	**1345**	**14053**	**140347**	**4889**	**445223**

7.9 The agricultural pump population occupied by the different districts is given below based on the location and pump capacity.

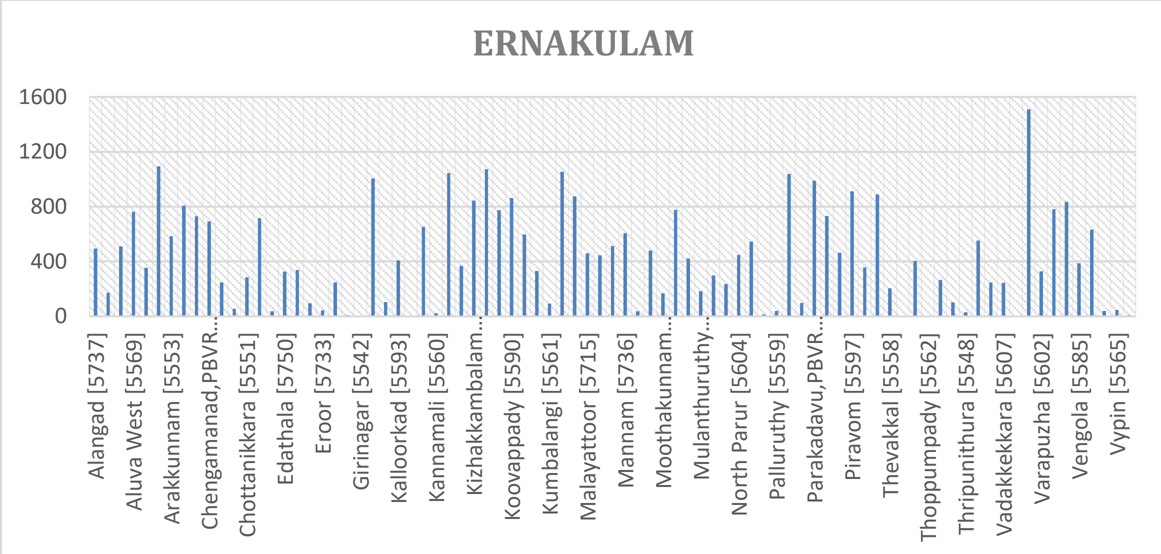
ALAPPUZHA			
Location/KSEB Section	**No**	**Location/KSEB Section**	**No**
Alappuzha North [5501]	74	Kainakari [5511]	87
Alappuzha South [5503]	31	Kalavoor [5726]	306
Alappuzha Town [5502]	14	Kallissery [5534]	112
Ambalappuzha [5505]	169	Karthikappally [5526]	68
Arookutty [5705]	408	Karuvatta [5525]	292
Aroor [5515]	170	Kattanam [5528]	188
Arthinkal [5518]	815	Kayamkulam East [5531]	116
Chambakulam [5508]	193	Kayamkulam West [5532]	128
Charummood [5527]	78	Kidangara [5510]	229
Chenganoor [5533]	114	Kollakadavu [5537]	113
Chennithala [5538]	288	Krishnapuram [4568]	211
Cheppad [5530]	196	Kuthiathode [5516]	318
Cherthala [5512]	203	Mankombu [5509]	175
Cherthala East [5704]	350	Mannar [5539]	138
Edathua [5507]	173	Mavelikkara [5522]	192
Harippad [5524]	250	Pallippad [5725]	155
Muhamma [5519]	759	Pathirappally [5521]	282
Mulakuzha [5536]	32	Pattanakadu [5517]	580
Muthukulam [5741]	155	Poochakkal [5514]	826
Nooranad [5529]	62	Thakazhy [5506]	214
Punnapra [5504]	147	Thannermukkom [5513]	548
S.L.Puram [5520]	1005	Thattarambalam [5523]	129
Venmony [5824]	73	Vallikunnam [5754]	192
Grand Total		**11358**	

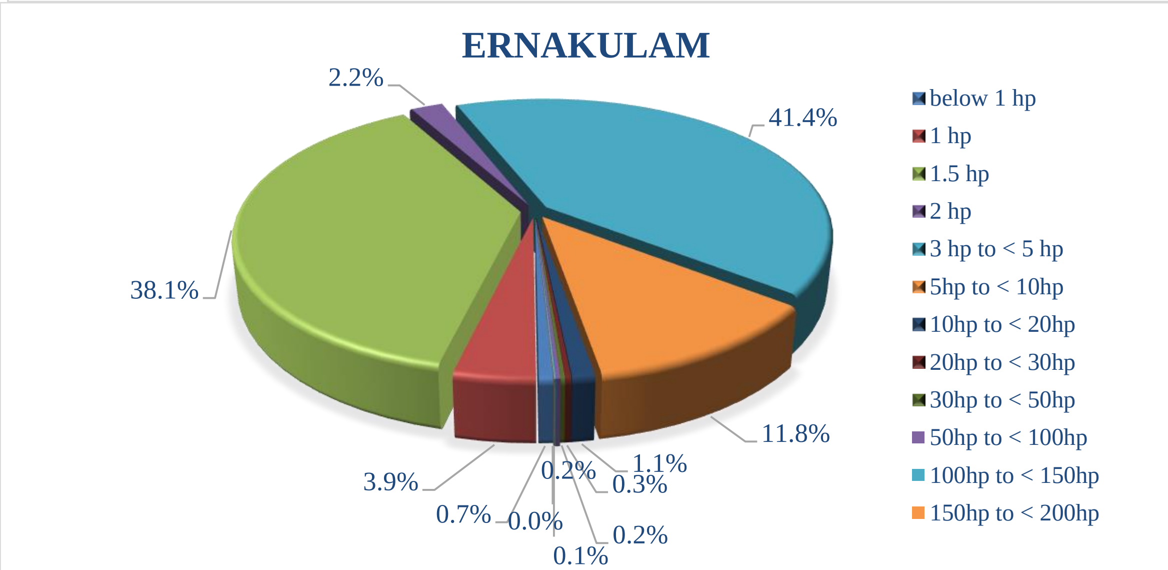




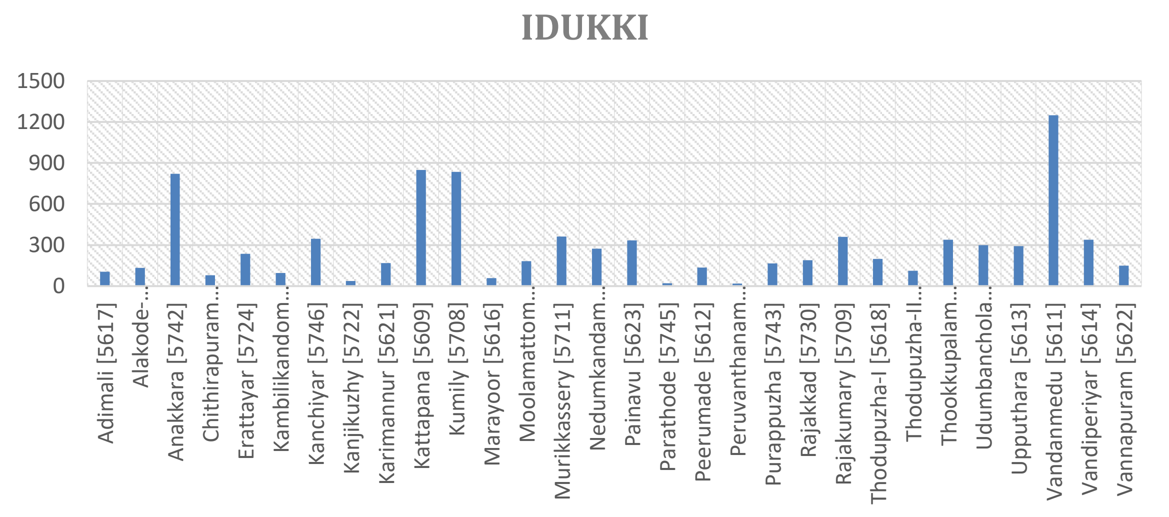
ERNAKULAM			
Location/KSEB Section	**No**	**Location/KSEB Section**	**No**
Alangad [5737]	493	Fort Cochin [5564]	8
Aluva North [5568]	172	Girinagar [5542]	3
Aluva Town [5567]	511	Kalady [5576]	1005
Aluva West [5569]	763	Kalamassery [5573]	105
Amballoor [5552]	353	Kalloorkad [5593]	408
Angamaly [5579]	1093	Kaloor [5545]	4
Arakkunnam [5553]	586	Kanjoor [5747]	653
Athani [5572]	806	Kannamali [5560]	23
Chendamangalam [5606]	729	Karakutty [5581]	1046
Chengamanad,PBVR [5571]	693	Keerampara [5713]	367
Cherai [5605]	247	Kizhakkambalam [5586]	845
Cheranellore [5739]	55	Kolencherry [5554]	1072
Chottanikkara [5551]	283	Koothattukulam [5598]	773
Chowara [5570]	715	Koovappady [5590]	863
Edappally [5544]	36	Kothamangalam-I [5600]	596
Edathala [5750]	325	Kothamangalam-II [5601]	331
Edayar(Muppathadom) [5712]	337	Kumbalangi [5561]	93
Eloor [5574]	95	Kunnukara [5575]	1055
Eroor [5733]	43	Kurupampady [5588]	875
Ezhikkara [5603]	246	Malayattoor [5715]	460
Vennala [5732]	39	Vypin [5565]	45
Manjalloor [5752]	445	Moovattupuzha-II [5594]	422
Manjapra [5578]	513	Mulanthuruthy [5748]	184
Mannam [5736]	605	Nellikuzhy [5751]	298
Maradu [5550]	37	Njarackkal [5566]	234
Mookannur [5582]	480	North Parur [5604]	447
Moothakunnam [5608]	166	Okkal [5738]	546
Moovattupuzha-I [5591]	777	Palarivattom [5543]	14

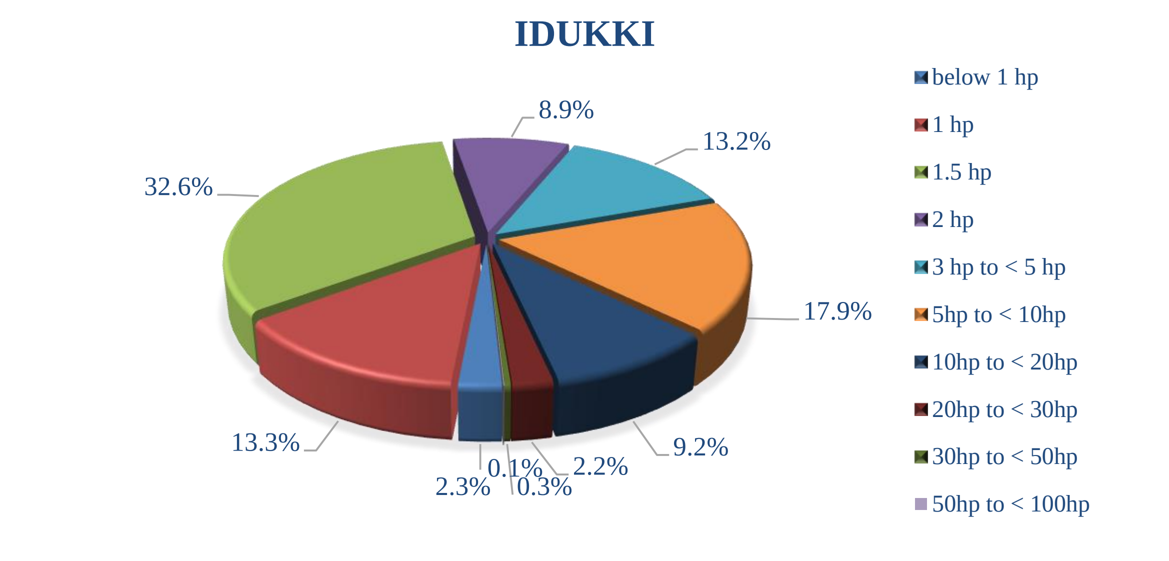
Piravom [5597]	911	Thripunithura [5548]	29
Pothanikad [5592]	357	Thuravoor [5577]	553
Puthencruz [5555]	888	Udayamperoor [5549]	247
Thevakkal [5558]	205	Vadakkekkara [5607]	244
Thevara [5541]	4	Vaduthala [5547]	4
Thiruvaniyoor [5734]	402	Valayanchirangara [5596]	1510
Thoppumpady [5562]	5	Varapuzha [5602]	329
Thrikkakkara [5557]	266	Vazhakulam [5584]	781
Thrikkakkara West [5731]	102	Velloorkunnam [5595]	834
Velloorkunnam [5595]	834	Pampakuda [5599]	1037
Vengola [5585]	386	Panangad [5735]	97
Vengoor [5589]	632	Parakadavu,PBVR [5580]	988
Palluruthy [5559]	38	Pattimattam [5587]	732
Vyttila [5556]	8	Perumbavoor [5583]	464
Grand Total		**36471**	



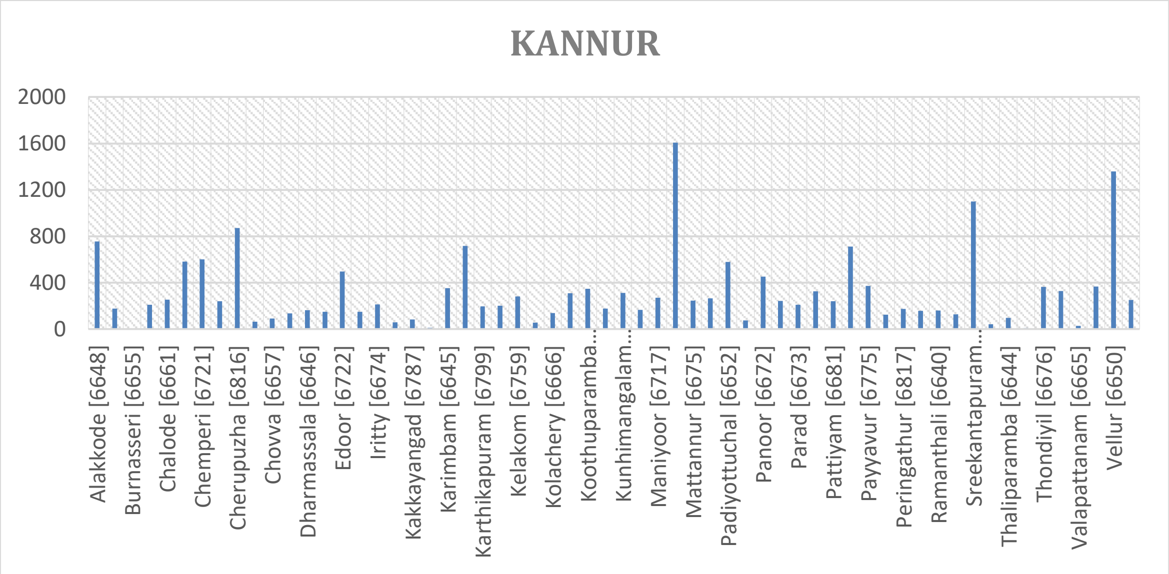


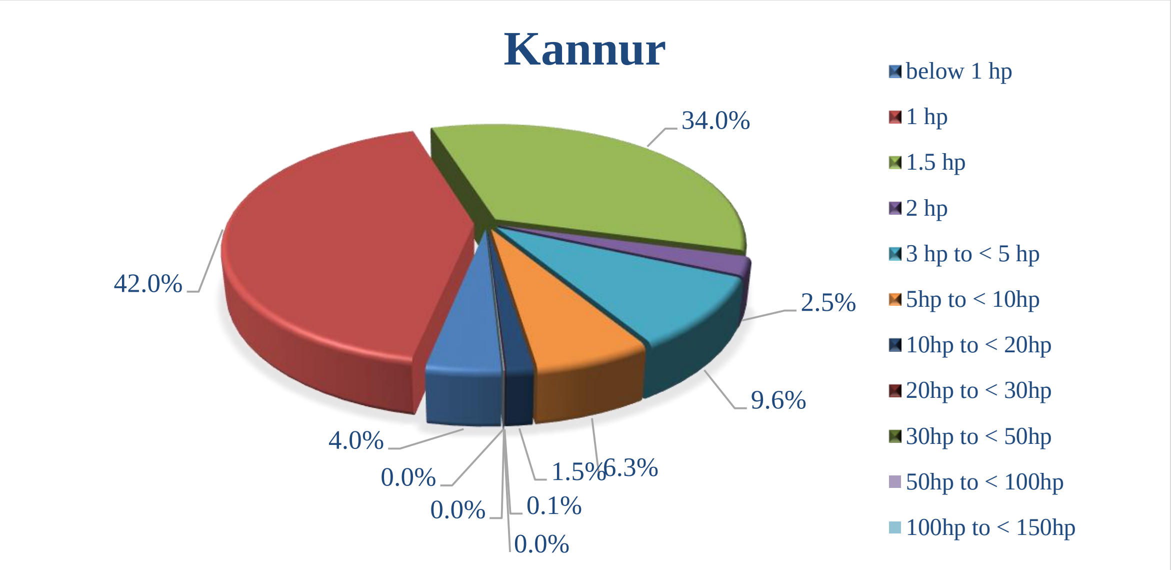
IDUKKI			
Location/KSEB Section	**No**	**Location/KSEB Section**	**No**
Adimali [5617]	105	Painavu [5623]	334
Alakode-Thodupuzha [5753]	132	Parathode [5745]	20
Anakkara [5742]	821	Peerumade [5612]	134
Chithirapuram [5615]	78	Peruvanthanam [5720]	17
Erattayar [5724]	235	Purappuzha [5743]	166
Kambilikandom [5710]	96	Rajakkad [5730]	189
Kanchiyar [5746]	345	Rajakumary [5709]	359
Kanjikuzhy [5722]	36	Thodupuzha-I [5618]	198
Karimannur [5621]	168	Thodupuzha-II [5620]	111
Kattapana [5609]	848	Thookkupalam [5723]	339
Kumily [5708]	836	Udumbanchola [5755]	298
Marayoor [5616]	57	Upputhara [5613]	291
Moolamattom [5619]	181	Vandanmedu [5611]	1250
Murikkassery [5711]	362	Vandiperiyar [5614]	339
Nedumkandam [5610]	274	Vannapuram [5622]	148
Grand Total		**8767**	



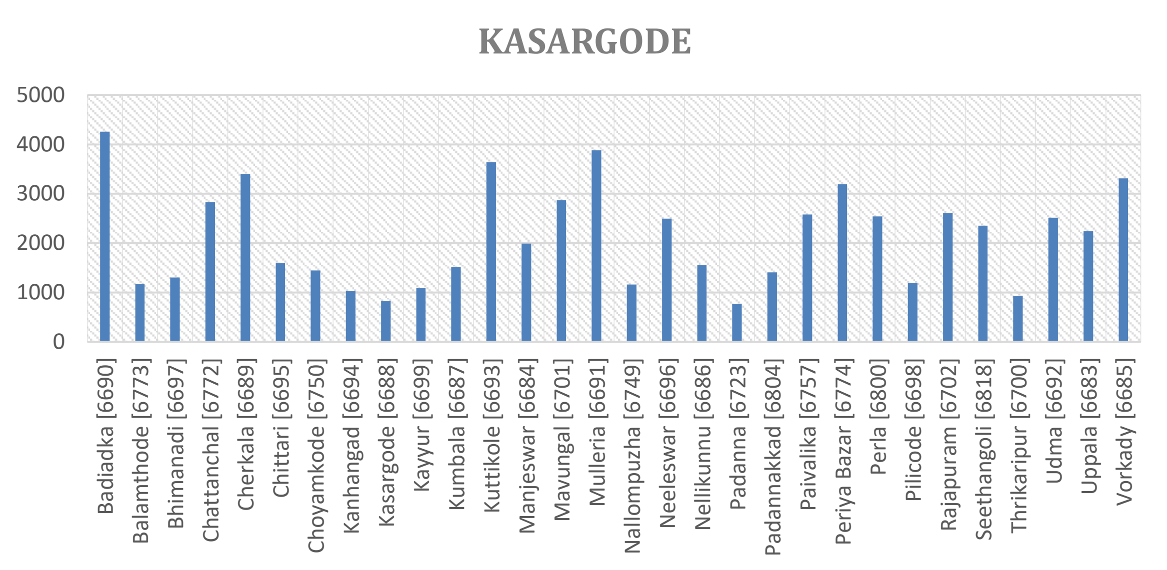


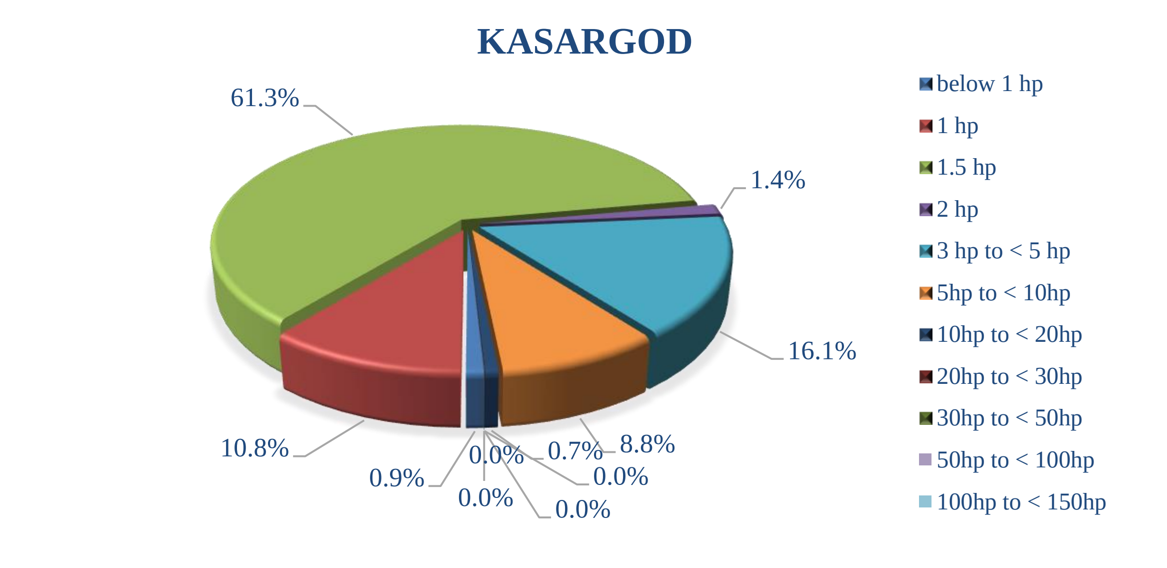
KANNUR			
Location/KSEB Section	**No**	**Location/KSEB Section**	**No**
Alakkode [6648]	755	Karimbam [6645]	353
Azheekode [6662]	177	Karivellur [6651]	718
Burnasseri [6655]	3	Karthikapuram [6799]	198
Chakkarakallu [6660]	212	Kathiroor [6682]	203
Chalode [6661]	254	Kelakom [6759]	281
Chapparappadavu [6745]	582	Kodiyeri [6670]	56
Chemperi [6721]	603	Kolachery [6666]	139
Cherukunnu [6664]	241	Kolayad [6758]	310
Cherupuzha [6816]	872	Koothuparamba [6680]	348
Chokli [6671]	66	Korom [6806]	177
Chovva [6657]	93	Kunhimangalam [6639]	313
Dharmadom [6677]	137	Madai [6643]	167
Dharmassala [6646]	163	Maniyoor [6717]	270
Eaichur [6659]	151	Mathamangalam [6641]	1607
Edoor [6722]	498	Mattannur [6675]	246
Irikkur [6649]	151	Mayyil [6667]	265
Iritty [6674]	213	Padiyottuchal [6652]	580
Kadachira [6658]	59	Pallikunnu [6653]	77
Kakkayangad [6787]	83	Panoor [6672]	453
Kannur [6654]	12	Pappinisseri [6663]	244
Parad [6673]	211	Ramanthali [6640]	161
Pariyaram,Kannur [6760]	327	Sivapuram [6776]	129
Pattiyam [6681]	240	Sreekantapuram [6647]	1101
Payyanur [6638]	712	Thalassery South [6668]	43
Payyavur [6775]	374	Thaliparamba [6644]	97
Peralassery [6790]	124	Thayyil [6656]	9
Peringathur [6817]	174	Thondiyil [6676]	366
Pinarayi [6679]	159	Ulikkal [6761]	328
Valapattanam [6665]	28	Vellur [6650]	1359
Vallithode [6813]	369	Vengad [6678]	252
Grand Total		**18893**	





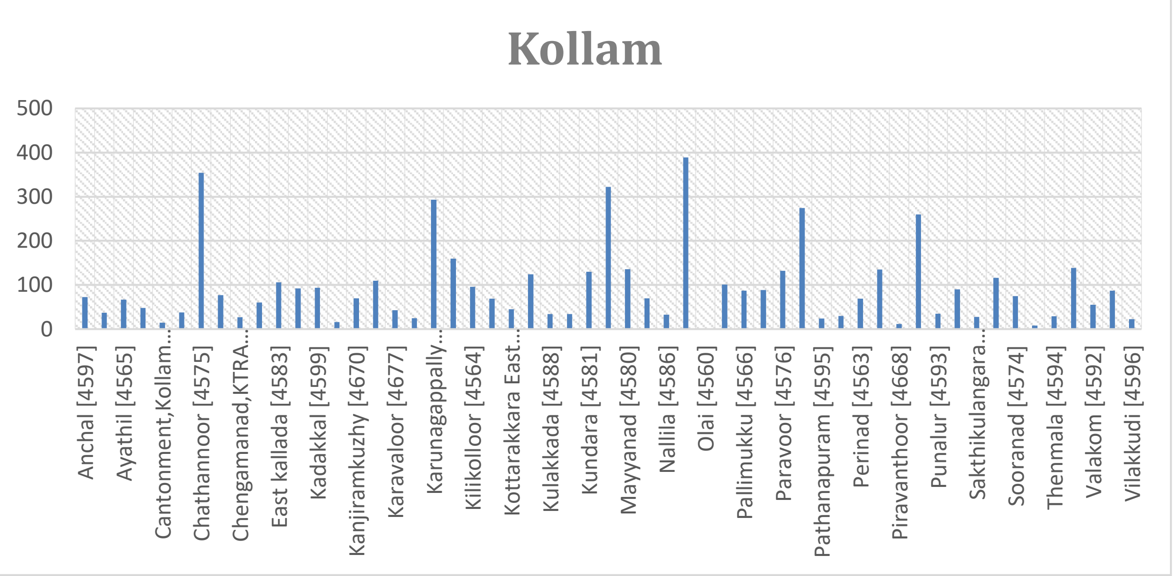
KASARGODE			
Location/KSEB Section	**No**	**Location/KSEB Section**	**No**
Badiadka [6690]	4259	Nallompuzha [6749]	1159
Balamthode [6773]	1166	Neeleswar [6696]	2497
Bhimanadi [6697]	1303	Nellikunnu [6686]	1553
Chattanchal [6772]	2830	Padanna [6723]	766
Cherkala [6689]	3399	Padannakkad [6804]	1404
Chittari [6695]	1591	Paivalika [6757]	2576
Choyamkode [6750]	1441	Periya Bazar [6774]	3197
Kanhangad [6694]	1022	Perla [6800]	2537
Kasargode [6688]	828	Pilicode [6698]	1192
Kayyur [6699]	1087	Rajapuram [6702]	2609
Kumbala [6687]	1514	Seethangoli [6818]	2351
Kuttikole [6693]	3638	Thrikaripur [6700]	923
Manjeswar [6684]	1986	Udma [6692]	2515
Mavungal [6701]	2868	Uppala [6683]	2242
Mulleria [6691]	3880	Vorkady [6685]	3310
Grand Total		**63643**	

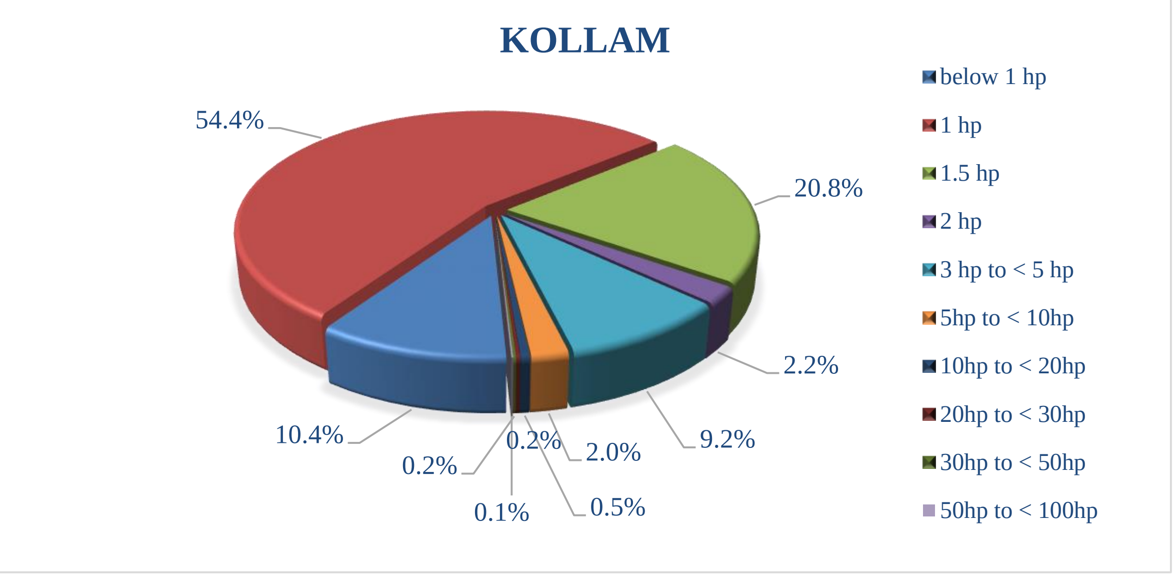




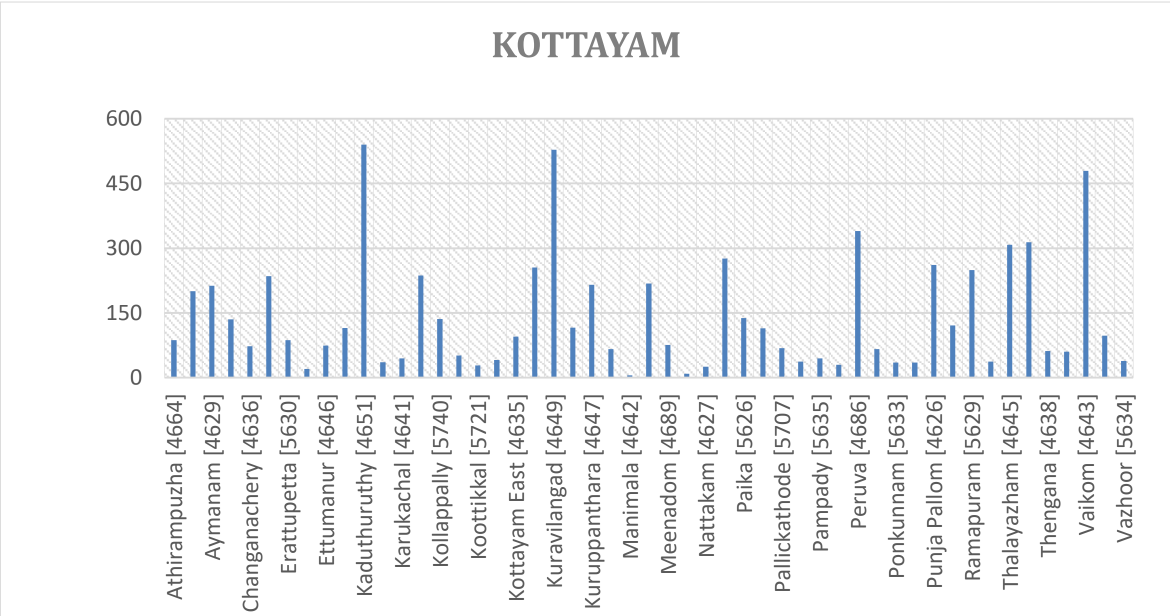
KOLLAM					
Location/KSEB Section	**No**	**Location/KSEB Section**	**No**	**Location/KSEB Section**	**No**
Anchal [4597]	73	Karunagappally [4570]	160	Parippally [4577]	274
Anchal West [4669]	37	Kilikolloor [4564]	96	Pathanapuram [4595]	24
Ayathil [4565]	67	Kottarakkara [4587]	69	Pattazhy [4685]	30
Ayoor [4591]	48	Kottarakkara East [4683]	45	Perinad [4563]	69
Cantonment,Kollam [4558]	15	Kottiyam [4578]	124	Perumpuzha [4585]	135
Chadayamangalam [4672]	38	Kulakkada [4588]	34	Piravanthoor [4668]	12
Chathannoor [4575]	354	Kulathupuzha [4598]	34	Poothakulam [4671]	260
Chavara [4571]	77	Kundara [4581]	130	Punalur [4593]	35
Chengamanad, [4590]	27	Manappally [4658]	322	Puthur,Kottarakkara [4589]	90
Chithara [4662]	60	Mayyanad [4580]	136	Sakthikulangara [4561]	28
East kallada [4583]	106	Mynagappally [4659]	70	Sasthamcotta [4573]	116

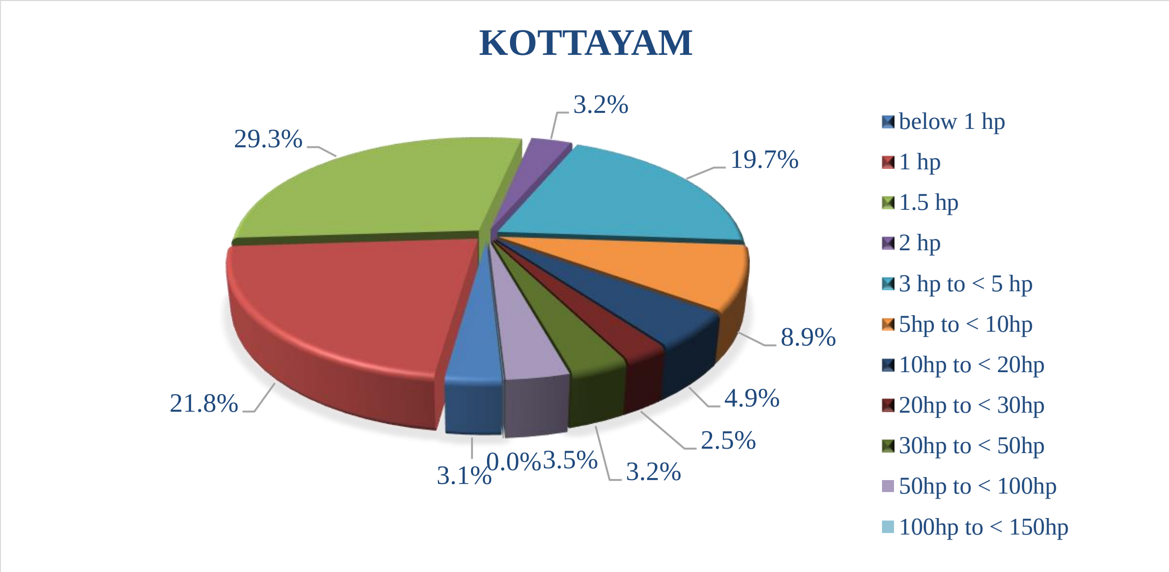
Ezhukone [4582]	92	Nallila [4586]	33	Sooranad [4574]	75
Kadakkal [4599]	94	Oachira [4567]	389	Thankasserry [4562]	8
Kadappakkada [4559]	16	Olai [4560]	1	Thenmala [4594]	29
Kanjiramkuzhy [4670]	70	Oyoor [4660]	101	Thevalakkara [4572]	139
Kannanalloor [4579]	110	Pallimukku [4566]	87	Valakom [4592]	55
Karavaloor [4677]	43	Panmana [4682]	89	Veliyam [4584]	87
Karukone [4661]	25	Paravoor [4576]	132	Vilakkudi [4596]	23
Karunagappally [4569]	293	**Grand Total**		**5186**	



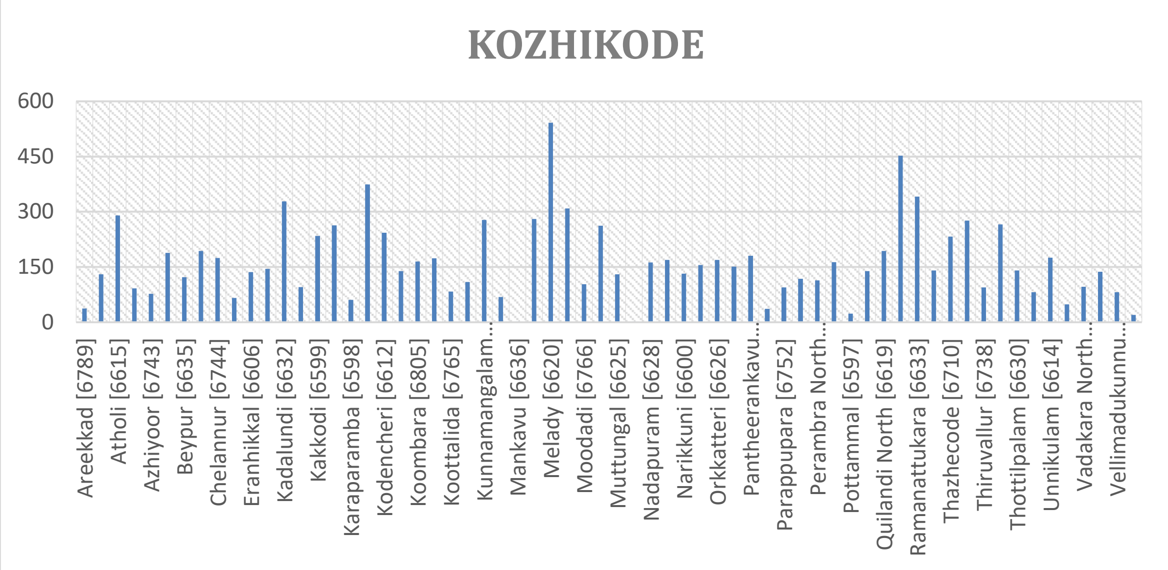


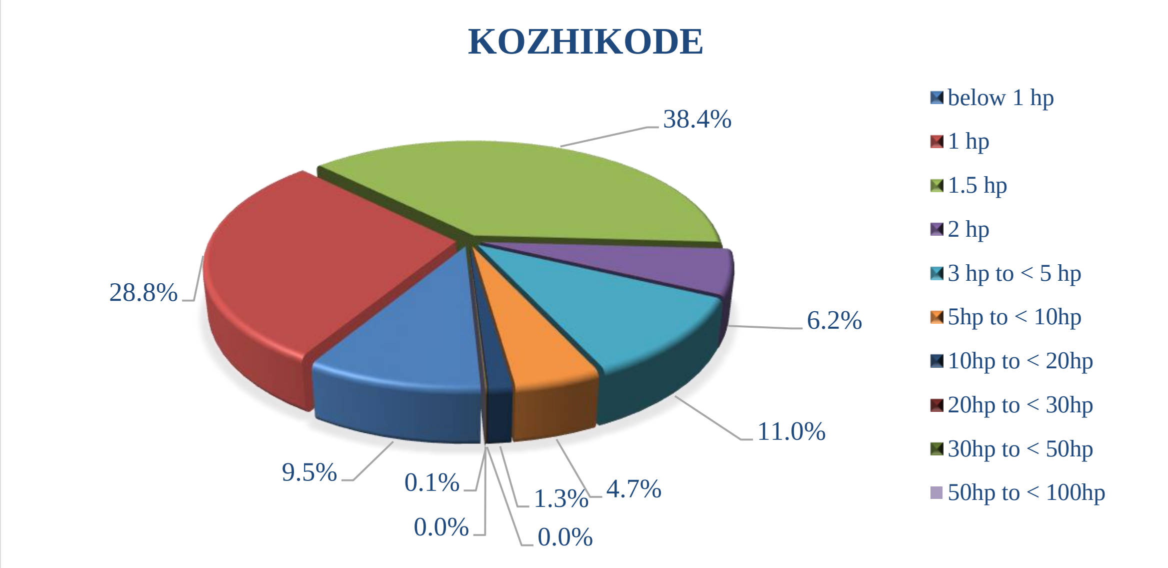
KOTTAYAM					
Location/KSEB Section	**No**	**Location/KSEB Section**	**No**	**Location/KSEB Section**	**No**
Athirampuzha [4664]	87	Kottayam Cntrl [4634]	41	Pampady [5635]	45
Ayarkunnam [4632]	200	Kottayam East [4635]	95	Pathanad [4684]	30
Aymanam [4629]	213	Kumarakam [4630]	255	Peruva [4686]	340
Bharananganam [5627]	135	Kuravilangad [4649]	528	Pinnakkanad [5632]	66
Changanachery [4636]	73	Kurichy [4637]	116	Ponkunnam [5633]	35
Chempu [4644]	235	Kuruppanthara [4647]	215	Poonjar [5631]	35
Erattupetta [5630]	87	Manarcad [4631]	66	Punja Pallom [4626]	261
Erumely [5637]	20	Manimala [4642]	5	Puthuppally [4633]	121
Ettumanur [4646]	74	Marangattupally [5628]	218	Ramapuram [5629]	249
Gandhinagar [4628]	115	Meenadom [4689]	76	Teekoy [5744]	37
Kaduthuruthy [4651]	540	Mundakkayam [5638]	9	Thalayazham [4645]	308
Kanjirappally [5636]	36	Nattakam [4627]	25	Thalayolaparambu [4650]	314
Karukachal [4641]	45	Neendoor [4648]	276	Thengana [4638]	62
Kidangoor [5625]	237	Paika [5626]	138	Thrikkodithanam [4640]	60
Kollappally [5740]	136	Pala [5624]	114	Vaikom [4643]	479
Kooroppada [5749]	51	Pallickathode [5707]	68	Vakathanam [4639]	97
Koottikkal [5721]	28	Pallom [4625]	37	Vazhoor [5634]	39
Grand Total			**7172**		





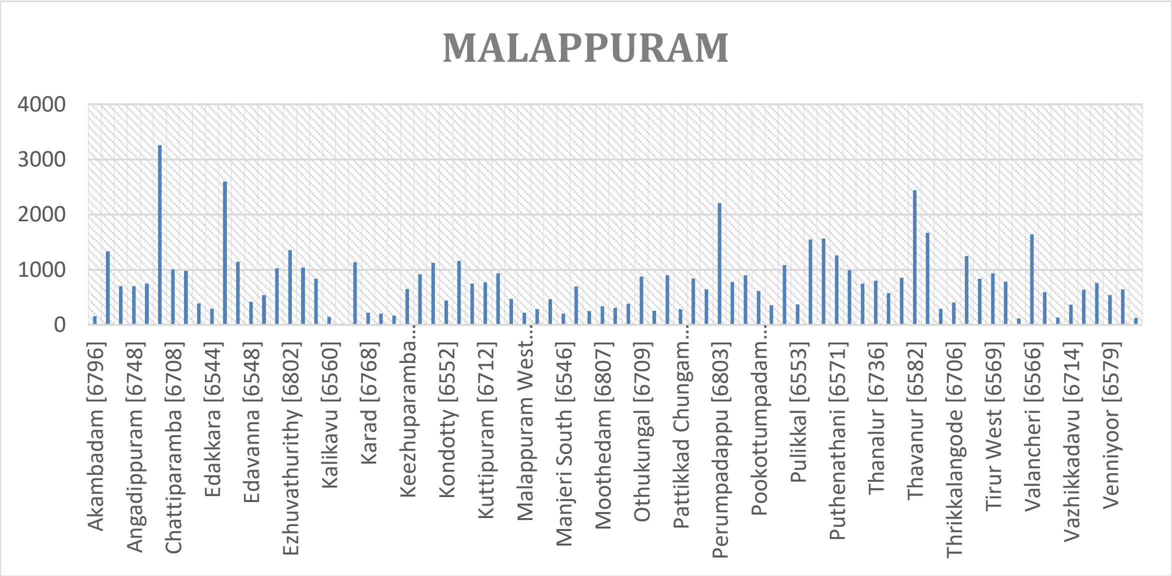
KOZHIKODE					
Location/KSEB Section	**No**	**Location/KSEB Section**	**No**	**Location/KSEB Section**	**No**
Areekkad [6789]	37	Karaparamba [6598]	60	Muttungal [6625]	130
Areekkulam [6767]	130	Kattangal [6747]	374	Nadakkave [6601]	1
Atholi [6615]	290	Kodencheri [6612]	243	Nadapuram [6628]	162
Ayenchery [6624]	92	Koduvally [6611]	139	Naduvannur [6618]	169
Azhiyoor [6743]	77	Koombara [6805]	165	Narikkuni [6600]	132
Balussery [6613]	188	Koorachundu [6763]	173	Omassery [6751]	155
Beypur [6635]	122	Koottalida [6765]	83	Orkkatteri [6626]	169
Chakkittapara [6716]	193	Kovoor [6595]	109	Pannikkode [6777]	151
Chelannur [6744]	174	Kunnamangalam [6607]	278	Pantheerankavu [6637]	180
Edacherri [6627]	66	Kuttiyadi [6629]	68	Parakkadavu,kkd [6724]	36
Eranhikkal [6606]	136	Mankavu [6636]	1	Parappupara [6752]	94
Feroke [6631]	145	Mavoor [6596]	280	Perambra [6616]	118
Kadalundi [6632]	328	Melady [6620]	542	Perambra North [6778]	113
Kakkattil [6735]	95	Meppayoor [6617]	309	Perumanna [6734]	163
Kakkodi [6599]	234	Moodadi [6766]	103	Pottammal [6597]	23
Kakkoor [6764]	263	Mukkam [6608]	262	Puthuppady [6732]	139
Quilandi North [6619]	193	Thiruvallur [6738]	94	Vadakara Beach [6737]	48
Quilandi South [6621]	452	Thiruvambadi [6609]	265	Vadakara North [6623]	96
Ramanattukara [6633]	341	Thottilpalam [6630]	140	Vadakara South [6622]	137
Thamarassery [6610]	140	Thuneri [6731]	81	Vellimadukunnu [6605]	81
Thazhecode [6710]	232	Unnikulam [6614]	175	WestHill [6604]	20
Thikkody [6746]	276	**Grand Total**		**10465**	

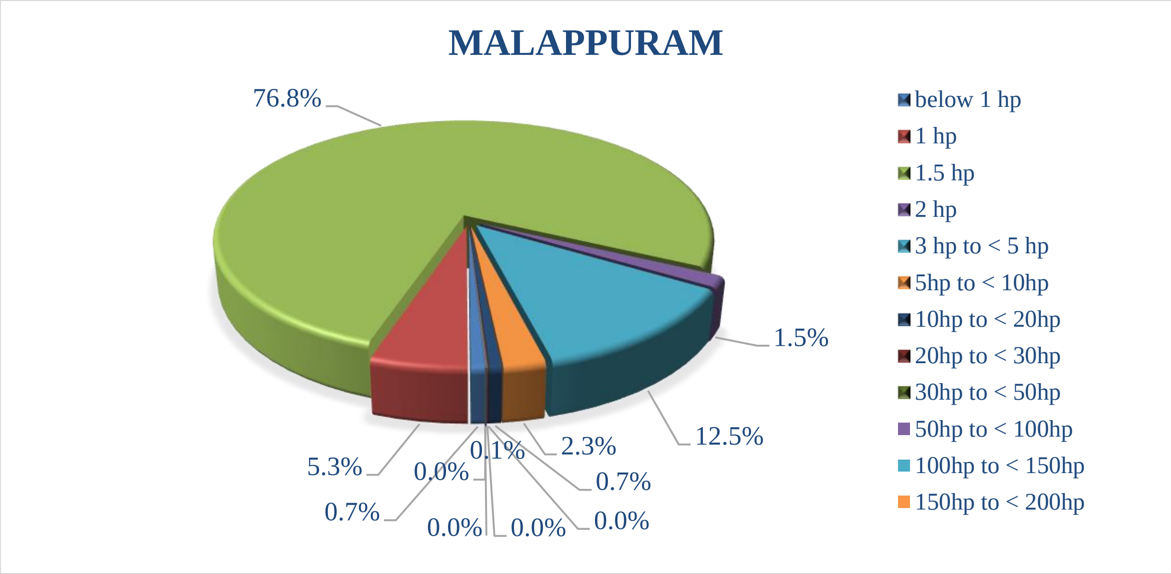




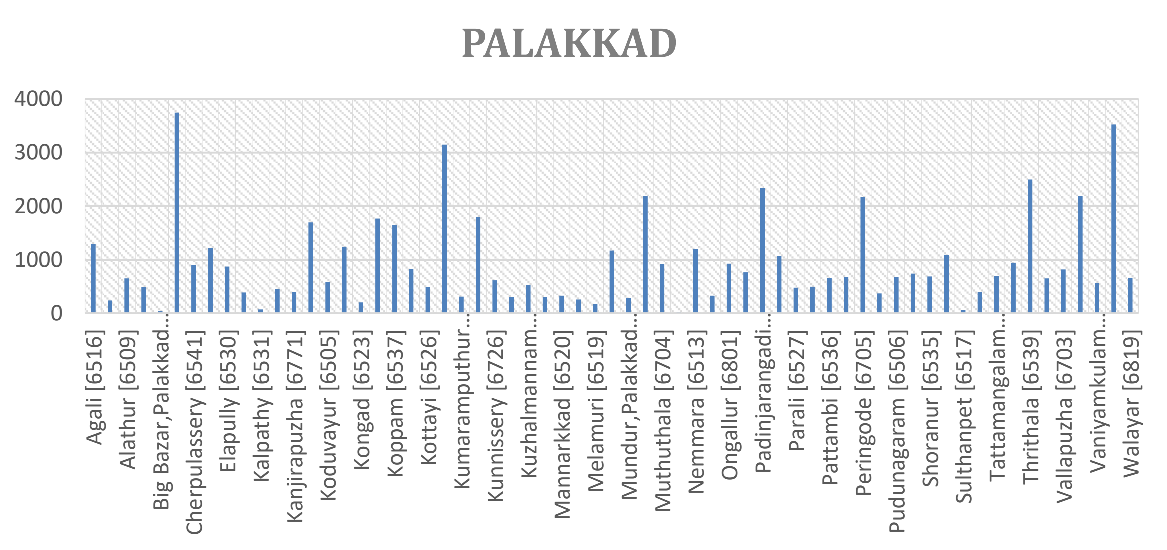
MALAPPURAM					
Location/KSEB Section	**No**	**Location/KSEB Section**	**No**	**Location/KSEB Section**	**No**
Akambadam [6796]	157	Karad [6768]	219	Oorakam [6808]	380
Alathiyur [6574]	1331	Karulai [6795]	205	Othukungal [6709]	876
Anakkayam [6756]	701	Karuvarakundu [6794]	170	Pandikkad [6561]	257
Angadippuram [6748]	703	Keezhuparamba [6707]	650	Parappanangadi [6575]	896
Areekode [6549]	748	Kizzhissery [6551]	916	Pattikkad Chungam [6779]	285
Changaramkulam [6585]	3259	Kolathur [6567]	1127	Payyangadi [6642]	841
Chattiparamba [6708]	1003	Kondotty [6552]	438	Perinthalmanna [6562]	644
Chelari [6577]	978	Kottakkal [6557]	1162	Perumpadappu [6803]	2209
Chungathara [6713]	387	Kunnumpuram (AR Nagar) [6739]	746	Ponmundam (Vylathur) [6570]	776
Edakkara [6544]	287	Kuttipuram [6712]	771	Ponnani [6581]	901
Edappal [6584]	2598	Makkaraparamba [6565]	933	Pookottumpadam [6545]	614

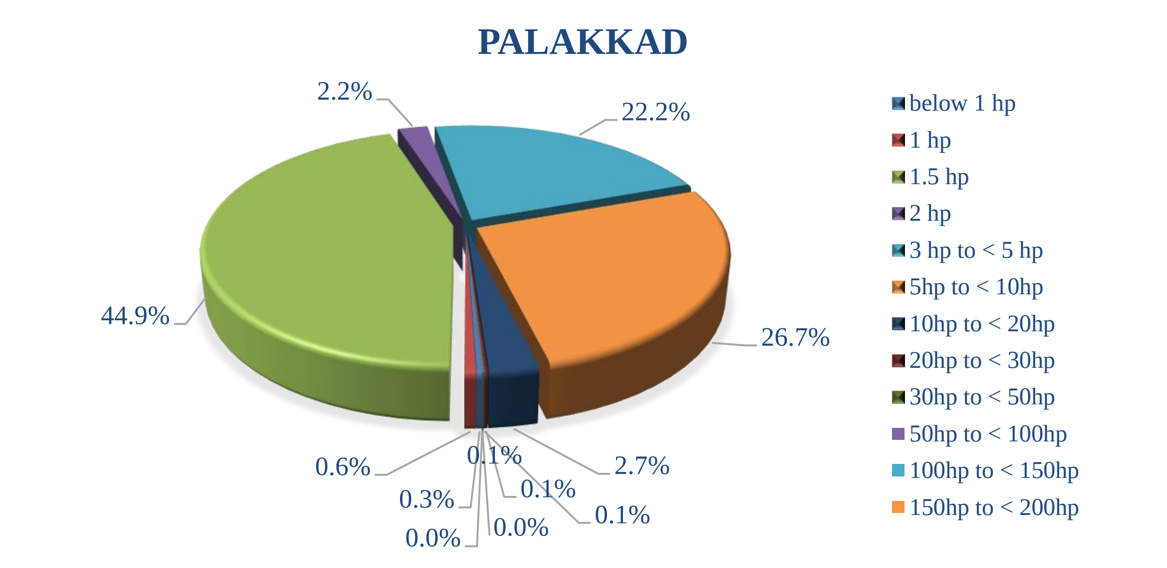
Edarikode [6558]	1141	Malappuram East [6555]	469	Pothukallu [6310]	352
Edavanna [6548]	418	Malappuram West [6780]	222	Pulamanthole [6564]	1083
Edavannappara [6550]	538	Mampad [6814]	283	Pulikkal [6553]	373
Edayoor [6769]	1027	Manjeri North [6547]	463	Purangu [6583]	1549
Ezhuvathurithy [6802]	1358	Manjeri South [6546]	203	Purathur [6781]	1568
Kadampuzha [6572]	1037	Mankada [6711]	698	Puthenathani [6571]	1260
Kadungathukundu [6741]	837	Melattoor [6563]	247	Puzhakkattiri [6820]	991
Kalikavu [6560]	145	Moothedam [6807]	337	Thalappara [6580]	747
Kallai [6634]	17	Nilambur [6543]	309	Thanalur [6736]	798
Kandanakom [6755]	1134	Thrikkalangode [6706]	408	Valancheri [6566]	1642
Thanur [6576]	571	Thuvvakkad [6797]	1248	Vallikunnu [6715]	590
Thanur East [6798]	851	Tirur East [6568]	834	Vaniyambalam [6793]	132
Thavanur [6582]	2439	Tirur West [6569]	934	Vazhikkadavu [6714]	367
Thirunavaya [6573]	1672	Tirurangadi [6578]	782	Velluvambram [6554]	635
Thiruvali [6770]	291	Tuvvur [6815]	118	Vengara [6556]	759
Venniyoor [6579]	537	Vettom [6730]	643	Wandoor [6559]	128
Grand Total			**63353**		



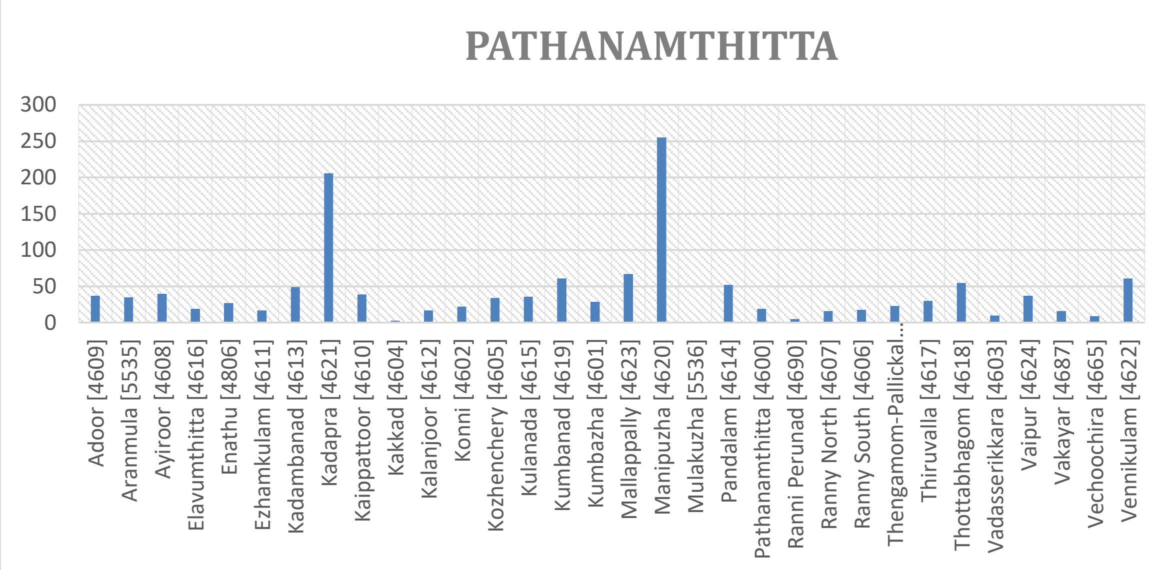


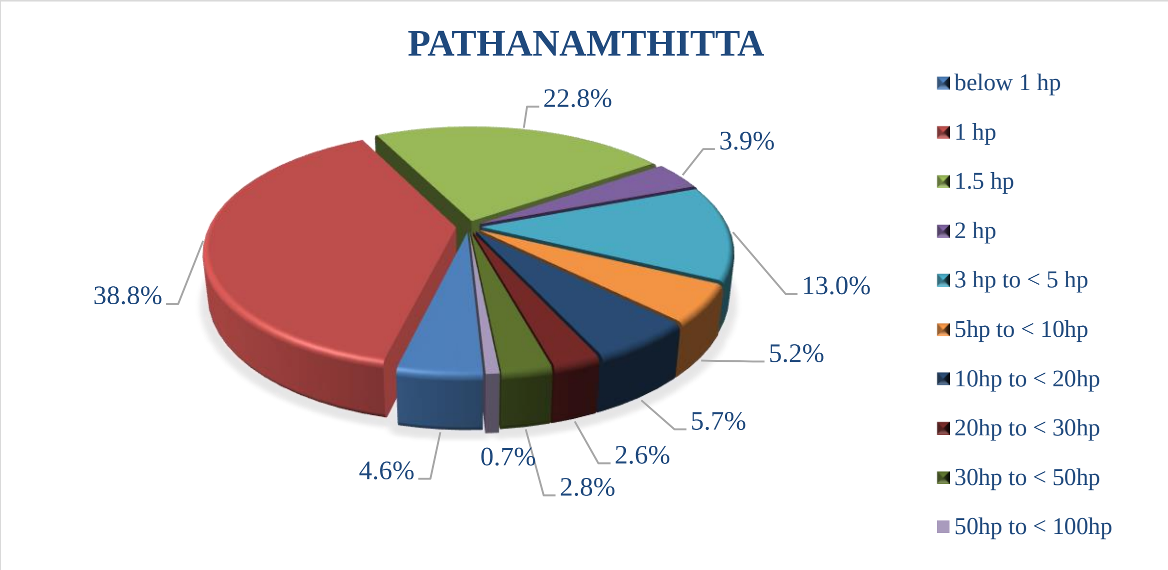
PALAKKAD					
Location/KSEB Section	**No**	**Location/KSEB Section**	**No**	**Location/KSEB Section**	**No**
Agali [6516]	1292	Kozhinjampara [6502]	3150	Parali [6527]	481
Alanallur [6521]	238	Kumaramputhur [6742]	310	Pathirippala [6729]	498
Alathur [6509]	651	Kumbidi [6812]	1797	Pattambi [6536]	656
Ambalappara [6534]	492	Kunnissery [6726]	614	Pengattiri [6784]	678
Big Bazar,Palakkad [6518]	42	Kuthannur [6728]	298	Peringode [6705]	2168
Chalissery [6538]	3750	Kuzhalmannam [6525]	532	Peringottukurissy [6727]	374
Cherpulassery [6541]	900	Malampuzha [6725]	306	Pudunagaram [6506]	678
Chittur [6501]	1219	Mannarkkad [6520]	327	Puthucode [6508]	739
Elapully [6530]	872	Marutharoad [6529]	257	Shoranur [6535]	688
Kadambazhippuram [6786]	389	Melamuri [6519]	173	Sreekrishnapuram [6524]	1090
Kalpathy [6531]	71	Mudappallur [6514]	1170	Sulthanpet [6517]	62
Kanjikode [6528]	449	Mundur,Palakkad [6740]	286	Tachampara [6522]	399
Kanjirapuzha [6771]	393	Muthalamada [6511]	2195	Tattamangalam [6504]	694
Kizhakkancherry [6754]	1697	Muthuthala [6704]	924	Thiruvegapura [6753]	943
Koduvayur [6505]	588	Nelliampathy [6512]	19	Thrithala [6539]	2498
Kollengode [6510]	1244	Nemmara [6513]	1199	Vadavannur [6810]	653
Kongad [6523]	203	Olavakkode [6532]	329	Vallapuzha [6703]	821
Koottupatha [6791]	1770	Ongallur [6801]	929	Vandithavalam [6809]	2188
Koppam [6537]	1649	Ottappalam [6533]	764	Vaniyamkulam [6733]	568
Kothakurussy [6542]	833	Padinjarangadi [6540]	2335	Velanthavalam [6503]	3526
Kottayi [6526]	489	Padoor [6507]	1068	Walayar [6819]	666
Grand Total			**59281**		





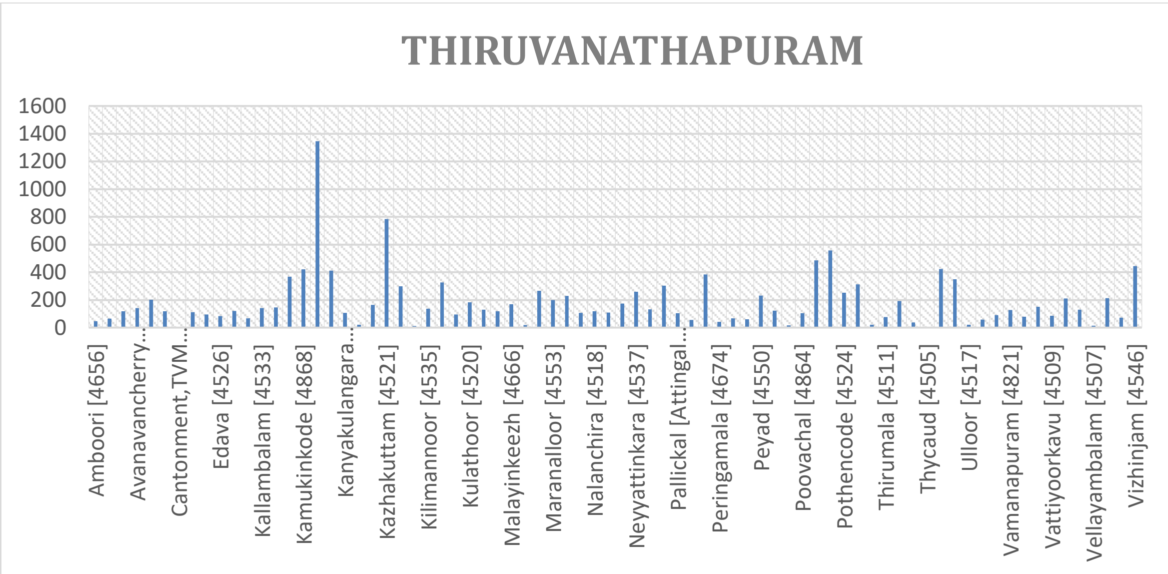
PATHANAMTHITTA					
Location/KSEB Section	**No**	**Location/KSEB Section**	**No**	**Location/KSEB Section**	**No**
Adoor [4609]	37	Mallappally [4623]	67	Vaipur [4624]	37
Aranmula [5535]	35	Manipuzha [4620]	255	Vakayar [4687]	16
Ayiroor [4608]	40	Mulakuzha [5536]	1	Vechoochira [4665]	9
Elavumthitta [4616]	19	Pandalam [4614]	52	Vennikulam [4622]	61
Enathu [4806]	27	Pathanamthitta [4600]	19	Kozhenchery [4605]	34
Ezhamkulam [4611]	17	Ranni Perunad [4690]	5	Kulanada [4615]	36
Kadambanad [4613]	49	Ranny North [4607]	16	Kumbanad [4619]	61
Kadapra [4621]	206	Ranny South [4606]	18	Kumbazha [4601]	29
Kaippattoor [4610]	39	Thengamom-Pallickal [4663]	23	Thottabhagom [4618]	55
Kakkad [4604]	3	Thiruvalla [4617]	30	Vadasserikkara [4603]	10
Kalanjoor [4612]	17	Konni [4602]	22		
Grand Total		**1345**			

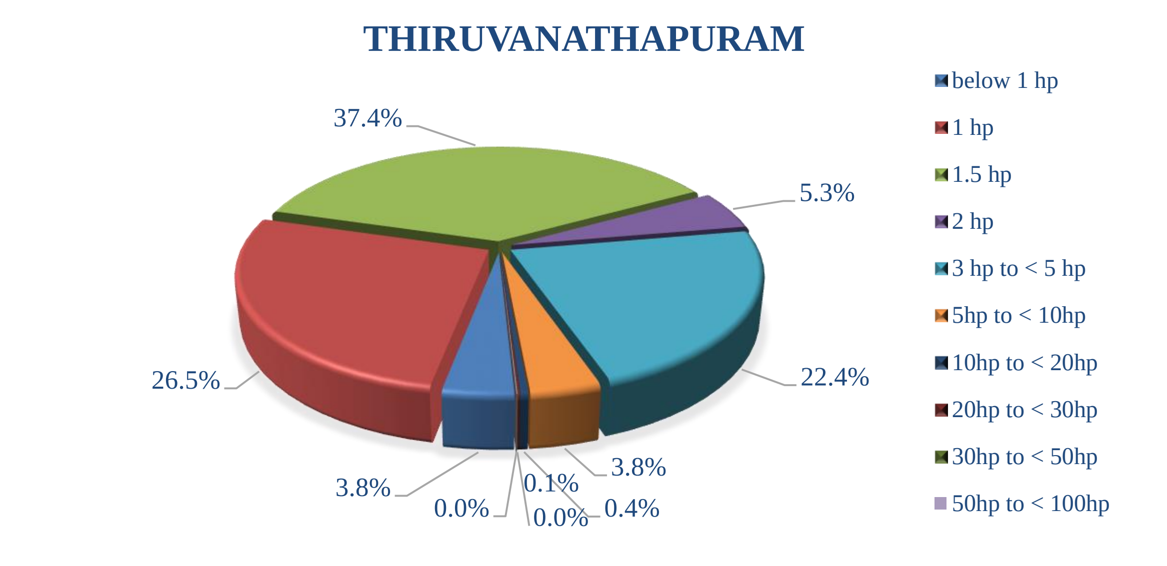




THIRUVANATHAPURAM					
Location/KSEB Section	**No**	**Location/KSEB Section**	**No**	**Location/KSEB Section**	**No**
Amboori [4656]	46	Karamana [4510]	21	Nemom [4543]	173
Aryanad [4652]	65	Kattakada [4552]	165	Neyyattinkara [4537]	260
Attingal [4531]	118	Kazhakuttam [4521]	785	Ottasekharamangalam [4554]	133
Avanavancherry [4532]	140	Kedakulam [4527]	299	Palachira [4534]	302
Balaramapuram [4542]	202	Kesavadasapuram [4516]	12	Pallickal [Attingal Dvn.] [4680]	103
Beach,Trivandrum [4513]	117	Kilimannoor [4535]	136	Palode [4548]	56
Cantonment,TVM [4506]	4	Kottukal [4657]	326	Parassala [4540]	383
Chirayinkeezhu [4529]	111	Kudappanakkunnu [4676]	95	Peringamala [4674]	42
Chullimanoor [4653]	96	Kulathoor [4520]	182	Peroorkada [4508]	68
Edava [4526]	83	Kunnathukal [4667]	129	Pettah [4514]	60

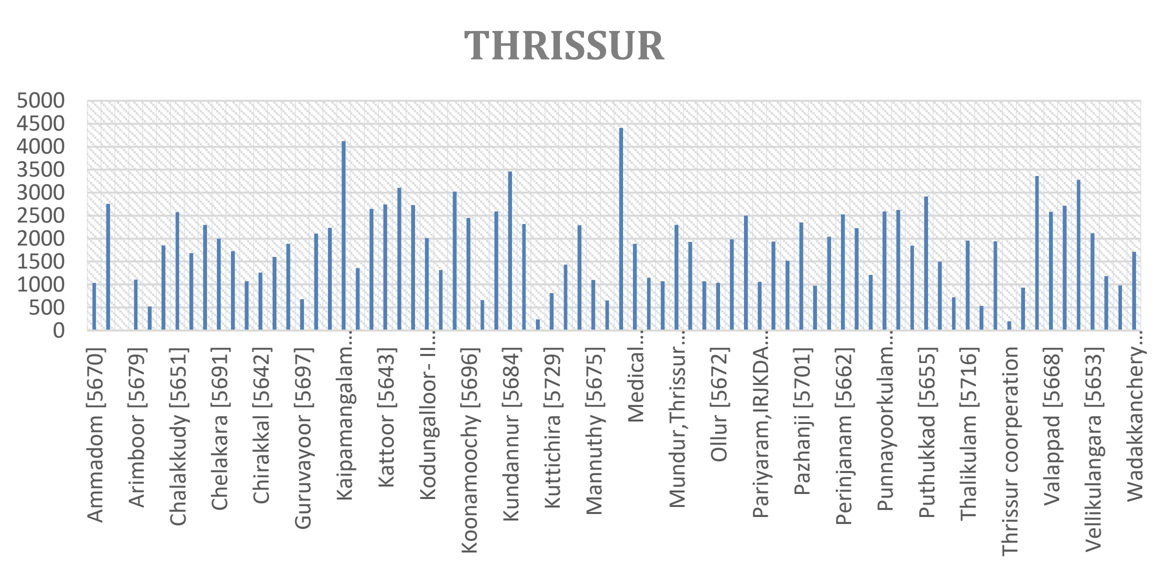
Kachani [4691]	121	Madavoor [4536]	119	Peyad [4550]	232
Kadakkavoor [4528]	68	Malayinkeezh [4666]	168	Poojappura [4512]	123
Kallambalam [4533]	142	Manacaud [4501]	19	Poonthura [4679]	16
Kallara [4557]	146	Mangalapuram [4523]	266	Poovachal [4864]	104
Kalliyoor [4675]	368	Maranalloor [4553]	200	Poovar [4545]	486
Kamukinkode [4868]	421	Marayamuttom [4539]	230	Poozhikunnu [4688]	558
Kaniyapuram [4522]	1346	Nagaroor [4654]	107	Pothencode [4524]	252
Kanjiramkulam [4544]	412	Nalanchira [4518]	118	Sreekariyam [4519]	313
Kanyakulangara [4556]	107	Nedumangad [4547]	108	Sreevaraham [4515]	20
Thirumala [4511]	77	Uzhamalakkal [4673]	57	Vellanad [4551]	211
Thiruvallam [4502]	192	Vakkom [4530]	90	Vellarada [4541]	130
Tholicode [4681]	36	Vamanapuram [4821]	128	Vellayambalam [4507]	13
Thycaud [4505]	1	Varkala [4525]	79	Venjaramood [4555]	212
Uchakkada [4655]	423	Vattappara [4678]	150	Vithura [4549]	71
Udiyankulangara [4538]	350	Vattiyoorkavu [4509]	85	Vizhinjam [4546]	445
Ulloor [4517]	21	**Grand Total**		**14053**	

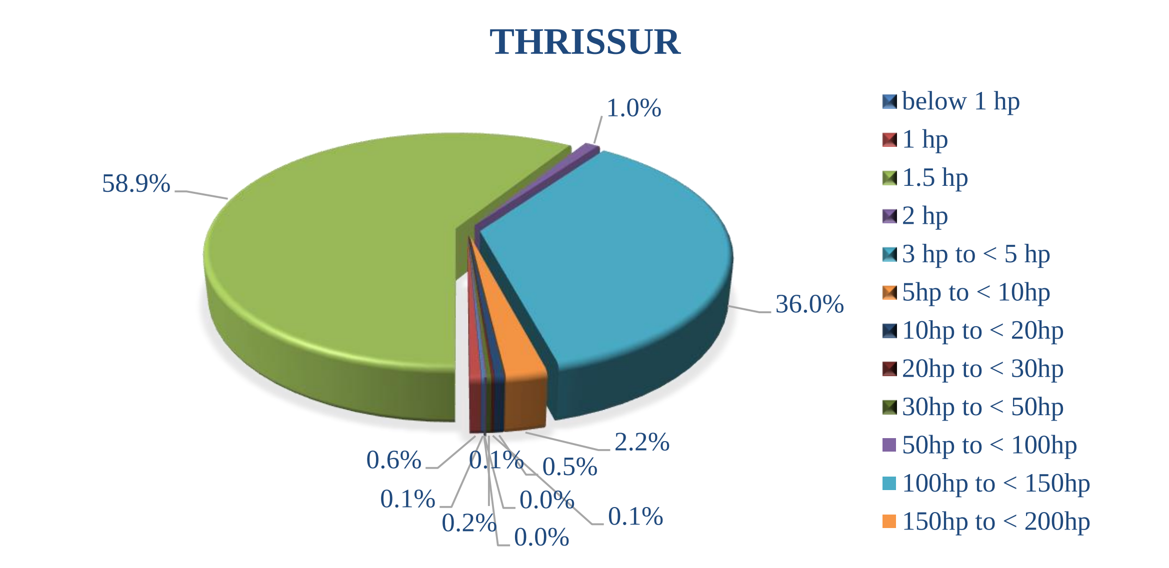




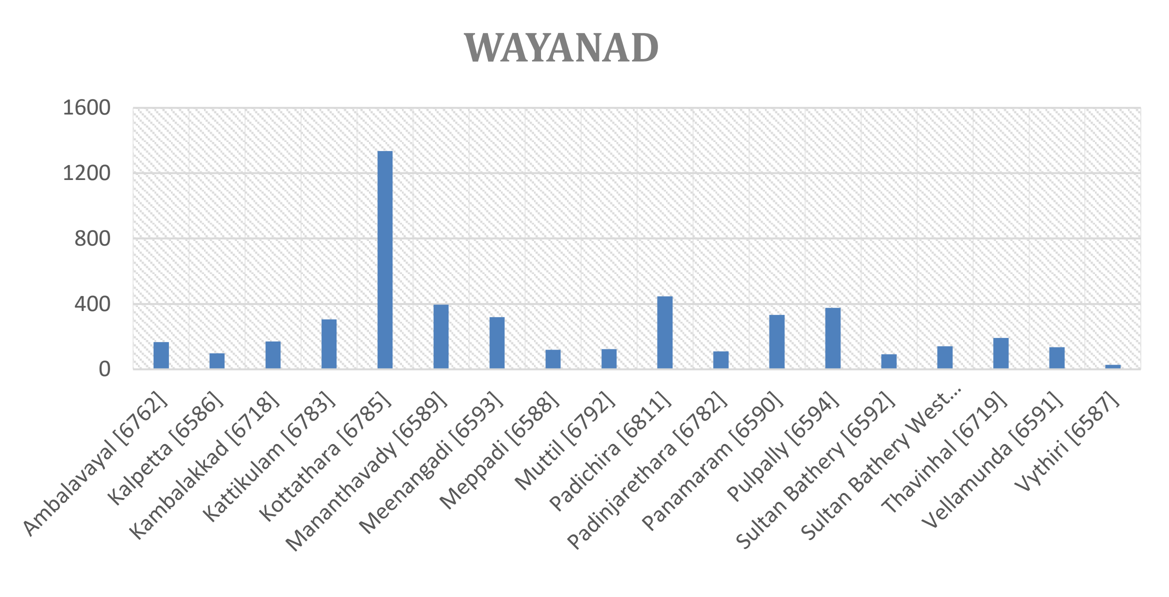
THRISSUR					
Location/KSEB Section	**No**	**Location/KSEB Section**	**No**	**Location/KSEB Section**	**No**
Ammadom [5670]	1037	Kandassankadavu [5689]	1358	Mathilakom [5661]	4412
Annamanada [5648]	2757	Karuvannur [5640]	2648	Medical College [5714]	1889
Arattupuzha [5833]	6	Kattoor [5643]	2741	Meloor [5650]	1147
Arimboor [5679]	1104	Kecheri [5694]	3103	Mulamkunnathukavu [5682]	1069
Ayyanthole [5678]	524	Kodakara [5654]	2729	Mundur,Thrissur [5695]	2298
Big Bazar,Thrissur [5702]	1851	Kodungalloor- II [5664]	2014	Muthuvara [5685]	1929
Chalakkudy [5651]	2576	Kodungalloor-I [5663]	1312	Nadathara [5677]	1074
Chavakkad [5698]	1681	Kombodinjamakkal [5645]	3023	Ollur [5672]	1038
Chavakkad Beach [5699]	2301	Koonamoochy [5696]	2454	Parappookara [5641]	1982
Chelakara [5691]	1999	Koorkancherry [5669]	659	Parappur [5686]	2497
Cherpu [5639]	1723	Koratty [5649]	2591	Pariyaram,IRJKDA [5652]	1060
Cheruthuruthy [5692]	1068	Kundannur [5684]	3463	Pattikad [5676]	1934
Chirakkal [5642]	1258	Kunnamkulam [5700]	2316	Pavaratty [5687]	1519
Desamangalam [5717]	1602	Kuriachira [5671]	240	Pazhanji [5701]	2355
Eriyad [5665]	1886	Kuttichira [5729]	815	Pazhayannur [5719]	971
Guruvayoor [5697]	680	Kuzhoor [5657]	1433	Peringottukara [5666]	2040
Irinjalakuda- I [5644]	2108	Mala [5658]	2291	Perinjanam [5662]	2525
Irinjalakuda-II [5647]	2234	Mannuthy [5675]	1101	Perumbilavu [5727]	2227
Kaipamangalam [5660]	4124	Marathakara [5673]	653	Punnamparambu [5718]	1214
Punnayoorkulam [5703]	2592	Thiruvillwamala [5693]	534	Varandarappally [5656]	2717
Puthenchira [5728]	2622	Thriprayar [5667]	1945	Vellangallur [5646]	3280
Puthenvelikkara [5659]	1846	Thrissur coorperation	197	Vellikulangara [5653]	2114
Puthukkad [5655]	2920	Vadakkumchery [6515]	935	Vengidange [5690]	1181
Puthur,Thrissur [5674]	1497	Vadanappally [5688]	3365	Viyur [5680]	981

Ramavarmapuram [5681]	722	Valappad [5668]	2584	Wadakkanchery [5683]	1713
Thalikulam [5716]	1959	**Grand Total**		**140347**	





WAYANAD			
Location/KSEB Section	**No**	**Location/KSEB Section**	**No**
Ambalavayal [6762]	167	Padichira [6811]	447
Kalpetta [6586]	98	Padinjarethara [6782]	111
Kambalakkad [6718]	170	Panamaram [6590]	334
Kattikulam [6783]	305	Pulpally [6594]	377
Kottathara [6785]	1335	Sultan Bathery [6592]	92
Mananthavady [6589]	396	Sultan Bathery West [6720]	141
Meenangadi [6593]	319	Thavinhal [6719]	192
Meppadi [6588]	120	Vellamunda [6591]	135
Muttil [6792]	123	Vythiri [6587]	27
Grand Total		**4889**	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1600
1200
800
400
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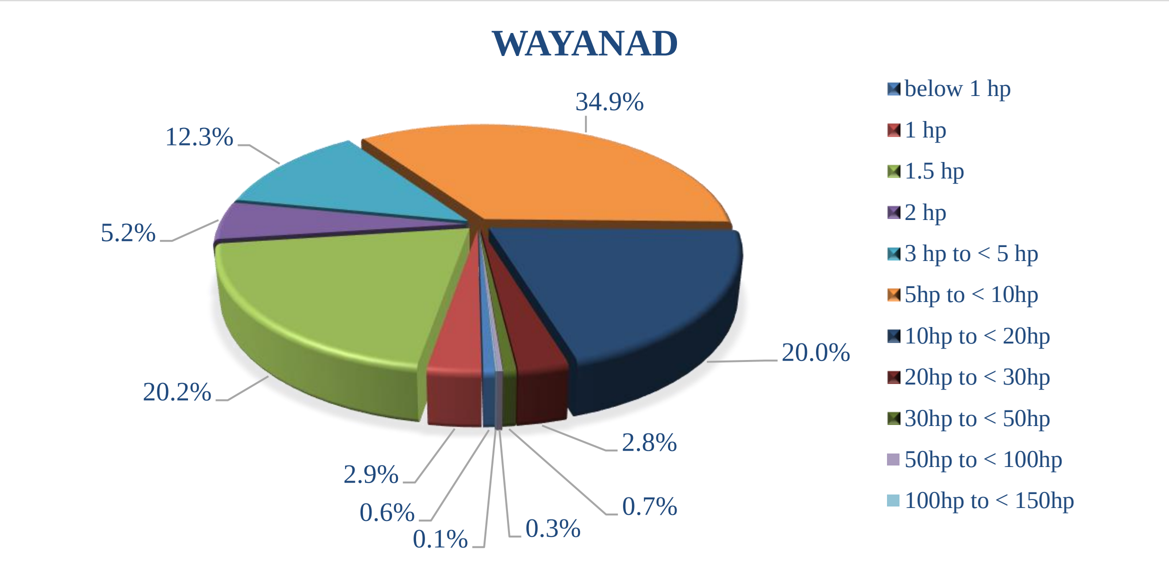
Ambalavayal [6762]
Kalpetta [6586]
Kambalakkad [6718]
Kattikulam [6783]
Kottathara [6785]
Mananthavady [6589]
Meenangadi [6593]
Meppadi [6588]
Muttil [6792]
Padichira [6811]
Padinjarethara [6782]
Panamaram [6590]
Pulpally [6594]
Sultan Bathery [6592]
Sultan Bathery West...
Thavinhal [6719]
Vellamunda [6591]
Vythiri [6587]


WAYANAD
34.9%
12.3%
5.2%
20.2%
20.0%
2.9%
0.6%
0.1%
0.3%
0.7%
2.8%
below 1 hp
1 hp
1.5 hp
2 hp
3 hp to < 5 hp
5hp to < 10hp
10hp to < 20hp
20hp to < 30hp
30hp to < 50hp
50hp to < 100hp
100hp to < 150hp

8. SURVEY & EFFICIENCY EVALUATION

8.1 After listing the entire pump population, representative samples of 150 pumps were identified across the state. The geographical identification of pumps covered under the study is given below.

8.2 The consumer number, location and the pump capacity details of the150 pumps taken as sample for energy efficiency is given below:

Table 4 List of Consumer for the Survey

Sl No	CONSUMER NO.	District	Type	Make	Location	Rated Pump Capacity HP
1	1155011019516	Alappuzha	Mono block	Kirloskar	Kottankulangara	1.5
2	1155011012624		Mono block	Crompton Greaves	Pallimukku	1.5
3	1155013016274		Mono block	V-Guard	Palm grove lake	1.5
4	1155010026471		Mono block	Raidco	Theerthasseri	1.5
5	1155011027488		Mono block	V-Guard	Thathampally	1.0
6	1155011027780		Mono block	Kirloskar	Thondankulangara	1.5
7	1155012029933		Mono block	ELLAI Lakshmi	Starting Point pattiam	1.5
8	1155012013466		Mono block	Kirloskar	Triveni-Indira Jn	1.5
9	1155011011569		Mono block	Kirloskar	Kommady	1.0
10	1155011029676		Mono block	ELLAI Lakshmi	Punnamada	1.5
11	1155010017229		Mono block	ELLAI Lakshmi	Thalodi	1.5
12	1155011027488		Mono block	Kirloskar	Thathampally	2.0
13	1155737004411	Ernakulam	Open well Submersible	Kirloskar	Kombankulam	3.0
14	1155733013087		Mono block	CRI	Kuttikattukara	1.0
15	1155731018133		Mono block	V-Guard	Palliamkara	1.5
16	1155732011743		Open well Submersible	Raidco	Cochin University	1.5
17	1155733006841		Mono block	V-Guard	Vidakuzha	1.0
18	1155733007122		Mono block	Kirloskar	Muttom	3.0
19	1155732012415		Mono block	ELLAI Lakshmi	NAD road	1.5
20	1155732022011		Mono block	Crompton Greaves	Rajagiri-Mythri Nagar	1.5
21	1155672000029		Mono block	Ellen	Keezhmadu	5.0
22	1155670006005		Mono block	Batuboi	Thottumugham	3.0
23	1155670013900		Mono block	Kirloskar	Ashokapuram	3.0
24	1155670010745		Mono block	Ellen	Chunagamvely	3.0
25	1155671001665		Split case	Kirloskar	Edepuram	3.0
26	1155671005035		Open well Submersible	Kirloskar	Valmiki Hill Keeramkunnu	5.0
27	1155670013412		Mono block	Crompton Greaves	Aluva Town	1.5
28	1155480019031		Mono block	Crompton Greaves	Choorakadu	1.0
29	1155482033984		Mono block	V-Guard	Puthiyakavu	0.5
30	1155483013862		Mono block	Vaisac-Renuka	Mekkara	0.5
31	1156183033719	Iduk	Mono block	Megha	Kumaramangalam	1.0

32	1156189035187		Mono block	Kirloskar	Chungam	1.0
33	1156182004206		Mono block	Texmo	Arikuzha	1.5
34	1156180031811		Split case	Crompton Greaves	Puthupariyaram	1.0
35	1156181007645		Mono block	Aquatex	Manakkad	1.5
36	1156183011927		Mono block	CRI	NRA-Manakkad	1.5
37	1156181002910		Mono block	Aquatex	Chittoor-Arikuzha	1.5
38	1156181008670		Mono block	Crompton Greaves	Arikuzha-Puthupariyaram	1.0
39	1156180003124		Mono block	Aquatex	Arikuzha-Parekkadavu	1.5
40	1156182023010		Mono block	Kirloskar	Nagapuzha	1.5
41	1156183002300		Mono block	Texmo	Puthupariyaram	1.5
42	1166380002728	Kannur	Mono block	Texmo	Kandangali	1.5
43	1166380006253		Mono block	Aquatex	Kanaayikanam	1.5
44	1166380006733		Mono block	Texmo	Kizhake Kandangali	0.5
45	1166380007296		Mono block	Texmo	Kanayi	3.0
46	1166380007319		Mono block	GEC	North Kanayi	3.0
47	1166380006265		Mono block	Texmo	Chittoor-Kanayi	3.0
48	1166380006344		Split case	GEC	Kanayi Main	1.5
49	1166380006297		Open well Submersible	Deccan	Kanayikanam	1.5
50	1166380006642		Mono block	GEC	Moorikoval	2.0
51	1166960007484	Kasargode	Mono block	Kirloskar	Pattenu	2.0
52	1166960037225		Mono block	Crompton Greaves	Pattinu	1.5
53	1166961003197		Mono block	Texmo	Chirapuram	1.5
54	1166960037336		Mono block	Kirloskar	Vaniyamvayal	1.5
55	1166960003225		Mono block	Kirloskar	Vadakkekkara	3.0
56	1166960039865		Mono block	Kirloskar	Kunniyoor	1.0
57	1166960028517		Mono block	ELLAI Lakshmi	Pallikara	1.5
58	1166960035957		Open well Submersible	Kirloskar	Neeleshwaram	1.5
59	1166961003148		Mono block	Kirloskar	Nileshwaram	1.0
60	1166961009936		Open well Submersible	Kirloskar	Palayi	1.0
61	1145690017004	Kollam	Mono block	Raidco	Puthiyakavu	1.0
62	1145690019901		Mono block	V-Guard	AVHS Junction	1.5
63	1145691021382		Mono block	Kirloskar	Sangapuram Junction	1.0
64	1145691021411		Mono block	Kirloskar	Kochalamoodu	1.5
65	1145691022987		Mono block	ELLAI Lakshmi	TB Hospital Junction	1.0
66	1145691023310		Mono block	Oriental	Velluthamanal	1.0
67	1145691025542		Mono block	Kirloskar	Pattassery mukku	1.0
68	1145691028850		Mono block	Kirloskar	Puthentheravu	1.0
69	1145690029993		Mono block	V-Guard	Kochalamoodu	0.5

70	1145690031442		Mono block	V-Guard	Puthenchantha mukku	0.5
71	1146363024285	Kottayam	Mono block	Crompton Greaves	Changanassery	1.5
72	1146361026202		Mono block	Kirloskar	Vazhappilly	2.0
73	1146349016780		Mono block	ELLAI Lakshmi	Kallupurackal	1.5
74	1146341014606		Mono block	ELLAI Lakshmi	Kallupurackal	1.5
75	1146347013732		Mono block	Kirloskar	Maliyepadi Junction	1.0
76	1146341018181		Mono block	Kirloskar	Puthangadi	1.0
77	1146348022270		Open Well Submersible	Crompton Greaves	Baker Hill	1.5
78	1146349006459		Open Well Submersible	Crompton Greaves	Baker Hill	1.5
79	1146349013674		Mono block	Kirloskar	Pullinackal	5.0
80	1146346019829		Mono block	ELLAI Lakshmi	15 kadavu puthenthodu	1.0
81	1146341014937		Mono block	Crompton Greaves	Thiruvathikal junction	2.0
82	1146340022199		Mono block	ELLAI Lakshmi	Velloor	0.5
83	1165983019849	Kozhikode	Open Well Submersible	Kirloskar	Kakkodi Bridge	1.5
84	1165980016716		Mono block	Kirloskar	Kannadikal	1.5
85	1165981013207		Vertical-Centrifugal	SSF	Kannadikal-Kulangara	1.0
86	1165988015579		Jet Centrifugal	Keragro	Vengeri	1.0
87	1165985015242		Mono block	Kirloskar	Kadampattuthazham	1.0
88	1165981016171		Mono block	Crompton Greaves	KrishnanNair Road-Kallissery	1.0
89	1165988011465		Mono block	Kirloskar	Karikamkulam	3.0
90	1165985022921		Mono block	Raidco	Karaparambu	1.0
91	1165987018871		Mono block	Kirloskar	Nadakkavu	1.0
92	1165985026138		Mono block	Kirloskar	Iranjipalam	2.0
93	1165553044980	Malappuram	Mono block	V-Guard	West Kodur	0.5
94	1165551046007		Open Well Submersible	Akash	Urdunagar	1.5
95	1165553017646		Mono block	Akash	Malayala Manorama Jn	1.5
96	1165551034763		Bore Well Submersible	Kirloskar	Varrikode	1.5
97	1165551012671		Mono block	Kirloskar	Peringhottupulam	1.5
98	1165551018027		Mono block	Kirloskar	Peringhottupulam madrassa	1.5
99	1165551010952		Open Well Submersible	Kirloskar	Thamarakuzhi	1.5
100	1165550014689		Mono block	Kirloskar	Kavungal	5.0

101	1165553013418		Open Well Submersible	CRI	Chemankadavu	1.5
102	1165551036309		Mono block	Kirloskar	Near Civil station	1.5
103	1165320005809	Palakkad	Mono block	Kirloskar	Railway Colony	3.0
104	1165320000772		Split case	Scroll	Valayapullikavu	5.0
105	1165320016497		Mono block	V-Guard	NSS Engg College-Pappadi	1.5
106	1165320000462		Bore well Compressor		Muttikulangara	5.0
107	1165320013777		Bore Well Submersible	Texmo	Pulichikottuthalam	7.5
108	1165320011739		Mono block	Kirloskar	Vallikkodu	1.5
109	1165320012992		Open Well Submersible	Kirloskar	Ummini	1.5
110	1165325006090		Mono block	Kirloskar	Vathalakkodu	3.0
111	1146002021665	Pathanamthitta	Mono block	Kirloskar	Elanthoor	1.5
112	1146007014697		Mono block	Texmo	Kadamanitta	0.5
113	1146007020333		Open Well Submersible	Kirloskar	Pathanamthitta Town	1.0
114	1146009009906		Mono block	Terra Pumps	Azhoor	0.5
115	1146037018881		Mono block	Crompton Greaves	Puthusserimala	1.0
116	1146037020907		Open Well Submersible	V-Guard	Vavolikandam	1.0
117	1146032021938		Mono block	ELLAI Lakshmi	Valiyakulam	1.0
118	1146034005989		Split case	Crompton Greaves	Perumbara-Kavanal	1.5
119	1146032022737		Mono block	Akash	Thalachira	0.5
120	1146170021029		Open Well Submersible	Kirloskar	Sreevallabha Jn	1.0
121	1146174020665		Mono block	Kirloskar	Manipuzha	1.5
122	1156720002975	Thrissur	Split case	Batuboi	Thalavanikkara	1.5
123	1156720006004		Open Well Submersible	Indica	Ollur	3.0
124	1156720004204		Mono block	ELLAI Lakshmi	Chittisery	1.5
125	1156720003058		Mono block	Worthington Simpson	Nenmanikkara	3.0
126	1156720005857		Bore Well Submersible	ELLAI Lakshmi	Thalore	1.5
127	1156720004535		Mono block	Texmo	Thalore	1.5
128	1156720005797		Mono block	Samudra	Thrilokhyamangalam	1.0
129	1156722008613		Mono block	ELLAI Lakshmi	Palliyekkara-Thalavanikara	1.5
130	1156720000192		Mono block	Crompton Greaves	Vailoppilly	3.0

131	1145431009798	Trivandrum	Mono block	Kirloskar	Poozhikunnu-Nemom	1.5
132	1145430013470		Mono block	ELLAI Lakshmi	Poozhikunnu-Nemom	1.0
133	1145430019904		Mono block	Kirloskar	Vellayani-Keerthy nagar	1.0
134	1145430010432		Mono block	Kirloskar	Karakamandapam	1.5
135	1145431021063		Open Well Submersible	ELLAI Lakshmi	Pazhayakarakamandapam	1.5
136	1145431012127		Mono block	ELLAI Lakshmi	Poozhikunnu	1.0
137	1145430012039		Mono block	Texmo	Nemom	1.0
138	1145430006698		Mono block	ELLAI Lakshmi	Poozhikunnu	1.0
139	1145431009957		Open Well Submersible	ELLAI Lakshmi	Pravachambalam	1.5
140	1145430024170		Mono block	Kirloskar	Edaicodu	5.0
141	1167821010562	Wayanad	Mono block	Kirloskar	Mundakutty	10.0
142	1167820001495		Mono block	ELLAI Lakshmi	Mill mukku	1.5
143	1167820010418		Mono block	CRI	Cheriyankolly	1.5
144	1167823010385		Split case	Kirloskar	Cherumkolli	7.5
145	1167823010474		Mono block	Crompton Greaves	Cherumkolli	10.0
146	1167820010586		Monoblock	Kirloskar	Padinjarathara-Mundakutty	10.0
147	1167821012408		Open Well Submersible	CRI	16 mile	1.5
148	1167821014450		Open Well Submersible	Shakthi	16 mile	1.5
149	1167821010166		Monoblock	Kirloskar	Puthusserikadavu	1.5
150	1167821011726		Open Well Submersible	V-Guard	Kappavayal	1.5

8.3 Overall approach for pump performance evaluation

8.3.1 The conventional method of evaluating pump set efficiency is by taking sample measurements of water flow, electrical power consumption, and total head comprised of suction and discharge head and the pipe dimensions along with number of elbows and bends etc. The overall approach in evaluating the pump performance is indicated in flow diagram as provided below

Standard Data Collection

- Standard data collection sheet was prepared and finalised prior to the commensment of the study to be filled at site.

Pump Specifications

- All pump specifications and observations were documented and entered in the data sheet

Measurements

- Motor Input power was measured by power meter and pump flow was measured by volumetric method.
- The suction length of open well water table was measured by measuring tape whereas for bore well the water table depth was recorded fromfarmer's data and also verified from boring agency in the region
- The discharge length of all piping was measured and also verified from famers data at site.
- Pipe inner diameter was measured at the suction and discharge end with the help of measuring tape.

Measurement Precautions

- Pump was started and flow allowed stablizing for few minutes. The readings were verified two to thre times to minimise errors
- Power consumed by the pump was simultaneously measured during all measurements with the help of a power meter to measure kW, Current, Voltage and Power factor

Stakeholder Consultations

- Energy Efficeicnt pump sets are selected with the help of pump manufacturers

8.3.2 The detailed survey involved the physical verification, discussion with the consumers, field tests like flow measurement, Head estimation, Power measurements, Pipe layout, document inspection etc. The survey is carried out based on the pre prepared format. The format sample used for the survey is given below:

Figure 8 Template of the survey format

<table>
<tr><th colspan="2">Pump ID</th><th></th><th>Consumer Number</th><th></th></tr>
<tr><td colspan="2">Consumer Name</td><td colspan="3"></td></tr>
<tr><td rowspan="2">Location</td><td>District</td><td></td><td rowspan="2">Address</td><td rowspan="2"></td></tr>
<tr><td>KSEB Section</td><td></td></tr>
<tr><td colspan="2">Land Area</td><td>Cent</td><td>Phone No.</td><td></td></tr>
<tr><td colspan="2">Pump Type</td><td></td><td rowspan="2">Crop Detail</td><td rowspan="2"></td></tr>
<tr><td colspan="2">Water Source</td><td></td></tr>
<tr><td colspan="2">Connected Load</td><td>W</td><td>Water Usage (Duration)</td><td>hr/day</td></tr>
<tr><td colspan="2">Pump Make</td><td></td><td>Average Consumption per month</td><td>kWh</td></tr>
<tr><td colspan="2">Phase</td><td>Φ</td><td>Age</td><td>Years</td></tr>
<tr><td colspan="2">Rated Discharge</td><td>lps</td><td>Rating(HP/kW)</td><td>HP</td></tr>
<tr><td colspan="2">Overall Efficiency</td><td>%</td><td>Rated Head</td><td>m</td></tr>
<tr><td colspan="2">Rewinding of the motor</td><td></td><td>Size (mm)</td><td></td></tr>
</table>

Suction Pipe Diameter	inch(mm)	Delivery Pipe Diameter	inch(mm)
Layout		**Photo**	
Measured Parameters			
Voltage	V	Discharge	lps
Current	A	Head	m
Power Factor		Power	kW

8.3.3 The details of the survey conducted for the 150 pumps are given in prescribed data sheet in the Appendix no.3.

8.4 Measurement and Technical Analysis

8.4.1 Pump performance has been evaluated by undertaking water flow measurements, power consumption measurements and head & loss estimation in pipe lengths.

8.4.2 Feasibility of water flow measurement using ultrasonic flow meter was tested. However due to site constraints it was not possible to use ultrasonic flow meter in all the locations hence same has been carried out by using volumetric flow measurement method. A portable three phase power analyzer has been used for electrical parameter measurements.

8.5 Water flow measurement by volumetric flow measurement method

8.5.1 During initial field visits at various agricultural pump sets, it was observed that most of the water pipelines are of PVC and are flexible, where ultrasonic flow meter can't be used. Hence, water flow has been collected in a barrel of known volume and time required in seconds to fill up the barrel has been measured using a stop watch. In order to minimize the human error the measurements were repeated for 2 to 3 times.

8.5.2 The water flow can be calculated with help of following formula,

$$\textbf{Water Flow (m}^3\textbf{/hr) = (Volume of Barrel} \times \textbf{3600)/(1000} \times \textbf{Time in seconds)}$$

8.6 Actual head measurement

8.6.1 Since water pipelines are PVC & flexible, there is no provision for pressure gauge /head measurement. Hence, head estimation by suction & discharge pressure measurement was not feasible.

8.6.2 For open well, water level below ground level is measured with measuring tape whereas for bore wells depth of water levels is noted based on farmers input and same has been verified from local boring agencies. Height of discharge from ground level and length& diameter of pipe were measured. All these constitute to actual pump head including losses.

8.7 Frictional / Pressure losses in pipes

8.7.1 Whenever water flows in a pipe, there will be some loss of pressure due to following factors:

- Friction: This is affected by the roughness of the inside surface of the pipe, the pipe diameter, and the physical properties of the fluid.
- Changes in size and shape or direction of flow.
- Obstructions: For normal cylindrical straight pipes, the major cause of pressure loss will be due to friction. Pressure loss in a fitting or valve is greater than a straight pipe. When fluid flows in a straight pipe, the flow pattern will be the same throughout the pipe. Valve or fitting, changes the flow pattern. This causes extra pressure drops.
- Pressure drop has been measured as per the following Darcy Weichbach equation.

$$H_f = \frac{4\ X\ f\ X\ L\ X\ V^2}{2\ X\ g\ X\ d}$$

Where,

H_f	=	Head loss to friction (m)
L	=	Length (m)
V	=	Flow velocity (m/s)
g	=	Gravitational constant (9.81 m/s^2)
d	=	Pipe inside diameter (m)
f	=	Friction factor (dimensionless)

8.8 Electrical Power Measurements

8.8.1 The electric parameters like current, voltage, power factor and active power for agriculture pumps were measured.

8.9 Pump set efficiency calculation

8.9.1 The pump set efficiency has been calculated with the help of following formula.

Pump set Efficiency $= \frac{Q \times h \times \rho \times g \times 100}{1000 \times 3600 \times kW_m}$

Where,

Q = Volume flow rate (m3/hr.)

h = (Net Static Head + Velocity Head at Suction & Discharge + Friction losses due to fittings & length), (m)

ρ = Density of the fluid (kg/m3)

g = Acceleration due to gravity (9.81 m/s2)

kW_m = Motor input power

8.10 Based on the site survey and field test conducted, the overall operating efficiencies of the individual pumps were calculated.

8.11 The sample efficiency evaluation of an agricultural pump is given below:

PUMP PERFORMANCE ANALYSIS		
Consumer No.		**1155012029933**
Pump Specifications		
Motor Rating	HP	1.5
	kW	1.125
Q	l/s	5.5
	m^3/sec	0.01
Rated head (H)	m	17
Pump Efficiency	=	Hydraulic Power (Ph) X 100 / Power Input to the pump shaft
Where, Hydraulic Power, P_h (KW) Q = Volume flow rate (m^3/s) r = density of the fluid (Kg/m^3) g = acceleration due to gravity (m/s^2) (h_d-h_s) = Total head in metres Pump shaft power P_s = P_m x h Motor		
Measured data		
Pump flow, Q	l/s	1.43
	m^3/s	0.001
Power absorbed, P	kW	1.05

Total head h	M	25.0
Motor efficiency	%	68.0
Type of drive : Direct coupled		
Density of water	kg/ m^3	1000
Pump efficiency		
Flow delivered by the pump	m^3/s	0.001
Hydraulic power	kW	0.35
Actual power consumption	kW	1.05
Overall system efficiency	**%**	**33.4**
Pump efficiency	%	49

8.12 Similarly, the overall efficiency of the 150 pumps were evaluated and the consolidated details are given below:

Table 5 Efficiency Evaluation of the Pumps

SL NO	Consumer No.	Type	Make	Rated Pump Details					Measured Details			Overall Efficiency	Deviation from rated Efficiency
				Power		Flow	Head	Rated Efficiency	Power	Flow	Head		
				HP	kW	lps	%	%	kW	lps	m	%	%
1	1155011019516	Mono block	Kirloskar	1.5	1.1				1.50	2.22	21.0	30.5%	
2	1155011012624	Mono block	Crompton Greaves	1.5	1.1				1.42	3.33	19.0	43.7%	
3	1155013016274	Mono block	V-Guard	1.5	1.1	5.50	14.0	47%	1.56	1.11	34.0	23.7%	23.3%
4	1155010026471	Mono block	Raidco	1.5	1.1	5.00	17.0	40%	1.56	2.22	21.0	29.3%	10.7%
5	1155011027488	Mono block	V-Guard	1.0	0.8	1.25	21.0	24%	0.94	0.40	28.0	11.7%	12.3%
6	1155011027780	Mono block	Kirloskar	1.5	1.1				1.46	1.11	34.0	25.4%	
7	1155012029933	Mono block	ELLAI Lakshmi	1.5	1.1	5.50	17.0	40%	1.05	1.43	25.0	33.4%	6.6%
8	1155012013466	Mono block	Kirloskar	1.5	1.1	3.50	8.0	40%	1.02	0.83	37.0	29.6%	10.4%
9	1155011011569	Mono block	Kirloskar	1.0	0.8				0.79	0.45	28.0	15.6%	
10	1155011029676	Mono block	ELLAI Lakshmi	1.5	1.1	3.50	18.0	40%	1.30	3.30	15.0	37.4%	2.6%
11	1155010017229	Mono block	ELLAI Lakshmi	1.5	1.1	3.50	18.0	40%	1.48	3.16	18.0	37.7%	2.3%
12	1155011027488	Mono block	Kirloskar	2.0	1.5		22.0		1.80	3.90	20.0	42.5%	
13	1155737004411	Open well Submersible	Kirloskar	3.0	2.3				2.40	2.10	34.0	29.2%	
14	1155733013087	Mono block	CRI	1.0	0.8	1.40	22.0	28%	1.01	0.31	38.0	11.4%	16.6%
15	1155731018133	Mono block	V-Guard	1.5	1.1	3.00	18.0	36%	1.30	1.59	24.0	28.8%	7.2%
16	1155732011743	Open well Submersible	Raidco	1.5	1.1	3.75	17.0	40%	1.10	0.83	37.0	27.4%	12.6%
17	1155733006841	Mono block	V-Guard	1.0	0.8	1.75	23.0	28%	0.96	1.67	16.0	27.3%	0.7%

18	1155733007122	Mono block	Kirloskar	3.0	2.3				2.10	4.00	26.0	48.6%	
19	1155732012415	Mono block	ELLAI Lakshmi	1.5	1.1	5.00	12.0		1.20	2.22	16.0	29.0%	
20	1155732022011	Mono block	Crompton Greaves	1.5	1.1	4.25	16.0	44%	1.14	2.60	17.0	38.0%	6.0%
21	1155672000029	Mono block	Ellen	5.0	3.8	10.00	30.0	50%	3.90	7.40	25.0	46.5%	3.5%
22	1155670006005	Mono block	Batuboi	3.0	2.3				3.90	3.80	29.0	27.7%	
23	1155670013900	Mono block	Kirloskar	3.0	2.3				4.80	4.10	27.0	22.6%	
24	1155670010745	Mono block	Ellen	3.0	2.3	5.50	20.0	45%	4.90	4.00	27.0	21.6%	23.4%
25	1155671001665	Split case	Kirloskar	3.0	2.3	9.00	16.0	56%	2.80	5.60	25.0	49.1%	7.0%
26	1155671005035	Open well Submersible	Kirloskar	5.0	3.8				4.40	5.00	18.0	20.1%	
27	1155670013412	Mono block	Crompton Greaves	1.5	1.1				1.40	2.10	19.0	28.0%	
28	1155480019031	Mono block	Crompton Greaves	1.0	0.8	3.17	14.5		0.96	0.53	31.0	16.8%	
29	1155482033984	Mono block	V-Guard	0.5	0.4	2.40	10.0	28%	0.86	1.67	12.0	22.9%	5.1%
30	1155483013862	Mono block	Vaisac-Renuka	0.5	0.4				0.68	1.00	11.0	15.9%	
31	1156183033719	Mono block	Megha	1.0	0.8	1.90	21.0	28%	1.29	2.11	17.0	27.3%	0.7%
32	1156189035187	Mono block	Kirloskar	1.0	0.8	1.40	19.0	28%	1.12	1.12	23.0	22.6%	5.4%
33	1156182004206	Mono block	Texmo	1.5	1.1	3.50	20.0		1.20	2.22	16.0	29.0%	
34	1156180031811	Split case	Crompton Greaves	1.0	0.8				1.10	0.52	27.0	12.5%	
35	1156181007645	Mono block	Aquatex	1.5	1.1	4.15	16.0	40%	1.32	2.22	17.0	28.0%	12.0%
36	1156183011927	Mono block	CRI	1.5	1.1	2.22	23.0	38%	1.30	1.13	34.0	29.0%	9.0%
37	1156181002910	Mono block	Aquatex	1.5	1.1	4.15	16.0	40%	1.24	3.90	10.0	30.9%	9.1%
38	1156181008670	Mono block	Crompton Greaves	1.0	0.8	2.20	12.0	28%	0.85	0.93	24.0	25.8%	2.2%

39	1156180003124	Mono block	Aquatex	1.5	1.1	3.00	24.0		1.93	1.01	35.0	18.0%	
40	1156182023010	Mono block	Kirloskar	1.5	1.1	4.00	17.0	50%	1.36	4.20	13.0	39.4%	10.6%
41	1156183002300	Mono block	Texmo	1.5	1.1				1.20	3.70	13.0	39.3%	
42	1166380002728	Mono block	Texmo	1.5	1.1	4.80	16.0	40%	1.40	2.10	17.0	25.0%	15.0%
43	1166380006253	Mono block	Aquatex	1.5	1.1	4.15	16.0	40%	0.98	0.98	35.0	34.3%	5.7%
44	1166380006733	Mono block	Texmo	0.5	0.4				0.40	0.89	11.0	24.1%	
45	1166380007296	Mono block	Texmo	3.0	2.3	5.50	23.0	44%	2.05	1.56	36.0	26.9%	17.1%
46	1166380007319	Mono block	GEC	3.0	2.3	5.30	19.0		2.22	3.20	31.0	43.8%	
47	1166380006265	Mono block	Texmo	3.0	2.3	5.50	23.0	44%	2.80	3.10	31.0	33.7%	10.3%
48	1166380006344	Split case	GEC	1.5	1.1	4.25	12.0	50%	1.50	2.20	21.0	30.2%	19.8%
49	1166380006297	Open well Submersible	Deccan	1.5	1.1				1.58	2.30	21.0	30.0%	
50	1166380006642	Mono block	GEC	2.0	1.5	4.25	12.2	44%	1.90	3.80	16.0	31.4%	12.6%
51	1166960007484	Mono block	Kirloskar	2.0	1.5	3.10	22.0	48%	1.60	3.10	24.0	45.6%	2.4%
52	1166960037225	Mono block	Crompton Greaves	1.5	1.1	4.25	16.0	44%	1.04	1.20	33.0	37.4%	6.6%
53	1166961003197	Mono block	Texmo	1.5	1.1	4.80	16.0	40%	1.40	1.90	21.0	28.0%	12.0%
54	1166960037336	Mono block	Kirloskar	1.5	1.1	4.00	17.0	50%	2.29	1.44	21.0	13.0%	37.0%
55	1166960003225	Mono block	Kirloskar	3.0	2.3	6.00	22.0	50%	2.10	2.90	32.0	43.4%	6.6%
56	1166960039865	Mono block	Kirloskar	1.0	0.8	1.50	20.0	29%	1.18	1.90	14.0	22.1%	6.9%
57	1166960028517	Mono block	ELLAI Lakshmi	1.5	1.1	3.75	17.0	40%	1.60	3.10	20.0	38.0%	2.0%
58	1166960035957	Open well Submersible	Kirloskar	1.5	1.1				1.20	2.60	21.0	44.6%	
59	1166961003148	Mono block	Kirloskar	1.0	0.8	1.80	18.0	30%	1.40	0.75	31.0	16.3%	13.7%
60	1166961009936	Open well Submersible	Kirloskar	1.0	0.8				1.10	1.40	21.0	26.2%	
61	1145690017004	Mono block	Raidco	1.0	0.8	2.50	20.0	25%	0.98	0.98	24.0	23.5%	1.5%

62	1145690019901	Mono block	V-Guard	1.5	1.1	3.00	18.0	36%	1.05	0.70	37.0	24.2%	11.8%
63	1145691021382	Mono block	Kirloskar	1.0	0.8	1.40	20.0	28%	1.09	0.53	31.0	14.8%	13.2%
64	1145691021411	Mono block	Kirloskar	1.5	1.1				1.30	0.90	36.0	24.4%	
65	1145691022987	Mono block	ELLAI Lakshmi	1.0	0.8	1.40	20.0	28%	0.99	0.83	29.0	23.9%	4.1%
66	1145691023310	Mono block	Oriental	1.0	0.8	1.90	21.0	28%	0.96	0.49	34.0	17.0%	11.0%
67	1145691025542	Mono block	Kirloskar	1.0	0.8	1.40	20.0	28%	1.02	0.67	30.0	19.3%	8.7%
68	1145691028850	Mono block	Kirloskar	1.0	0.8	1.10	25.0	27%	1.08	1.21	24.0	26.4%	0.6%
69	1145690029993	Mono block	V-Guard	0.5	0.4	0.70	12.0	23%	0.56	0.60	14.0	14.7%	8.3%
70	1145690031442	Mono block	V-Guard	0.5	0.4	0.67	16.0	41%	0.58	0.58	19.0	18.6%	22.4%
71	1146363024285	Mono block	Crompton Greaves	1.5	1.1				1.40	1.20	25.0	21.0%	
72	1146361026202	Mono block	Kirloskar	2.0	1.5				1.60	3.60	20.0	44.1%	
73	1146349016780	Mono block	ELLAI Lakshmi	1.5	1.1				1.61	0.90	36.0	19.7%	
74	1146341014606	Mono block	ELLAI Lakshmi	1.5	1.1	5.60	15.0	40%	1.69	1.40	31.0	25.2%	14.8%
75	1146347013732	Mono block	Kirloskar	1.0	0.8	1.50	22.0	28%	0.64	0.90	18.0	24.8%	3.2%
76	1146341018181	Mono block	Kirloskar	1.0	0.8	0.40	44.0		0.71	0.60	31.0	25.7%	
77	1146348022270	Open Well Submersible	Crompton Greaves	1.5	1.1	2.20	22.0		1.60	0.30	52.0	9.6%	
78	1146349006459	Open Well Submersible	Crompton Greaves	1.5	1.1	2.20	22.0		1.64	0.80	37.0	17.7%	
79	1146349013674	Mono block	Kirloskar	5.0	3.8				4.20	7.60	13.0	23.1%	
80	1146346019829	Mono block	ELLAI Lakshmi	1.0	0.8	2.30	20.0	35%	1.25	1.10	24.0	20.7%	14.3%
81	1146341014937	Mono block	Crompton Greaves	2.0	1.5				1.70	3.70	18.0	38.4%	

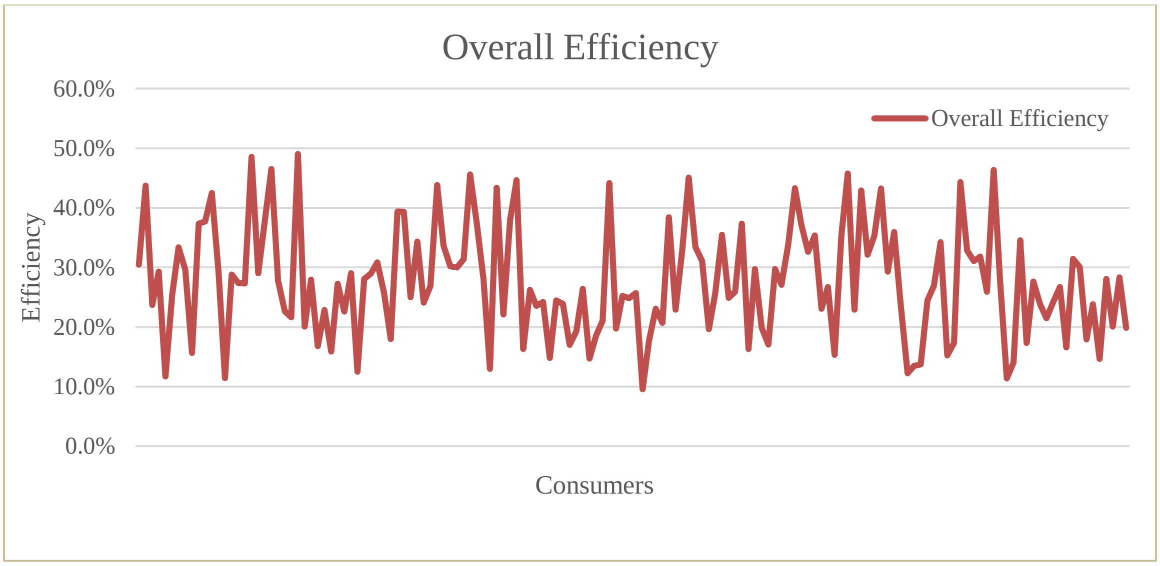
82	1146340022199	Mono block	ELLAI Lakshmi	0.5	0.4		50.0		0.60	0.50	28.0	22.9%	
83	1165983019849	Open Well Submersible	Kirloskar	1.5	1.1				1.13	2.00	19.0	33.0%	
84	1165980016716	Mono block	Kirloskar	1.5	1.1	4.00	17.0	50%	1.28	2.80	21.0	45.1%	4.9%
85	1165981013207	Vertical-Centrifugal	SSF	1.0	0.8				0.71	2.20	11.0	33.4%	
86	1165988015579	Jet Centrifugal	Keragro	1.0	0.8		25.0		0.73	1.10	21.0	31.0%	
87	1165985015242	Mono block	Kirloskar	1.0	0.8	2.20	20.0	28%	1.26	1.20	21.0	19.6%	8.4%
88	1165981016171	Mono block	Crompton Greaves	1.0	0.8		20.0	34%	1.10	3.20	9.0	25.7%	8.3%
89	1165988011465	Mono block	Kirloskar	3.0	2.3	4.50	30.0	40%	2.92	3.30	32.0	35.5%	4.5%
90	1165985022921	Mono block	Raidco	1.0	0.8	1.40	20.0	27%	0.78	1.10	18.0	24.9%	1.6%
91	1165987018871	Mono block	Kirloskar	1.0	0.8	1.40	20.0	28%	0.64	1.30	13.0	25.9%	2.1%
92	1165985026138	Mono block	Kirloskar	2.0	1.5				1.40	2.22	24.0	37.3%	
93	1165553044980	Mono block	V-Guard	0.5	0.4	1.00	15.0	25%	0.65	1.20	9.0	16.3%	8.7%
94	1165551046007	Open Well Submersible	Akash	1.5	1.1				1.92	2.77	21.0	29.7%	
95	1165553017646	Mono block	Akash	1.5	1.1				1.80	1.92	19.0	19.9%	
96	1165551034763	Bore Well Submersible	Kirloskar	1.5	1.1				1.90	1.27	26.0	17.0%	
97	1165551012671	Mono block	Kirloskar	1.5	1.1	4.00	17.0		1.85	2.67	21.0	29.7%	
98	1165551018027	Mono block	Kirloskar	1.5	1.1	4.00	17.0		1.90	2.50	21.0	27.1%	
99	1165551010952	Open Well Submersible	Kirloskar	1.5	1.1				1.13	1.86	21.0	33.8%	
100	1165550014689	Mono block	Kirloskar	5.0	3.8	10.00	23.5	50%	3.40	7.90	19.0	43.3%	6.7%
101	1165553013418	Open Well Submersible	CRI	1.5	1.1				1.30	2.90	17.0	37.2%	
102	1165551036309	Mono block	Kirloskar	1.5	1.1		13.0	45%	1.20	2.10	19.0	32.6%	12.4%

103	1165320005809	Mono block	Kirloskar	3.0	2.3				1.16	2.20	19.0	35.3%	
104	1165320000772	Split case	Scroll	5.0	3.8			33%	3.27	2.85	27.0	23.1%	9.4%
105	1165320016497	Mono block	V-Guard	1.5	1.1		18.0	36%	1.01	2.50	11.0	26.7%	9.3%
106	1165320000462	Bore well Compressor		5.0	3.8				3.50	1.66	33.0	15.4%	
107	1165320013777	Bore Well Submersible	Texmo	7.5	5.6				6.98	27.90	9.0	35.3%	
108	1165320011739	Mono block	Kirloskar	1.5	1.1	4.00	17.0	50%	1.13	3.10	17.0	45.8%	4.2%
109	1165320012992	Open Well Submersible	Kirloskar	1.5	1.1				2.16	2.40	21.0	22.9%	
110	1165325006090	Mono block	Kirloskar	3.0	2.3				2.40	4.20	25.0	42.9%	
111	1146002021665	Mono block	Kirloskar	1.5	1.1	3.50	17.0	50%	1.40	1.70	27.0	32.2%	17.8%
112	1146007014697	Mono block	Texmo	0.5	0.4	1.50	18.0	36%	0.40	0.72	20.0	35.3%	
113	1146007020333	Open Well Submersible	Kirloskar	1.0	0.8				0.54	1.40	17.0	43.2%	
114	1146009009906	Mono block	Terra Pumps	0.5	0.4	0.25	36.0		0.28	0.22	38.0	29.3%	
115	1146037018881	Mono block	Crompton Greaves	1.0	0.8				0.36	1.10	12.0	36.0%	
116	1146037020907	Open Well Submersible	V-Guard	1.0	0.8				0.65	1.11	14.0	23.5%	
117	1146032021938	Mono block	ELLAI Lakshmi	1.0	0.8				1.60	0.74	27.0	12.3%	
118	1146034005989	Split case	Crompton Greaves	1.5	1.1				1.80	0.65	38.0	13.5%	
119	1146032022737	Mono block	Akash	0.5	0.4		10.0	29%	0.90	0.35	36.0	13.7%	15.3%
120	1146170021029	Open Well Submersible	Kirloskar	1.0	0.8				0.80	0.95	21.0	24.5%	
121	1146174020665	Mono block	Kirloskar	1.5	1.1				1.40	1.60	24.0	26.9%	
122	1156720002975	Split case	Batuboi	1.5	1.1				1.10	1.60	24.0	34.2%	

123	1156720006004	Open Well Submersible	Indica	3.0	2.3				1.72	0.89	30.0	15.2%	
124	1156720004204	Mono block	ELLAI Lakshmi	1.5	1.1				1.40	0.65	38.0	17.3%	
125	1156720003058	Mono block	Worthington Simpson	3.0	2.3				1.70	2.40	32.0	44.3%	
126	1156720005857	Bore Well Submersible	ELLAI Lakshmi	1.5	1.1				1.30	1.50	29.0	32.8%	
127	1156720004535	Mono block	Texmo	1.5	1.1	3.00	18.0	35%	1.20	3.80	10.0	31.1%	3.9%
128	1156720005797	Mono block	Samudra	1.0	0.8	1.00	26.0	35%	0.65	1.11	19.0	31.8%	
129	1156722008613	Mono block	ELLAI Lakshmi	1.5	1.1	5.00	32.0		1.56	1.25	33.0	25.9%	
130	1156720000192	Mono block	Crompton Greaves	3.0	2.3	6.25	21.0	52%	2.10	3.10	32.0	46.3%	5.7%
131	1145431009798	Mono block	Kirloskar	1.5	1.1				1.10	1.11	28.0	27.7%	
132	1145430013470	Mono block	ELLAI Lakshmi	1.0	0.8	0.26	40.0		0.90	0.29	36.0	11.4%	
133	1145430019904	Mono block	Kirloskar	1.0	0.8	0.38	44.0		1.04	0.48	31.0	14.0%	
134	1145430010432	Mono block	Kirloskar	1.5	1.1	4.00	17.0	50%	1.25	2.00	22.0	34.5%	15.5%
135	1145431021063	Open Well Submersible	ELLAI Lakshmi	1.5	1.1				2.27	1.82	22.0	17.3%	
136	1145431012127	Mono block	ELLAI Lakshmi	1.0	0.8	2.30	21.5	35%	1.64	2.10	22.0	27.6%	7.4%
137	1145430012039	Mono block	Texmo	1.0	0.8				1.06	1.03	25.0	23.8%	
138	1145430006698	Mono block	ELLAI Lakshmi	1.0	0.8	0.26	16.0		1.40	1.33	23.0	21.4%	
139	1145431009957	Open Well Submersible	ELLAI Lakshmi	1.5	1.1				1.40	2.30	15.0	24.2%	
140	1145430024170	Mono block	Kirloskar	5.0	3.8				3.80	6.90	15.0	26.7%	

141	1167821010562	Mono block	Kirloskar	10.0	7.5				7.40	4.17	30.0	16.6%	
142	1167820001495	Mono block	ELLAI Lakshmi	1.5	1.1				1.03	1.50	22.0	31.4%	
143	1167820010418	Mono block	CRI	1.5	1.1	2.50	32.0	32%	0.98	1.20	25.0	30.0%	2.0%
144	1167823010385	Split case	Kirloskar	7.5	5.6	7.75	12.0	54%	5.78	5.55	19.0	17.9%	36.1%
145	1167823010474	Mono block	Crompton Greaves	10.0	7.5	20.00	24.0		7.90	6.00	32.0	23.8%	
146	1167820010586	Monoblock	Kirloskar	10.0	7.5				8.40	11.40	11.0	14.6%	
147	1167821012408	Open Well Submersible	CRI	1.5	1.1				1.23	2.20	16.0	28.1%	
148	1167821014450	Open Well Submersible	Shakthi	1.5	1.1				1.77	1.45	25.0	20.1%	
149	1167821010166	Monoblock	Kirloskar	1.5	1.1	1.60	24.0	32%	1.39	1.91	21.0	28.3%	3.7%
150	1167821011726	Open Well Submersible	V-Guard	1.5	1.1				1.60	0.90	36.0	19.9%	

8.13 The efficiency variation of the 150 consumers are plotted graphically and given below:

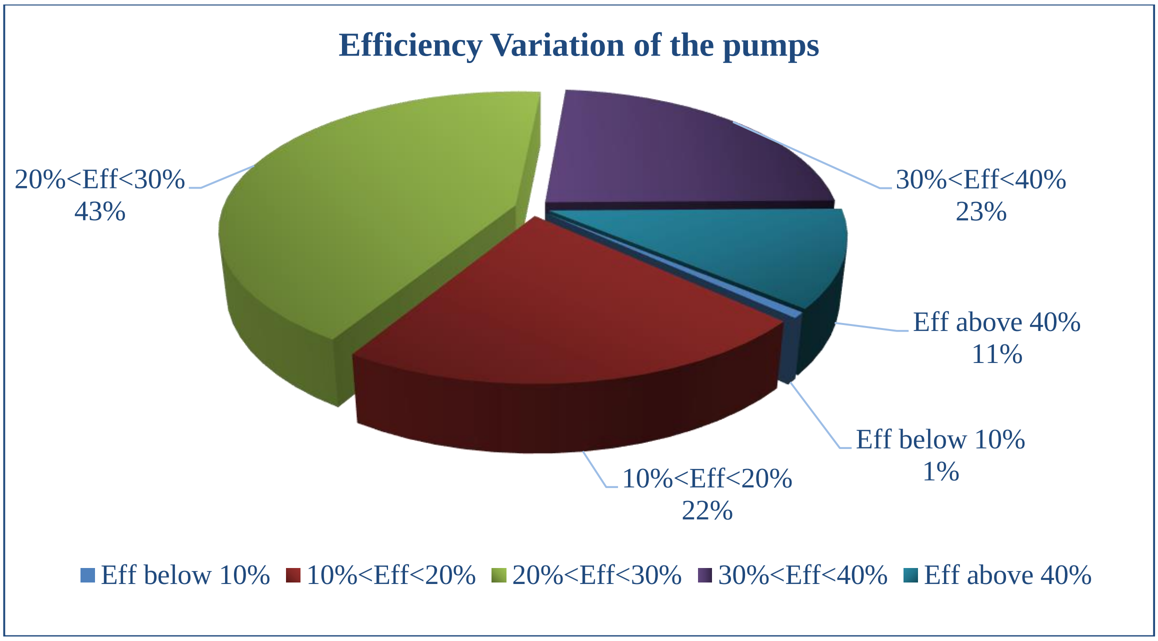


8.14 The summarized details of the efficiency evaluation is tabulated and given below:

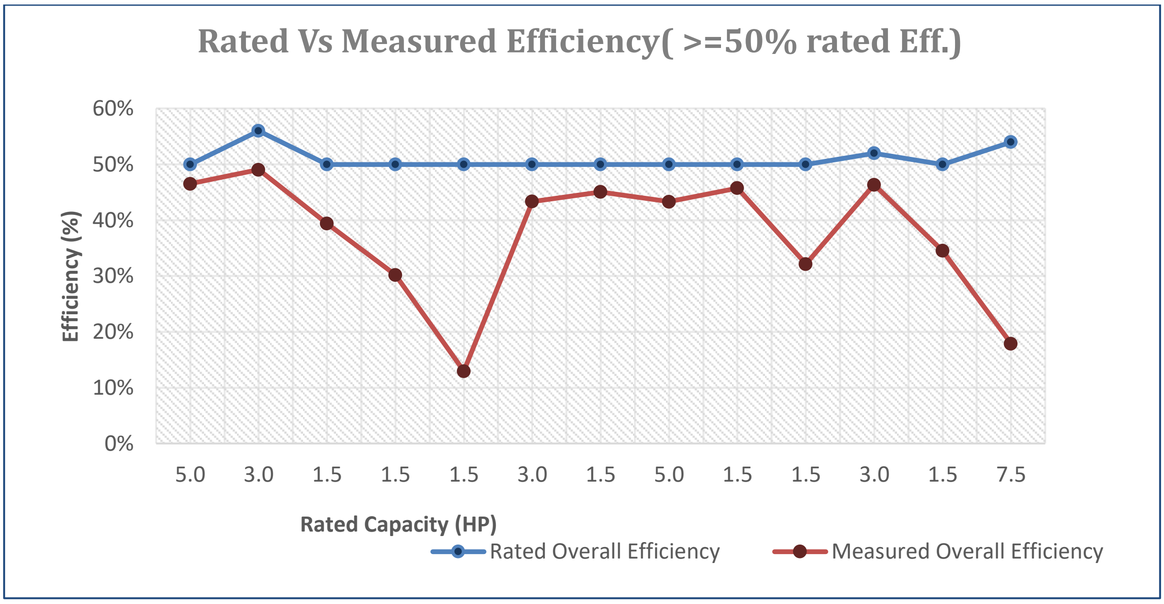
Pump Category	Pump Type	Percentage share different types of pumps covered	Average Measured Efficiency
below 1 hp	Mono Block	7%	21.4%
1 HP	Mono Block	23%	21.9%
	Open Well Submersible	3%	29.3%
1.5 HP	Mono Block	34%	29.6%
	Open Well Submersible	10%	26.4%
	Bore well Submersible	1%	24.9%
2 HP	Mono Block	4%	39.9%
3 HP to < 5HP	Mono Block	9%	37.3%
	Open Well Submersible	1%	22.2%
5hp to < 10 HP	Mono Block	6%	26.2%
	Open Well Submersible	1%	20.1%
	Bore well Submersible	1%	25.3%
Total/Average		**100%**	**27.6%**

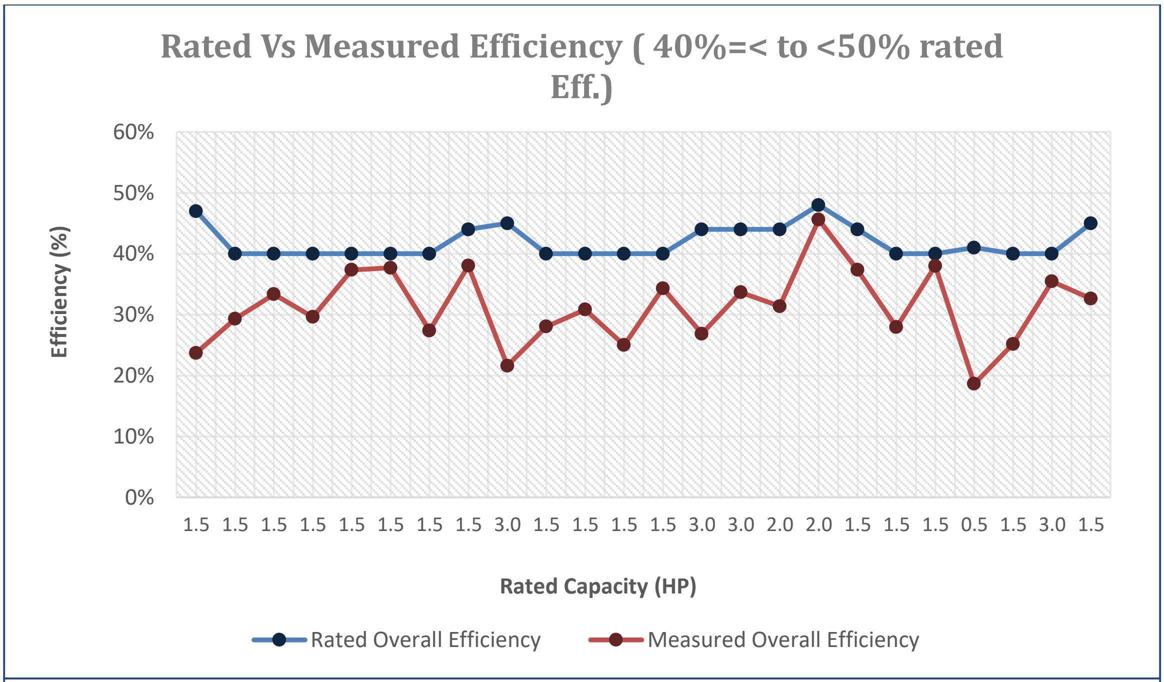
8.15 From the efficiency evaluation of 150 sampled pumps, the average overall efficiency obtained is about 27.6%. Among which maximum efficiency identified is 49.1% and the minimum efficiency is 9.6%.

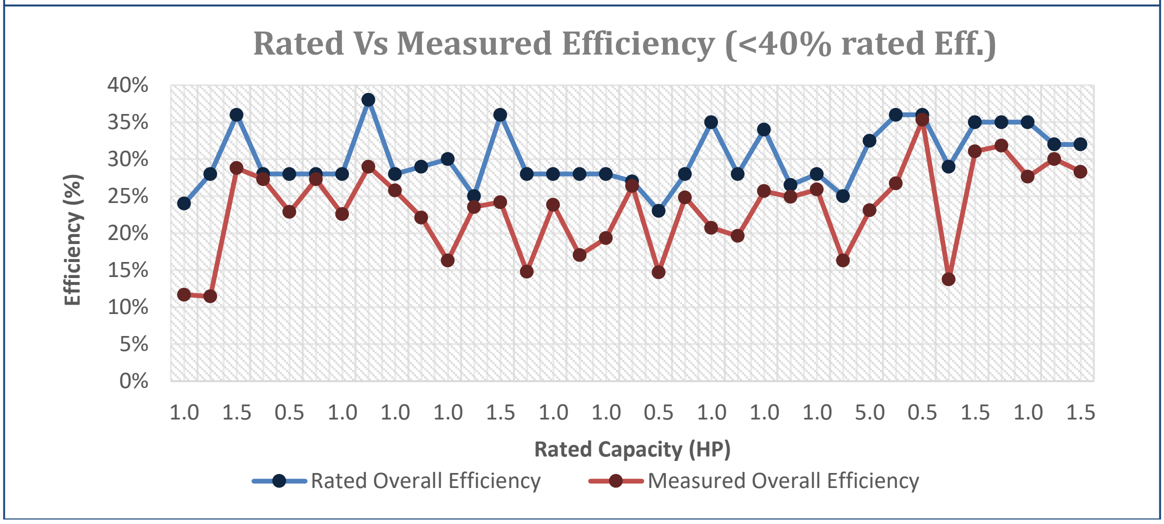
8.16 Efficiency level easily points out the poor working level of the agriculture pumping system of most of the cases. Only 11 % of the consumers are operating their pumps above 40%. The efficiency variation of the pumps are given below:



8.17 The comparative analysis has been carried out between present overall efficiency and rated efficiency of different category pumps. The details of analysis is given below:







8.18 From the above analysis we can see that, the higher overall efficiency achieved during the survey was only for pumps with higher rated efficiency and it is also observed that some pumps with high overall efficiency are operating with lesser operating efficiency.

8.19 Along with the overall efficiency evaluation of the pumps, the electricity consumption per m^3 of water pumping is also evaluated to compare the existing pumps with energy efficient pumps available in the market today and the details are given below:

Table 6 Evaluation of Specific Power Consumption (kWh/m^3)

SL NO	Consumer No.	Measured Details			Overall Efficiency	Specific Consumption
		Power	Flow	Head		
		kW	lps	m	%	kWh/m^3
1	1155011019516	1.50	2.22	21.0	30.5%	0.19
2	1155011012624	1.42	3.33	19.0	43.7%	0.12
3	1155013016274	1.56	1.11	34.0	23.7%	0.39
4	1155010026471	1.56	2.22	21.0	29.3%	0.20
5	1155011027488	0.94	0.40	28.0	11.7%	0.65
6	1155011027780	1.46	1.11	34.0	25.4%	0.37
7	1155012029933	1.05	1.43	25.0	33.4%	0.20
8	1155012013466	1.02	0.83	37.0	29.6%	0.34
9	1155011011569	0.79	0.45	28.0	15.6%	0.49
10	1155011029676	1.30	3.30	15.0	37.4%	0.11
11	1155010017229	1.48	3.16	18.0	37.7%	0.13
12	1155011027488	1.80	3.90	20.0	42.5%	0.13
13	1155737004411	2.40	2.10	34.0	29.2%	0.32
14	1155733013087	1.01	0.31	38.0	11.4%	0.91
15	1155731018133	1.30	1.59	24.0	28.8%	0.23
16	1155732011743	1.10	0.83	37.0	27.4%	0.37
17	1155733006841	0.96	1.67	16.0	27.3%	0.16
18	1155733007122	2.10	4.00	26.0	48.6%	0.15
19	1155732012415	1.20	2.22	16.0	29.0%	0.15
20	1155732022011	1.14	2.60	17.0	38.0%	0.12
21	1155672000029	3.90	7.40	25.0	46.5%	0.15
22	1155670006005	3.90	3.80	29.0	27.7%	0.29
23	1155670013900	4.80	4.10	27.0	22.6%	0.33
24	1155670010745	4.90	4.00	27.0	21.6%	0.34
25	1155671001665	2.80	5.60	25.0	49.1%	0.14
26	1155671005035	4.40	5.00	18.0	20.1%	0.24
27	1155670013412	1.40	2.10	19.0	28.0%	0.19
28	1155480019031	0.96	0.53	31.0	16.8%	0.50
29	1155482033984	0.86	1.67	12.0	22.9%	0.14
30	1155483013862	0.68	1.00	11.0	15.9%	0.19
31	1156183033719	1.29	2.11	17.0	27.3%	0.17
32	1156189035187	1.12	1.12	23.0	22.6%	0.28
33	1156182004206	1.20	2.22	16.0	29.0%	0.15
34	1156180031811	1.10	0.52	27.0	12.5%	0.59
35	1156181007645	1.32	2.22	17.0	28.0%	0.17
36	1156183011927	1.30	1.13	34.0	29.0%	0.32
37	1156181002910	1.24	3.90	10.0	30.9%	0.09
38	1156181008670	0.85	0.93	24.0	25.8%	0.25
39	1156180003124	1.93	1.01	35.0	18.0%	0.53
40	1156182023010	1.36	4.20	13.0	39.4%	0.09
41	1156183002300	1.20	3.70	13.0	39.3%	0.09

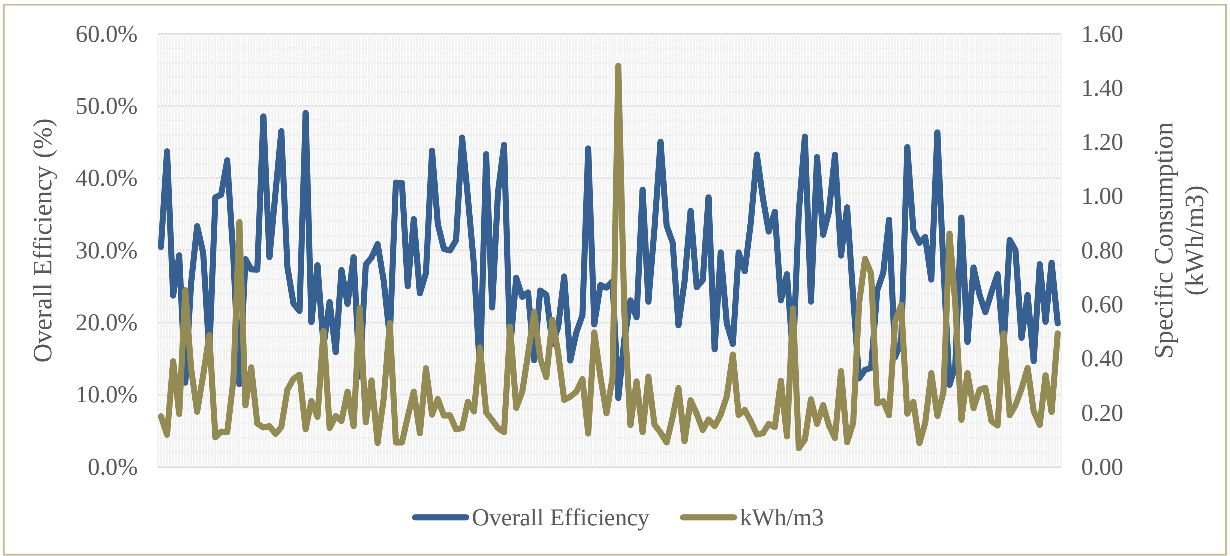
42	1166380002728	1.40	2.10	17.0	25.0%	0.19
43	1166380006253	0.98	0.98	35.0	34.3%	0.28
44	1166380006733	0.40	0.89	11.0	24.1%	0.12
45	1166380007296	2.05	1.56	36.0	26.9%	0.37
46	1166380007319	2.22	3.20	31.0	43.8%	0.19
47	1166380006265	2.80	3.10	31.0	33.7%	0.25
48	1166380006344	1.50	2.20	21.0	30.2%	0.19
49	1166380006297	1.58	2.30	21.0	30.0%	0.19
50	1166380006642	1.90	3.80	16.0	31.4%	0.14
51	1166960007484	1.60	3.10	24.0	45.6%	0.14
52	1166960037225	1.04	1.20	33.0	37.4%	0.24
53	1166961003197	1.40	1.90	21.0	28.0%	0.20
54	1166960037336	2.29	1.44	21.0	13.0%	0.44
55	1166960003225	2.10	2.90	32.0	43.4%	0.20
56	1166960039865	1.18	1.90	14.0	22.1%	0.17
57	1166960028517	1.60	3.10	20.0	38.0%	0.14
58	1166960035957	1.20	2.60	21.0	44.6%	0.13
59	1166961003148	1.40	0.75	31.0	16.3%	0.52
60	1166961009936	1.10	1.40	21.0	26.2%	0.22
61	1145690017004	0.98	0.98	24.0	23.5%	0.28
62	1145690019901	1.05	0.70	37.0	24.2%	0.42
63	1145691021382	1.09	0.53	31.0	14.8%	0.57
64	1145691021411	1.30	0.90	36.0	24.4%	0.40
65	1145691022987	0.99	0.83	29.0	23.9%	0.33
66	1145691023310	0.96	0.49	34.0	17.0%	0.54
67	1145691025542	1.02	0.67	30.0	19.3%	0.42
68	1145691028850	1.08	1.21	24.0	26.4%	0.25
69	1145690029993	0.56	0.60	14.0	14.7%	0.26
70	1145690031442	0.58	0.58	19.0	18.6%	0.28
71	1146363024285	1.40	1.20	25.0	21.0%	0.32
72	1146361026202	1.60	3.60	20.0	44.1%	0.12
73	1146349016780	1.61	0.90	36.0	19.7%	0.50
74	1146341014606	1.69	1.40	31.0	25.2%	0.34
75	1146347013732	0.64	0.90	18.0	24.8%	0.20
76	1146341018181	0.71	0.60	31.0	25.7%	0.33
77	1146348022270	1.60	0.30	52.0	9.6%	1.48
78	1146349006459	1.64	0.80	37.0	17.7%	0.57
79	1146349013674	4.20	7.60	13.0	23.1%	0.15
80	1146346019829	1.25	1.10	24.0	20.7%	0.32
81	1146341014937	1.70	3.70	18.0	38.4%	0.13
82	1146340022199	0.60	0.50	28.0	22.9%	0.33
83	1165983019849	1.13	2.00	19.0	33.0%	0.16
84	1165980016716	1.28	2.80	21.0	45.1%	0.13
85	1165981013207	0.71	2.20	11.0	33.4%	0.09
86	1165988015579	0.73	1.10	21.0	31.0%	0.18

87	1165985015242	1.26	1.20	21.0	19.6%	0.29
88	1165981016171	1.10	3.20	9.0	25.7%	0.10
89	1165988011465	2.92	3.30	32.0	35.5%	0.25
90	1165985022921	0.78	1.10	18.0	24.9%	0.20
91	1165987018871	0.64	1.30	13.0	25.9%	0.14
92	1165985026138	1.40	2.22	24.0	37.3%	0.18
93	1165553044980	0.65	1.20	9.0	16.3%	0.15
94	1165551046007	1.92	2.77	21.0	29.7%	0.19
95	1165553017646	1.80	1.92	19.0	19.9%	0.26
96	1165551034763	1.90	1.27	26.0	17.0%	0.42
97	1165551012671	1.85	2.67	21.0	29.7%	0.19
98	1165551018027	1.90	2.50	21.0	27.1%	0.21
99	1165551010952	1.13	1.86	21.0	33.8%	0.17
100	1165550014689	3.40	7.90	19.0	43.3%	0.12
101	1165553013418	1.30	2.90	17.0	37.2%	0.12
102	1165551036309	1.20	2.10	19.0	32.6%	0.16
103	1165320005809	1.16	2.20	19.0	35.3%	0.15
104	1165320000772	3.27	2.85	27.0	23.1%	0.32
105	1165320016497	1.01	2.50	11.0	26.7%	0.11
106	1165320000462	3.50	1.66	33.0	15.4%	0.59
107	1165320013777	6.98	27.90	9.0	35.3%	0.07
108	1165320011739	1.13	3.10	17.0	45.8%	0.10
109	1165320012992	2.16	2.40	21.0	22.9%	0.25
110	1165325006090	2.40	4.20	25.0	42.9%	0.16
111	1146002021665	1.40	1.70	27.0	32.2%	0.23
112	1146007014697	0.40	0.72	20.0	35.3%	0.15
113	1146007020333	0.54	1.40	17.0	43.2%	0.11
114	1146009009906	0.28	0.22	38.0	29.3%	0.35
115	1146037018881	0.36	1.10	12.0	36.0%	0.09
116	1146037020907	0.65	1.11	14.0	23.5%	0.16
117	1146032021938	1.60	0.74	27.0	12.3%	0.60
118	1146034005989	1.80	0.65	38.0	13.5%	0.77
119	1146032022737	0.90	0.35	36.0	13.7%	0.71
120	1146170021029	0.80	0.95	21.0	24.5%	0.23
121	1146174020665	1.40	1.60	24.0	26.9%	0.24
122	1156720002975	1.10	1.60	24.0	34.2%	0.19
123	1156720006004	1.72	0.89	30.0	15.2%	0.54
124	1156720004204	1.40	0.65	38.0	17.3%	0.60
125	1156720003058	1.70	2.40	32.0	44.3%	0.20
126	1156720005857	1.30	1.50	29.0	32.8%	0.24
127	1156720004535	1.20	3.80	10.0	31.1%	0.09
128	1156720005797	0.65	1.11	19.0	31.8%	0.16
129	1156722008613	1.56	1.25	33.0	25.9%	0.35
130	1156720000192	2.10	3.10	32.0	46.3%	0.19
131	1145431009798	1.10	1.11	28.0	27.7%	0.28

132	1145430013470	0.90	0.29	36.0	11.4%	0.86
133	1145430019904	1.04	0.48	31.0	14.0%	0.60
134	1145430010432	1.25	2.00	22.0	34.5%	0.17
135	1145431021063	2.27	1.82	22.0	17.3%	0.35
136	1145431012127	1.64	2.10	22.0	27.6%	0.22
137	1145430012039	1.06	1.03	25.0	23.8%	0.29
138	1145430006698	1.40	1.33	23.0	21.4%	0.29
139	1145431009957	1.40	2.30	15.0	24.2%	0.17
140	1145430024170	3.80	6.90	15.0	26.7%	0.15
141	1167821010562	7.40	4.17	30.0	16.6%	0.49
142	1167820001495	1.03	1.50	22.0	31.4%	0.19
143	1167820010418	0.98	1.20	25.0	30.0%	0.23
144	1167823010385	5.78	5.55	19.0	17.9%	0.29
145	1167823010474	7.90	6.00	32.0	23.8%	0.37
146	1167820010586	8.40	11.40	11.0	14.6%	0.20
147	1167821012408	1.23	2.20	16.0	28.1%	0.16
148	1167821014450	1.77	1.45	25.0	20.1%	0.34
149	1167821010166	1.39	1.91	21.0	28.3%	0.20
150	1167821011726	1.60	0.90	36.0	19.9%	0.49

8.20 The inverse relation between the overall efficiency and the specific Power consumption (kWh/m^3) of pumping system is plotted and given below:

Figure 9 Relationship between Overall efficiency & Specific Power Consumption



8.21 Major observations during the site study are listed below

8.21.1 Mono block pump sets are installed by most of the consumers. Submersible pump sets are also installed in some of the open wells & bore wells. In case of agriculture pumps, physical accurate head measurement was not possible.

8.21.2 Flexible P.V.C. pipes were commonly used for both suction and delivery sides.

8.21.3 The nameplate details of the submersible and most of the aged Mono block pumps are not available.

8.21.4 The workmanship quality for pump set installation was poor.

8.22 Observations: Factors effecting the overall efficiency of agriculture pumps

8.22.1 **Actual Pump set rating higher than name plate rating and sanctioned load**: It is a observed that even though sanctioned demand is 3 HP or 5 HP, power rating of most of the pump sets is higher than sanctioned demand. The reason for measured power consumption rating higher than sanctioned demand is that most of the farmers have rewound the pump sets suitably to draw more power and deliver higher water discharge. Since farmers are not charged for energy consumption. This is the major reason for no encouragement for deployment of more efficient pumps. It is difficult to make the farmers agree to have their pumps replaced, as it requires repeated efforts to make the farmers fully conversant to the objectives of the project.

8.22.2 It is also observed that the power consumption of the most of locally made lower rated pumps is much higher than the name plate rated capacity. Even though it will give higher flow the operating efficiency will be very low. This will have an inverse effect to the energy efficient pump promotion as the farmers are comparing the pump with low rate high flow parameter.

8.22.3 **Mismatching pump and system Head-Flow characteristic**: - The pump efficiency varies with flow and pressure and it is highest at one particular flow rate. When a pump is installed in a system, the operating point will always be intersecting point of two curves (pump and system curves). The pumps are operating at efficiencies less than the optimum efficiency because the units are not operating in the high efficiency range of Q and H. In the above scenario pumps are not operated at the BEP which results in the deviation in the characteristic curve his results in the lower efficiency than rated. This is mainly due to the improper selection of the pumps. Oversized pumps are main reasons for the curve shifting. Due to the variation in the water level seasonally, the pumps are selected considering the worst scenario.

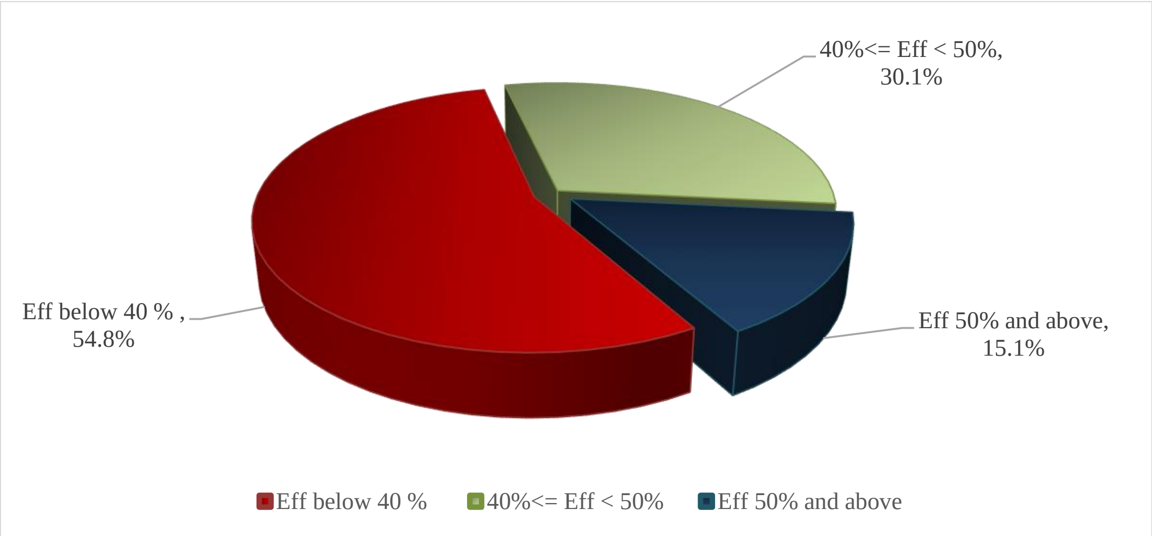
8.23 There are various parameters that could affect the pump set efficiency performance. Parameters identified that could affect the pump performance are listed below and discussed in detail in subsequent sections,

- Energy inefficient pump sets
- Improper pump selection and usage
- Undersized pipes

- Suction head variations and large discharge lengths
- Motor rewinding and low voltage profile
- Water table variations
- Other common causes

8.23.1 **Energy Inefficient pump sets: -**Due to lack of awareness about energy efficiency and low tariff structure for agriculture sector, energy aspect is overlooked by the farmers while selecting the pump sets. As the agriculture pumps owned by the consumers are not included in the scheme, the agriculture department has no control over the standard of the equipment. Though department aid the farmers to procure the pumps by some subsidy schemes all are not benefitted. Krishi bhavan provides necessary directions for the pump installation but are not followed properly by the farmers. To avoid the heavy cost burden and unawareness on energy efficiency consumers will be opting low cost local made pumps. This scenario develops high market for the inferior quality pumps. The following is the statistical inference of the overall efficiency level of the pump set

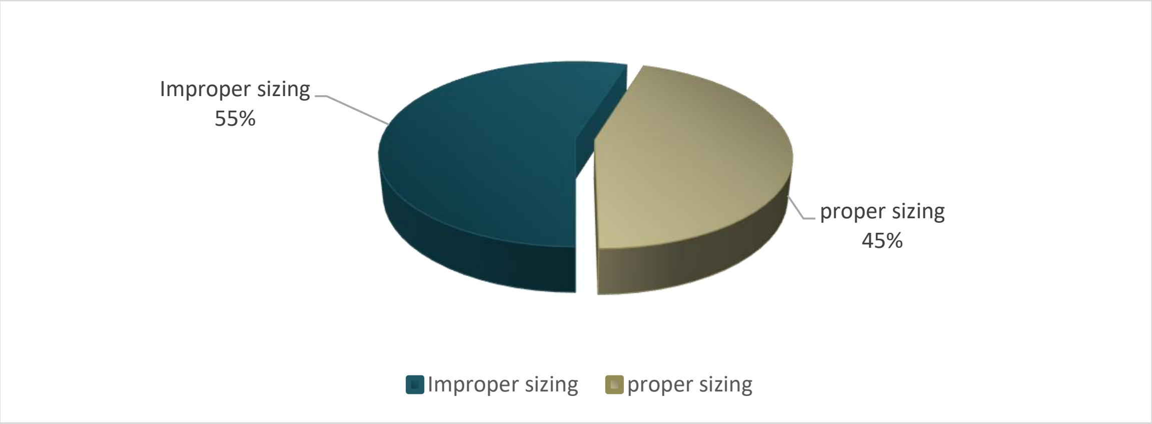
Figure 10 Rated Overall Efficiency of existing pumps



8.23.2 **Improper pump selection and usage:-**Lack of Farmer awareness about pump selection and to understand the technological aspects of pump operation. This leads to lack of awareness on pump selection, operation & maintenance. The improper selection and operation leads to poor efficiencies and wastage of energy. Field study has indicated that average overall efficiency of the pump sets is around 27.6%. Major reason for pump set efficiencies being lesser than the optimum efficiency is because the pump sets are not operating in the high efficiency range of flow and head. This is due to large range of suction & discharge heads for which the pump has been selected.

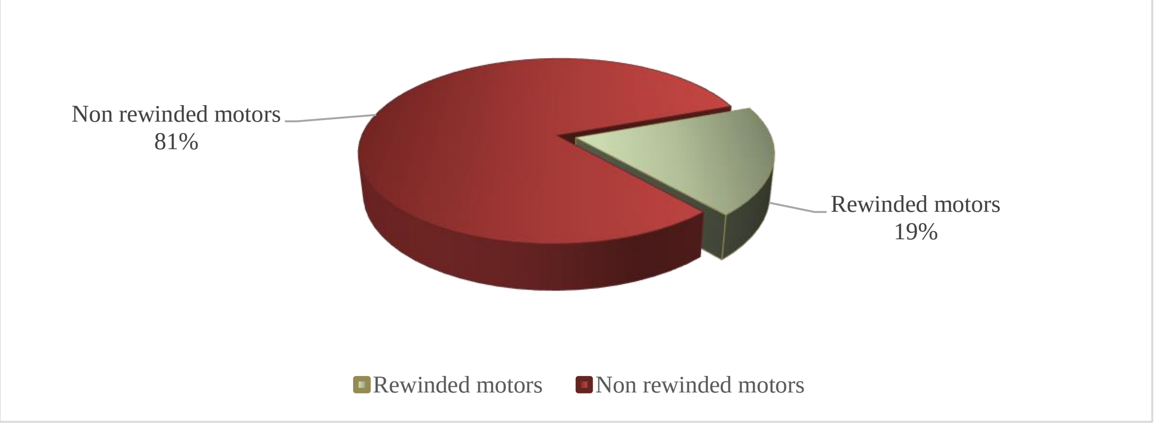
8.23.3 **Improper sizing of pipes: -**Efficiency of pumping system is a function of efficiency of the system components, i.e. η system = *f* (η Pump-set , η Piping).Sizing of the pipes for the system is also a major factor influencing the efficiency of the overall system is due to the inverse relationship between the pipe dia. and frictional loss. The intersecting point between the economy curve and the friction curve is considered to be the pipe selection criteria. The undersized pipes in the system reduce the initial cost but increase the head loss. The oversized pipe dia reduces the frictional loss but increases the initial cost also the increases the power consumption. The improper selection of the pipe dia will affect the operating curve of the pump. The survey indicates 55% of the pumping systems are provided with improper pipe configuration.

Figure 11 Sizing of the pipelines for Existing Pumps



8.23.4 **Rewinding of motors: -**It is common practice to rewind burnt-out motors. Careful rewinding can sometimes maintain motor efficiency at previous levels, but in most cases, losses in efficiency result. Rewinding can affect a number of factors that contribute to deteriorated motor efficiency: winding and slot design, winding material, insulation performance, and operating temperature. However, if proper measures are taken, motor efficiency can be maintained, and in some cases increased, after rewinding. From the survey, it is identified that18% of the sampled pumps were rewounded more than 2 times

Figure 12 Rewinding Motors of existing Pump sets



The efficiency of a pump set also varies with input voltage. Low power supply often, leads to motor burnouts and several hours of downtime for maintenance & repair. The efficiency and life of a motor can be increased by achieving low iron loss, copper loss, windage loss and suitability for operation at low voltage levels. Hence motors for agriculture pumps are always designed for a wide voltage band. The improvement in the quality of power in terms of frequency and supply voltage by fully implementing HVDS can significantly improve pump set efficiency and realize energy savings. The efficiency of motors in EEPS is higher due to low iron, copper & windage losses. Better design and quality control have resulted in development of energy efficient pump sets. To overcome the issues of lower voltage operation, the new motors are also designed for a voltage fluctuation between 300 V to 440 V.

8.23.5 **Inferior quality network: -**The fittings provided by most of the farmers are very poor resulting in large losses and leakage. Head losses in a poor quality foot valves are high. An efficient low friction ISI mark foot-valve, though slightly costlier, pays back fast the extra cost by saving. Similarly the head loss in the sharp bends are also high. The farmers are mostly ignorant about the operational quality of the components. Low friction pipe (HDPE) network can also reduce the friction loss, eventually improves the efficiency of the system. Also proper pipe layout reduces the length and reduces friction loss.

The energy requirement of a pumping system operating over a period of time ‘t’ can be expressed as,

$$E_p = \frac{t\ x\ Q\ x\ \Delta p}{\eta}$$

Where,

t = time (sec)
Q = volume flow rate (m3/sec)

ΔP = total pressure drop (m)
η = motor pump set efficiency

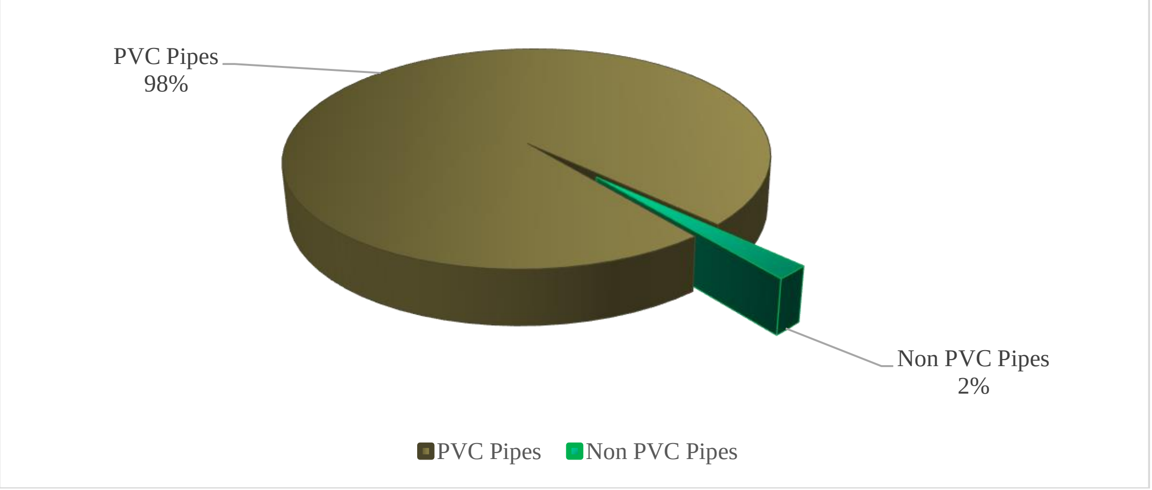
Assuming that the only losses are due to friction, ΔP is proportional to the square of volume flow (ΔP ~ Q2). Therefore, the power required to overcome friction increases as the cube of the volume flow. This relationship can be used to quantify the effect of diameter on energy costs. For a given volume flow rate, the above expression for (ΔP) indicates that pumping energy is inversely proportional to piping diameter raised to the 5th power and directly proportional to friction factor. Since the friction factor also has a slight dependence on diameter, the pumping energy required to overcome friction in piping for different diameter is,

$$\frac{EP1}{EP2} = (\frac{D2}{D1})^{4.84}$$

As per the Darcy Weichbach equation for frictional factor (H_f) estimation for frictional loss to be minimum pipe diameter should be as large as possible. The suction pipe length should be short, just adequate to keep the foot valve submerged and straight with minimum bends. Bends wherever unavoidable, should be of long radius. The coefficient of friction is less in case of PVC pipes. The friction loss will increase drastically in GI pipes, as they are prone to corrosion as compared to PVC pipes. The latest low friction loss PVC pipes will be installed in place of GI pipes, wherever applicable, to reduce the frictional loss on a sustained basis. The problems of erosion, corrosion and resultant clogging will also be avoided.

Most farmers are using PVC pipeline and the details is given below:

Figure 13 Pipe Type for Existing pump sets



8.23.6 **Selection of Discharge Pipe:** It will always be economical to select a PVC pipe and having a diameter a next size higher than the pump discharge size so as to have lower pressure drop and pipe resistance. The general practice is to select a pipe diameter that is able to maintain water velocity between 3 to 5 ft/sec. Below table indicates maximum water flow rates for a given pipe diameter so as to restrict the water velocity up to 5 ft/sec.

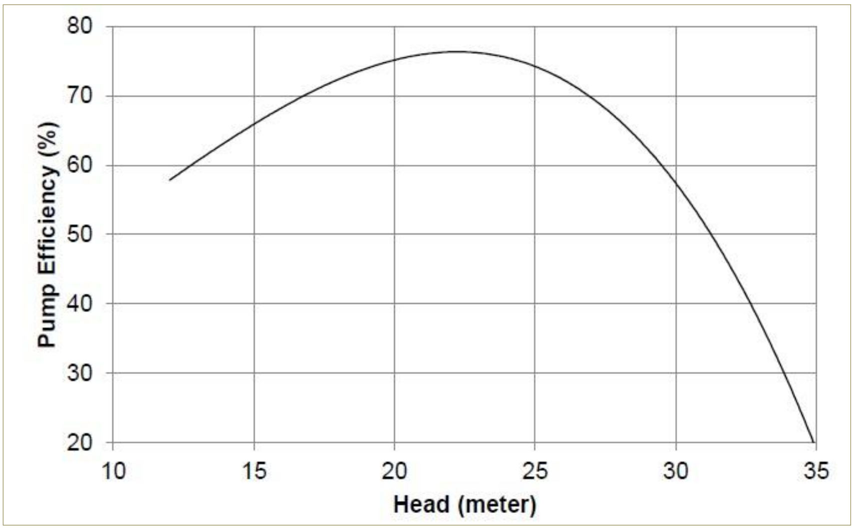
Table 7 Pipeline Selection with Respect to Flow Requirement

Sl.No.	Pipe Diameter (Inch)	Flow Rate	
		m^3/hr	LPM
1	0.5	0.693	11.56
2	0.75	1.561	26.02
3	1	2.775	46.25
4	1.25	4.336	72.27
5	1.5	6.243	104.07
6	1.75	8.498	141.64
7	2	11.100	185.01
8	2.25	14.048	234.15
9	2.5	17.344	289.07
10	2.75	20.986	349.78
11	3	24.975	416.26
12	3.25	29.311	488.53
13	3.5	33.994	566.58
14	3.75	39.024	650.41
15	4	44.401	740.02
16	4.25	50.124	835.42
17	4.5	56.195	936.59
18	4.75	62.612	1043.55
19	5	69.377	1156.28
20	5.25	76.488	1274.80
21	5.5	83.946	1399.10
22	5.75	91.751	1529.19
23	6	99.903	1665.05

8.23.7 **Suction Head Variations and Large Discharge Lengths:-**The most of the pumps installed across the studied feeders are of Mono block and submersible type. The suction head varies seasonally. The seasonal variation is more severe than the annual water level depletion. According to the pump manufacturer the pump should be installed 20 ft away from the total depth of the bore well to take avoid the blockage of pump due to mud. The discharge pipe length is of more concern. Farmer increases the discharge pipe as per there requirement without considering the effect on the pump efficiency. The pipe should be adequate size and material so as to reduce the friction loss to the accepted level.

8.23.8 **Water Table Variation:-**The change in water table will have a significant impact on all existing agriculture pump sets operating efficiency. Selection of pump-sets according to water levels/head plays an important role in the context of overall efficiency of the pump-set. The figure below presents a typical head Vs efficiency range for submersible pump of 3 kW. From the graph provide, it is observed that the pump efficiency is maximum (75%) at water levels/head in the range between 22 m and 26 m approximately. (Source: M/s Shakti Pumps)

Figure 14 Variation of efficiency with respect to water table



Note: Efficiency shown in the graph is pump efficiency and not the overall efficiency submersible pump. For overall efficiency it is to be multiplied with the motor efficiency.

Thus the EEPS could be appropriately sized based on measured head and flow for maximum efficiency for maximum operating period.

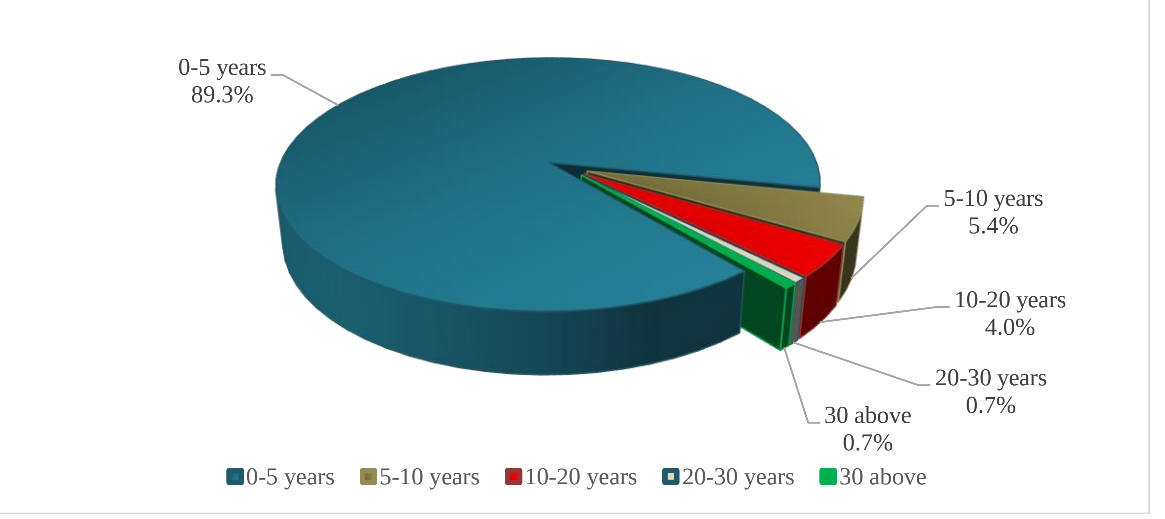
8.23.9 Other Common Causes

In addition to above there are other common reason affecting the pump set efficiency performance. Some of the more common causes of unsatisfactory performance and their remedies are discussed below:

Damaged impellers also result in poor performance: Three common causes of impeller damage are cavitation's (low temperature boiling of pumped water), sand pumping and improper impeller adjustment. Sometimes only the impellers need to be changed, but more often the permanent solution is to replace the entire bowl assembly. If this is done, it is likely that a different model of pump bowls should be used to fit present well conditions.

Ageing of pump sets: - Due to the ageing of the pump sets, the characteristic curve may deviated from the standard. The percentage distribution of the 150 pump sets based on the life is also been analyzed and the distribution is graphically represented below:

Figure 15Ageing of existing pump sets



8.24 Economics on Energy Efficiency Up gradation of Existing Pumps

8.24.1 The overall weighted average operating efficiency for existing pump sets is arrived at 27.6% based on Energy Efficiency Calculations done for 150 pumps. However, to be on conservative side minimum overall efficiency of BEE 5 star labelled pumps (150nos) and achievable overall efficiency (in field conditions) for different category pumps considered for the up gradation is tabulated below:

Pump Category	Average Minimum efficiency of measured pumps (IS Std)	5 Star Labelled Minimum efficiency	Minimum Expected Efficiency (in field condition)
below 1 hp	23.9%	28.6%	20%
1 HP	27.6%	33.1%	25%
1.5 HP	37.8%	45.3%	35%
2 HP	38.5%	46.2%	35%
3 HP to < 5HP	44.3%	53.2%	40%
5hp to < 10 HP	50.9%	61.1%	40%

8.24.2 The anticipated economic benefit achieved by improving the overall average operating efficiency (field condition) of the present pumping system as per above table of the 150 pump sets is tabulated and given below:

Table 8 Estimated Annual Energy Savings

SL NO	Consumer No	Rated Pump Power		Measured Power	Overall Efficiency	Average Consumption per month	Annual Consumption	Annual Operating Hours	Hydraulic Power	Power Consumption @ proposed Efficiency	Savings in Power Consumption	Estimated Annual Energy Savings
		HP	kW	kW	%	kWh	kWh	hrs	kW	kW	kW	kWh
1	1155011019516	1.5	1.1	1.50	30.5%	10	120	80	0.46	1.31	0.19	15.46
2	1155011012624	1.5	1.1	1.42	43.7%	20	240	169	0.62	1.77	0.00	0.00
3	1155013016274	1.5	1.1	1.56	23.7%	22	264	169	0.37	1.06	0.50	84.99
4	1155010026471	1.5	1.1	1.56	29.3%	3	36	23	0.46	1.31	0.25	5.85
5	1155011027488	1.0	0.8	0.94	11.7%	4	48	51	0.11	0.44	0.50	25.56
6	1155011027780	1.5	1.1	1.46	25.4%	22	264	181	0.37	1.06	0.40	72.73
7	1155012029933	1.5	1.1	1.05	33.4%	5	60	57	0.35	1.00	0.05	2.82
8	1155012013466	1.5	1.1	1.02	29.6%	2	24	24	0.30	0.86	0.16	3.67
9	1155011011569	1.0	0.8	0.79	15.6%	11	132	167	0.12	0.49	0.30	49.39
10	1155011029676	1.5	1.1	1.30	37.4%	5	60	46	0.49	1.39	0.00	0.00
11	1155010017229	1.5	1.1	1.48	37.7%	1	12	8	0.56	1.59	0.00	0.00
12	1155011027488	2.0	1.5	1.80	42.5%	4	48	27	0.77	2.19	0.00	0.00
13	1155737004411	3.0	2.3	2.40	29.2%	422	5064	2110	0.70	1.75	0.65	1369.21
14	1155733013087	1.0	0.8	1.01	11.4%	29	348	345	0.12	0.46	0.55	188.73
15	1155731018133	1.5	1.1	1.30	28.8%	72	864	665	0.37	1.07	0.23	153.15
16	1155732011743	1.5	1.1	1.10	27.4%	27	324	295	0.30	0.86	0.24	70.47
17	1155733006841	1.0	0.8	0.96	27.3%	18	216	225	0.26	1.05	0.00	0.00
18	1155733007122	3.0	2.3	2.10	48.6%	11	132	63	1.02	2.55	0.00	0.00
19	1155732012415	1.5	1.1	1.20	29.0%	1	12	10	0.35	1.00	0.20	2.04

20	1155732022011	1.5	1.1	1.14	38.0%	2	24	21	0.43	1.24	0.00	0.00
21	1155672000029	5.0	3.8	3.90	46.5%	8	96	25	1.81	4.54	0.00	0.00
22	1155670006005	3.0	2.3	3.90	27.7%	17	204	52	1.08	2.70	1.20	62.63
23	1155670013900	3.0	2.3	4.80	22.6%	60	720	150	1.09	2.71	2.09	312.76
24	1155670010745	3.0	2.3	4.90	21.6%	83	996	203	1.06	2.65	2.25	457.61
25	1155671001665	3.0	2.3	2.80	49.1%	5	60	21	1.37	3.43	0.00	0.00
26	1155671005035	5.0	3.8	4.40	20.1%	2	24	5	0.88	2.21	2.19	11.96
27	1155670013412	1.5	1.1	1.40	28.0%	24	288	206	0.39	1.12	0.28	57.94
28	1155480019031	1.0	0.8	0.96	16.8%	4	48	50	0.16	0.64	0.32	15.76
29	1155482033984	0.5	0.4	0.86	22.9%	7	84	98	0.20	0.98	0.00	0.00
30	1155483013862	0.5	0.4	0.68	15.9%	6	72	106	0.11	0.54	0.14	14.87
31	1156183033719	1.0	0.8	1.29	27.3%	1	12	9	0.35	1.41	0.00	0.00
32	1156189035187	1.0	0.8	1.12	22.6%	5	60	54	0.25	1.01	0.11	5.85
33	1156182004206	1.5	1.1	1.20	29.0%	2	24	20	0.35	1.00	0.20	4.09
34	1156180031811	1.0	0.8	1.10	12.5%	1	12	11	0.14	0.55	0.55	5.99
35	1156181007645	1.5	1.1	1.32	28.0%	26	312	236	0.37	1.06	0.26	61.97
36	1156183011927	1.5	1.1	1.30	29.0%	50	600	462	0.38	1.08	0.22	102.99
37	1156181002910	1.5	1.1	1.24	30.9%	2	24	19	0.38	1.09	0.15	2.84
38	1156181008670	1.0	0.8	0.85	25.8%	41	492	579	0.22	0.88	0.00	0.00
39	1156180003124	1.5	1.1	1.93	18.0%	6	72	37	0.35	0.99	0.94	35.04
40	1156182023010	1.5	1.1	1.36	39.4%	20	240	176	0.54	1.53	0.00	0.00
41	1156183002300	1.5	1.1	1.20	39.3%	3	36	30	0.47	1.35	0.00	0.00
42	1166380002728	1.5	1.1	1.40	25.0%	7	84	60	0.35	1.00	0.40	23.96
43	1166380006253	1.5	1.1	0.98	34.3%	22	264	269	0.34	0.96	0.02	5.02
44	1166380006733	0.5	0.4	0.40	24.1%	1	12	30	0.10	0.48	0.00	0.00
45	1166380007296	3.0	2.3	2.05	26.9%	24	288	140	0.55	1.38	0.67	94.50
46	1166380007319	3.0	2.3	2.22	43.8%	52	624	281	0.97	2.43	0.00	0.00
47	1166380006265	3.0	2.3	2.80	33.7%	13	156	56	0.94	2.36	0.44	24.69

48	1166380006344	1.5	1.1	1.50	30.2%	25	300	200	0.45	1.29	0.21	41.02
49	1166380006297	1.5	1.1	1.58	30.0%	94	1128	714	0.47	1.35	0.23	161.50
50	1166380006642	2.0	1.5	1.90	31.4%	1	12	6	0.60	1.70	0.20	1.24
51	1166960007484	2.0	1.5	1.60	45.6%	31	372	233	0.73	2.09	0.00	0.00
52	1166960037225	1.5	1.1	1.04	37.4%	2	24	23	0.39	1.11	0.00	0.00
53	1166961003197	1.5	1.1	1.40	28.0%	31	372	266	0.39	1.12	0.28	74.84
54	1166960037336	1.5	1.1	2.29	13.0%	1	12	5	0.30	0.85	1.44	7.56
55	1166960003225	3.0	2.3	2.10	43.4%	32	384	183	0.91	2.28	0.00	0.00
56	1166960039865	1.0	0.8	1.18	22.1%	8	96	81	0.26	1.04	0.14	11.08
57	1166960028517	1.5	1.1	1.60	38.0%	6	72	45	0.61	1.74	0.00	0.00
58	1166960035957	1.5	1.1	1.20	44.6%	9	108	90	0.54	1.53	0.00	0.00
59	1166961003148	1.0	0.8	1.40	16.3%	2	24	17	0.23	0.91	0.49	8.36
60	1166961009936	1.0	0.8	1.10	26.2%	4	48	44	0.29	1.15	0.00	0.00
61	1145690017004	1.0	0.8	0.98	23.5%	17	204	208	0.23	0.92	0.06	11.88
62	1145690019901	1.5	1.1	1.05	24.2%	56	672	640	0.25	0.73	0.32	207.40
63	1145691021382	1.0	0.8	1.09	14.8%	1	12	11	0.16	0.64	0.45	4.90
64	1145691021411	1.5	1.1	1.30	24.4%	1	12	9	0.32	0.91	0.39	3.62
65	1145691022987	1.0	0.8	0.99	23.9%	50	600	606	0.24	0.94	0.05	27.57
66	1145691023310	1.0	0.8	0.96	17.0%	10	120	125	0.16	0.65	0.31	38.28
67	1145691025542	1.0	0.8	1.02	19.3%	27	324	318	0.20	0.79	0.23	73.46
68	1145691028850	1.0	0.8	1.08	26.4%	5	60	56	0.28	1.14	0.00	0.00
69	1145690029993	0.5	0.4	0.56	14.7%	17	204	364	0.08	0.41	0.15	53.91
70	1145690031442	0.5	0.4	0.58	18.6%	15	180	310	0.11	0.54	0.04	12.25
71	1146363024285	1.5	1.1	1.40	21.0%	3	36	26	0.29	0.84	0.56	14.38
72	1146361026202	2.0	1.5	1.60	44.1%	2	24	15	0.71	2.02	0.00	0.00
73	1146349016780	1.5	1.1	1.61	19.7%	5	60	37	0.32	0.91	0.70	26.16
74	1146341014606	1.5	1.1	1.69	25.2%	25	300	178	0.43	1.22	0.47	84.06
75	1146347013732	1.0	0.8	0.64	24.8%	15	180	281	0.16	0.64	0.00	1.21

76	1146341018181	1.0	0.8	0.71	25.7%	2	24	34	0.18	0.73	0.00	0.00
77	1146348022270	1.5	1.1	1.60	9.6%	35	420	263	0.15	0.44	1.16	305.22
78	1146349006459	1.5	1.1	1.64	17.7%	26	312	190	0.29	0.83	0.81	154.16
79	1146349013674	5.0	3.8	4.20	23.1%	1	12	3	0.97	2.42	1.78	5.08
80	1146346019829	1.0	0.8	1.25	20.7%	18	216	173	0.26	1.04	0.21	36.99
81	1146341014937	2.0	1.5	1.70	38.4%	1	12	7	0.65	1.87	0.00	0.00
82	1146340022199	0.5	0.4	0.60	22.9%	16	192	320	0.14	0.69	0.00	0.00
83	1165983019849	1.5	1.1	1.13	33.0%	3	36	32	0.37	1.07	0.06	2.07
84	1165980016716	1.5	1.1	1.28	45.1%	5	60	47	0.58	1.65	0.00	0.00
85	1165981013207	1.0	0.8	0.71	33.4%	3	36	51	0.24	0.95	0.00	0.00
86	1165988015579	1.0	0.8	0.73	31.0%	2	24	33	0.23	0.91	0.00	0.00
87	1165985015242	1.0	0.8	1.26	19.6%	2	24	19	0.25	0.99	0.27	5.16
88	1165981016171	1.0	0.8	1.10	25.7%	8	96	87	0.28	1.13	0.00	0.00
89	1165988011465	3.0	2.3	2.92	35.5%	9	108	37	1.04	2.59	0.33	12.21
90	1165985022921	1.0	0.8	0.78	24.9%	5	60	77	0.19	0.78	0.00	0.23
91	1165987018871	1.0	0.8	0.64	25.9%	3	36	56	0.17	0.66	0.00	0.00
92	1165985026138	2.0	1.5	1.40	37.3%	39	468	334	0.52	1.49	0.00	0.00
93	1165553044980	0.5	0.4	0.65	16.3%	6	72	111	0.11	0.53	0.12	13.32
94	1165551046007	1.5	1.1	1.92	29.7%	19	228	119	0.57	1.63	0.29	34.39
95	1165553017646	1.5	1.1	1.80	19.9%	2	24	13	0.36	1.02	0.78	10.37
96	1165551034763	1.5	1.1	1.90	17.0%	22	264	139	0.32	0.92	0.98	135.50
97	1165551012671	1.5	1.1	1.85	29.7%	2	24	13	0.55	1.57	0.28	3.61
98	1165551018027	1.5	1.1	1.90	27.1%	69	828	436	0.52	1.47	0.43	186.74
99	1165551010952	1.5	1.1	1.13	33.8%	8	96	85	0.38	1.09	0.04	3.16
100	1165550014689	5.0	3.8	3.40	43.3%	140	1680	494	1.47	3.68	0.00	0.00
101	1165553013418	1.5	1.1	1.30	37.2%	30	360	277	0.48	1.38	0.00	0.00
102	1165551036309	1.5	1.1	1.20	32.6%	19	228	190	0.39	1.12	0.08	15.52
103	1165320005809	3.0	2.3	1.16	35.3%	11	132	114	0.41	1.03	0.13	15.35

104	1165320000772	5.0	3.8	3.27	23.1%	56	672	206	0.75	1.89	1.38	284.17
105	1165320016497	1.5	1.1	1.01	26.7%	1	12	12	0.27	0.77	0.24	2.84
106	1165320000462	5.0	3.8	3.50	15.4%	27	324	93	0.54	1.34	2.16	199.63
107	1165320013777	7.5	5.6	6.98	35.3%	39	468	67	2.46	6.16	0.82	55.10
108	1165320011739	1.5	1.1	1.13	45.8%	4	48	42	0.52	1.48	0.00	0.00
109	1165320012992	1.5	1.1	2.16	22.9%	28	336	156	0.49	1.41	0.75	116.26
110	1165325006090	3.0	2.3	2.40	42.9%	73	876	365	1.03	2.58	0.00	0.00
111	1146002021665	1.5	1.1	1.40	32.2%	3	36	26	0.45	1.29	0.11	2.92
112	1146007014697	0.5	0.4	0.40	35.3%	2	24	60	0.14	0.71	0.00	0.00
113	1146007020333	1.0	0.8	0.54	43.2%	3	36	67	0.23	0.93	0.00	0.00
114	1146009009906	0.5	0.4	0.28	29.3%	4	48	171	0.08	0.41	0.00	0.00
115	1146037018881	1.0	0.8	0.36	36.0%	1	12	33	0.13	0.52	0.00	0.00
116	1146037020907	1.0	0.8	0.65	23.5%	25	300	462	0.15	0.61	0.04	18.56
117	1146032021938	1.0	0.8	1.60	12.3%	275	3300	2063	0.20	0.78	0.82	1682.97
118	1146034005989	1.5	1.1	1.80	13.5%	9	108	60	0.24	0.69	1.11	66.46
119	1146032022737	0.5	0.4	0.90	13.7%	8	96	107	0.12	0.62	0.28	30.08
120	1146170021029	1.0	0.8	0.80	24.5%	6	72	90	0.20	0.78	0.02	1.54
121	1146174020665	1.5	1.1	1.40	26.9%	8	96	69	0.38	1.08	0.32	22.20
122	1156720002975	1.5	1.1	1.10	34.2%	4	48	44	0.38	1.08	0.02	1.03
123	1156720006004	3.0	2.3	1.72	15.2%	21	252	147	0.26	0.65	1.07	156.06
124	1156720004204	1.5	1.1	1.40	17.3%	25	300	214	0.24	0.69	0.71	151.65
125	1156720003058	3.0	2.3	1.70	44.3%	25	300	176	0.75	1.88	0.00	0.00
126	1156720005857	1.5	1.1	1.30	32.8%	50	600	462	0.43	1.22	0.08	37.27
127	1156720004535	1.5	1.1	1.20	31.1%	13	156	130	0.37	1.07	0.13	17.54
128	1156720005797	1.0	0.8	0.65	31.8%	3	36	55	0.21	0.83	0.00	0.00
129	1156722008613	1.5	1.1	1.56	25.9%	182	2184	1400	0.40	1.16	0.40	565.35
130	1156720000192	3.0	2.3	2.10	46.3%	39	468	223	0.97	2.43	0.00	0.00
131	1145431009798	1.5	1.1	1.10	27.7%	7	84	76	0.30	0.87	0.23	17.48

132	1145430013470	1.0	0.8	0.90	11.4%	12	144	160	0.10	0.41	0.49	78.45
133	1145430019904	1.0	0.8	1.04	14.0%	6	72	69	0.15	0.58	0.46	31.58
134	1145430010432	1.5	1.1	1.25	34.5%	3	36	29	0.43	1.23	0.02	0.48
135	1145431021063	1.5	1.1	2.27	17.3%	1	12	5	0.39	1.12	1.15	6.07
136	1145431012127	1.0	0.8	1.64	27.6%	18	216	132	0.45	1.81	0.00	0.00
137	1145430012039	1.0	0.8	1.06	23.8%	1	12	11	0.25	1.01	0.05	0.56
138	1145430006698	1.0	0.8	1.40	21.4%	6	72	51	0.30	1.20	0.20	10.27
139	1145431009957	1.5	1.1	1.40	24.2%	51	612	437	0.34	0.97	0.43	189.29
140	1145430024170	5.0	3.8	3.80	26.7%	97	1164	306	1.02	2.54	1.26	386.47
141	1167821010562	10.0	7.5	7.40	16.6%	58	696	94	1.23	3.07	4.33	407.43
142	1167820001495	1.5	1.1	1.03	31.4%	43	516	501	0.32	0.92	0.11	52.63
143	1167820010418	1.5	1.1	0.98	30.0%	4	48	49	0.29	0.84	0.14	6.82
144	1167823010385	7.5	5.6	5.78	17.9%	536	6432	1113	1.03	2.59	3.19	3554.11
145	1167823010474	10.0	7.5	7.90	23.8%	5	60	8	1.88	4.71	3.19	24.24
146	1167820010586	10.0	7.5	8.40	14.6%	269	3228	384	1.23	3.08	5.32	2046.15
147	1167821012408	1.5	1.1	1.23	28.1%	2	24	20	0.35	0.99	0.24	4.75
148	1167821014450	1.5	1.1	1.77	20.1%	21	252	142	0.36	1.02	0.75	107.34
149	1167821010166	1.5	1.1	1.39	28.3%	17	204	147	0.39	1.12	0.27	39.01
150	1167821011726	1.5	1.1	1.60	19.9%	123	1476	923	0.32	0.91	0.69	638.25

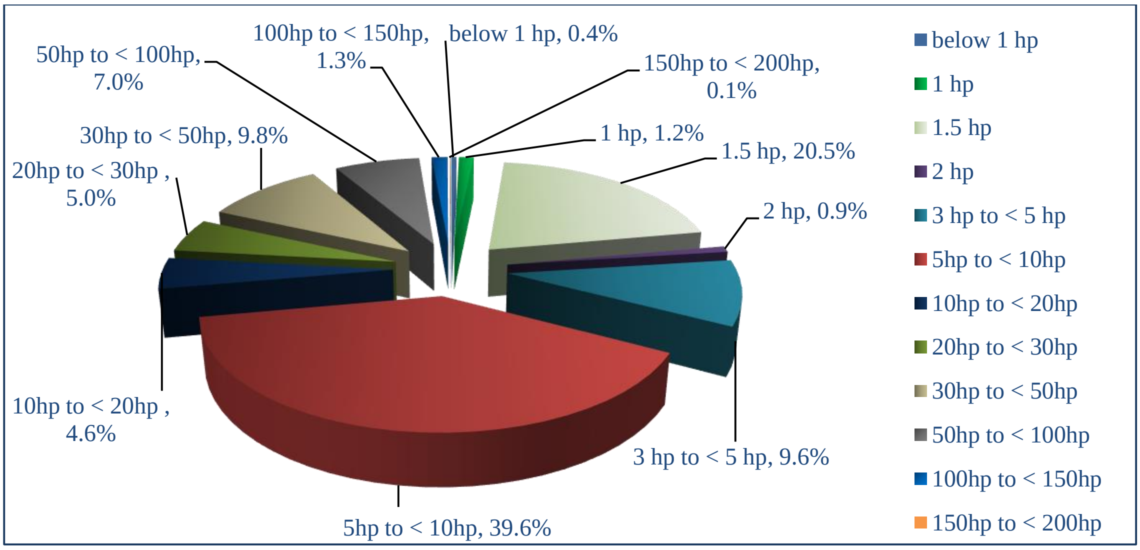
8.25 The economics on efficiency enhancement by improving the average overall efficiency to the anticipated efficiencies is summarized and given below:

Power Consumption of the 150 no. of pumps	=	254.4	kW
Total Consumption of 150 no of pumps	=	52776	kWh
Power Estimated at anticipated overall efficiencies	=	199.8	kW
Savings in the power	=	54.6	kW
Percentage Savings in Power	=	21.5%	
Estimated Consumption after improving the overall efficiency	=	36615	kWh
Total Estimated savings on consumption of 150 no of pumps	=	16161	kWh
Estimated percentage Savings	=	30.6%	

8.26 The energy saving potential is estimated only for improvement in the system efficiency due to replacement of existing pump sets with energy efficient pump sets.

8.27 The consumption pattern of the various rated pumps are also analyzed during the study and the percentage contribution of each to the total consumption is given below:

Figure 16 Consumption pattern of the different rated pumps



8.28 Based on the above the Contribution each category to the savings is estimated and given below:

8.29 Irrigation Pumps

8.29.1 From the study conducted it is found a that around 600 number of higher rated pumps are been utilized by the irrigation department for the irrigation purpose. A separate analysis has been carried out to understand the nature of operation and efficiency level of these pumps.

8.29.2 Based on the above it is observed that irrigation pumps are operating 16 hrs per day and overall efficiency level of these pumps are falling in the range of 40% - 45%.

8.29.3 This consumes around 5% of the total consumption. As the pumps are operating throughout the year, improving the overall efficiency to 65% has a better influence on the percentage reduction in consumption. It is identified to have scope for separate study on the energy efficiency improvement in this sector.

9. CARBON FOOTPRINT ANALYSIS

9.1 Greenhouse gases (GHGs) can be emitted through land clearance and the production and consumption of food, fuels, manufactured goods, materials, wood, roads, buildings, transportation and other services. It is often expressed in terms of the amount of carbon dioxide, or its equivalent of other GHGs, emitted. The growing concern for issues related to climate change by describing anything from the narrowest to the widest interpretation of greenhouse gas measurement and reduction, the carbon foot print tool is been used .

9.2 As part of the DPR Study conducted, an analysis has been carried out to find out the existing CO_2 emission due to the energy consumption in the agriculture pumps.

9.3 The standardCO_2 emissions values for electrical energy (kWh) are given below.

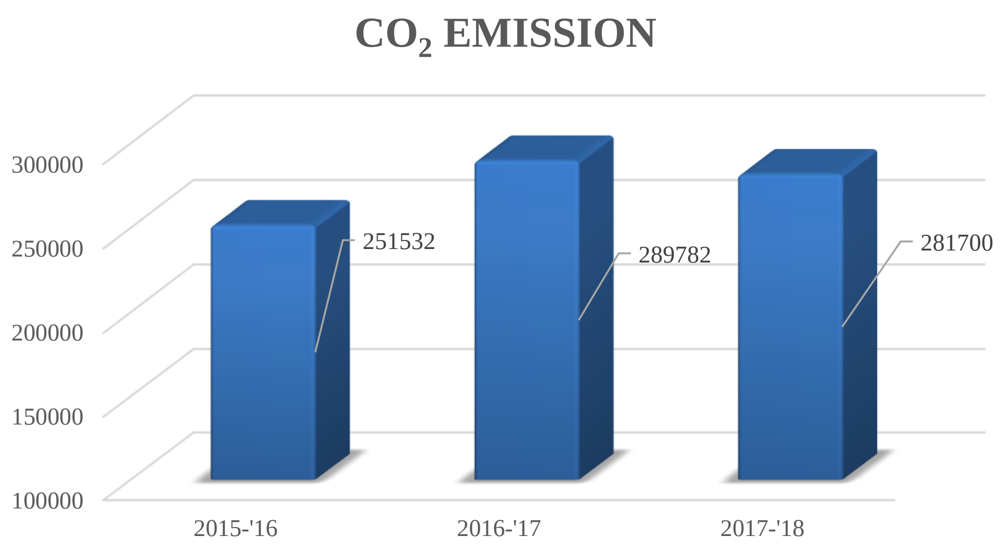
1 kWh = 0.9 kg CO_2

Source : UNFCC

9.4 The carbon footprint emission due to the agricultural pump operation throughout the state for the past three years is given below:

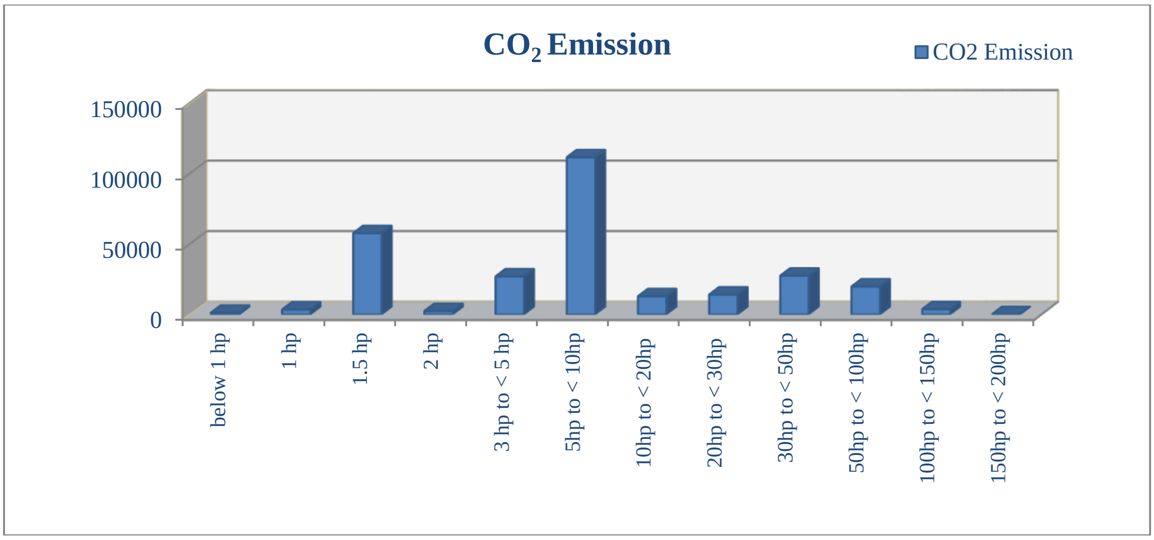
Table 9 Analysis of CO_2 Emission

	2015-'16	2016-'17	2017-'18	
Electrical Energy Consumption	279.48	321.98	313	MU
AnnualCO_2 Emission	251532	289782	281700	Tons



Source: 19th Electric Power Survey by Central Electricity Authority

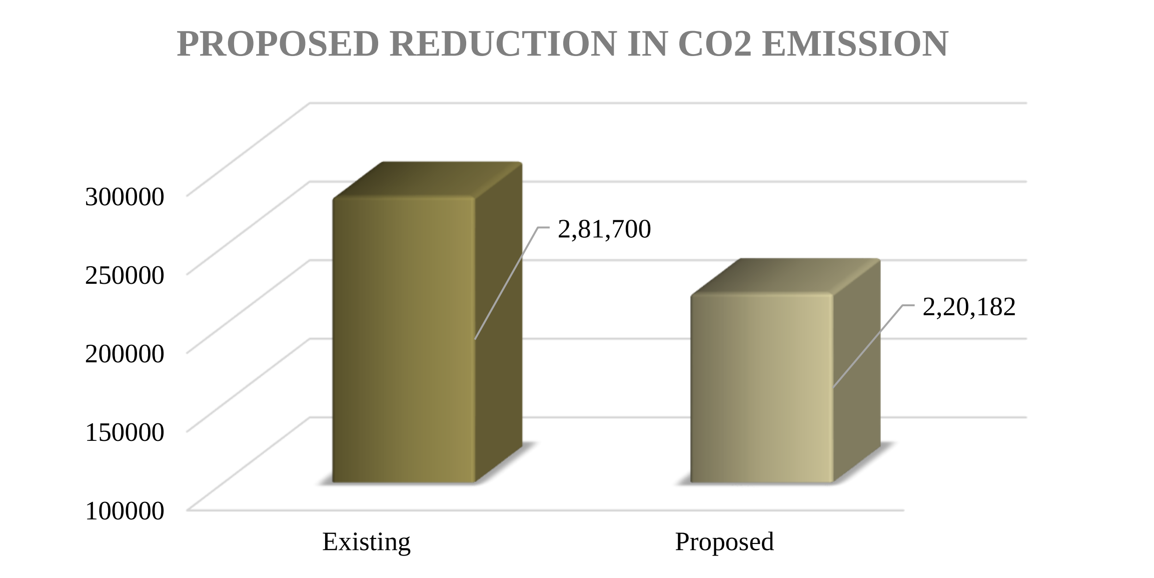
9.5 The CO_2 contribution of the different category of the pumps for the year 2017-'18 is given below:



9.6 Based on the proposed reduction in energy consumption, the reduction in the CO_2 with respect to the previous year is given below:

Table 10 Reduction in CO_2 Emission

	Existing	Proposed	
Electrical Energy Consumption	313	244.6	MU
AnnualCO_2 Emission	281700	220182	Ton

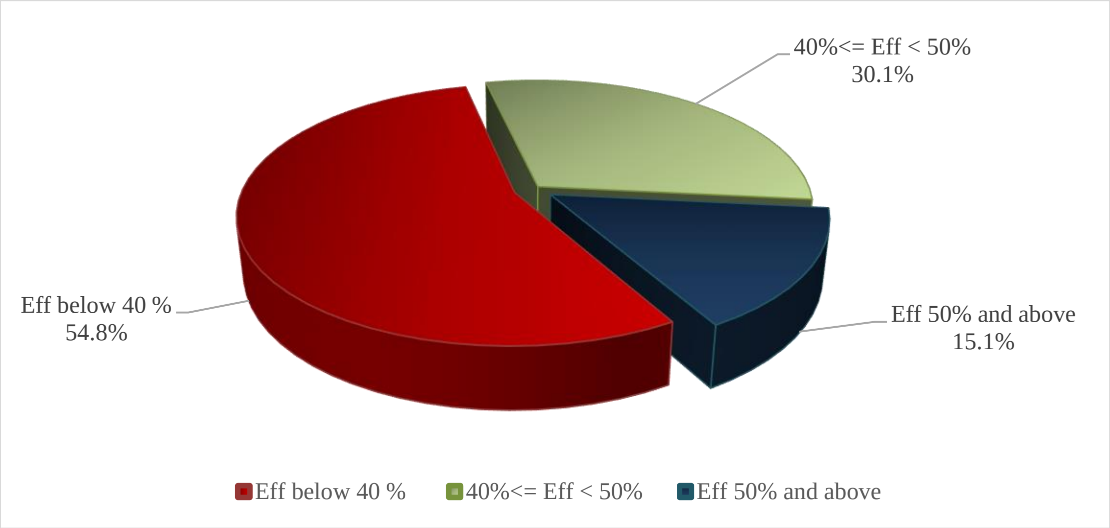


10. PROJECT PHASE

10.1 Among the 4,45,223 agriculture pump sets in Kerala, 97.8% of total pumps is falling under the category of below 10 hp capacity and its consumption is around 72.2% of the total consumption.

10.2 The overall rated efficiency of 54.8% of sampled pumps of 150 Nos is only less than 40%. From the analysis it is estimated that the present average overall efficiency of these pumps is only 23.3%.

10.3 The chart below shows the rated efficiency variation of the sampled pumps.



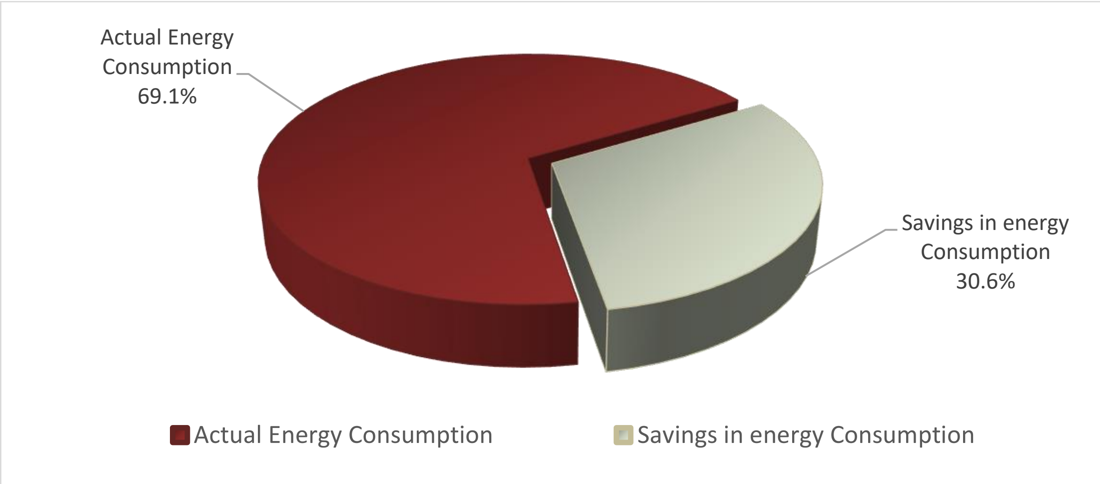
10.4 The inferior quality pumps used in the sector is identified as one of the primary reasons for the poor operating efficiency in agriculture pumping sector. Implementation of replacement is recommended to carry out phase by phase.

10.5 **Phase -1 : Replacement of pump sets with overall rated efficiency less than 40% with energy efficient pump sets**

10.5.1 Based on the analysis carried out, a savings potential of about 69 MU per year has been identified by the replacement existing local made & low rated overall efficiency (below 40% efficiency) pumps falling under below 10 hp category. The detailed analysis is given below:

Pump Category	Total No. of pumps	Total No. of pumps below 40 % rated overall efficiency	Approx. Cost per Pump	Total Cost of the pumps (lakhs)	Percentage share of Total Energy Consumption of the pumps	Total Consumption (MU)	Savings in Energy Consumption by Pump Replacement @ 30.6%	Cost savings (lakhs)
below 1 hp	5445	2984	4500	134.3	0.4%	1.3	0.40	8.0
1 hp	37546	20575	7500	1543.1	1.2%	3.8	1.18	23.6
1.5 hp	239303	131138	8500	11146.7	20.5%	64.1	19.64	392.8
3hp to < 5hp	107293	58797	13000	7643.6	9.6%	30.0	9.19	183.8
5hp to < 10hp	36781	20156	23000	4635.9	39.6%	123.9	37.94	758.8
Total	**426368**	**233650**		**25103.6**			**68.35**	**1367.1**

Figure 17 Savings in Energy Consumption



10.6 Phase -2 : Efficiency improvement by matching the operating conditions with pump characteristics

10.6.1 Based on the survey conducted, the rated overall efficiency of around 45.2% of the total agricultural pump sets in Kerala is above 40% efficiency of which most of the pumps are higher rated pumps but the present operating efficiency of most of the pumps are below 30% only. This lower operating efficiency of these pumps is mainly due to the following reasons.

- Undersized pipes
- Suction head variations and large discharge lengths
- Motor rewinding and low voltage profile
- Water table variations

10.6.2 Considering the above facts and higher rating of the pumps, it would be feasible to improve the operating efficiency of these pumps by improving the operational condition rather going for pump replacement. This can be implemented by adopting the following :

- A proper study should be carried out focusing on matching the existing operating point of pumps to the BEP by analyzing the flow, head, average water table on different locations, layouts, capacity analysis etc.
- The modification of the pipe layout maybe done to match the designed head-flow of the existing pumps.
- After the doing the above exercises and next phase study pumps operating with lesser efficiency may be replaced with star labeled/energy efficient pumps as next stage.

10.7 Business model for replacement of inefficient pump sets to conserve energy

10.7.1 The purpose of the exhaustive study on agricultural pumps across Kerala is to develop an implementable Detailed Project Report for replacement of inefficient pump sets to conserve energy.

10.7.2 Implementations of pump replacement projects offer opportunity to reduce overall energy consumption, cut down energy bill to the farmers, reduces subsidy burdens on the distribution companies and state governments and mitigate the energy shortage situation while improving the water extraction efficiency. However for sustainable investment in the project it is required to develop business models to assure sustainability of the savings for loan repayments and to provide adequate incentives to the investors.

Guiding Parameters

10.7.3 To capitalize the potential savings, it requires to develop effective financing and business models to create benefits and incentives for all stakeholders which includes distribution utilities, farmers, private sector participants (ESCOS) investing for implementation of pump replacement projects, state governments etc.

10.7.4 Hence an effective business model must meet the objectives of all key parties which include distribution utilities, regulatory commission, ESCO or contractor, investor, farmers and local communities etc.

Project Financing

10.7.5 To create appropriate framework for market based interventions in agriculture pumping sector through Public Private Partnership (PPP) mode, the Agriculture pump replacement project funding has to come from ESCO which will be repaid over time from the stream of project benefits.

10.7.6 To create appropriate framework for market based interventions in agriculture pumping sector through Public Private Partnership (PPP) mode, the Agriculture pump replacement project funding has to come from ESCO which will be repaid over time from the stream of project benefits.

10.7.7 With the above-noted background in mind and after taken in to account the possible financing options, two different business models can be been developed and categorized as ESCO Mode and DISCOM Mode as described below:

10.7.8 In ESCO Mode business model, ESCO has to sign a contract with participant Company to finance and implement project; the ESCO would borrow the project debt and repay it from project revenues.

10.7.9 Overall Project Cost: The total project cost estimate for the Project, is about Rs. 31505Lakh

Particulars	Value in (lakhs)
Cost of Energy Efficient Pump Sets (EEPS) (Rs.)	25103.6
Cost of dismantling existing pump sets and installing EEPS (approx.10%)(Rs.)	2510.4
Contingencies (approx.3.5%) (Rs.)	878.6
Project Management Consultancy (approx.12%) (Rs.)	3012.4
Total project cost (Rs.)	**31505.0**
Estimated Annual Savings (Rs.) @ Rs. 2/kWh –LT-V Tariff	1367.1
Simple payback period (years) @ Rs. 2/kWh –LT-V Tariff	23.0
Estimated Annual Savings (Rs.) @ Rs. 6.2/kWh –Purchase Tariff	4237.9
Simple payback period (years) @ Rs. 6.2/kWh –Purchase Tariff	7.4
Demand Savings	
Estimated annual Savings (MU)	68.35
Average annual pump operating days	250
Average daily pump operating hours (hrs)	2.75
Daily savings in energy consumption (kWh)	273413
Anticipated Demand Savings (MW)	**100**

11. POLICY REVIEW

11.1 Existing Policy

11.1.1 Agriculture Department does not properly documenting the details of the agriculture consumers falling under each Krishi Bhavan.

11.1.2 No comparative analysis on energy consumption of agriculture consumers.

11.1.3 No updation on consumer data base like existing land occupied, capacity of pump installed, crop details, eligibility for availing the agriculture scheme etc.

11.1.4 Pump purchase policy for purchasing new pump by the consumer is not standardized.

11.1.5 No system for encouraging consumers to buy energy efficient pumps to improve the overall pumping efficiency.

11.1.6 Though Energy Management Centre-Kerala had issued an order in 2011 stating that all agriculture pump sets purchasing hereafter shall be star labeled /ISI marked , the present agriculture pumping system reveals not that much impact on the pumping energy efficiency improvement. The details of the GO is given below:

11.1.7 Existing Policy for agriculture pump sets purchasing (Kerala Gazette No. 21/2015/PD dated 11th June 2015)

- All new connections to the agricultural pump sets must mandatory use Bureau of Energy Efficiency (BEE) Star labelled pump sets(with minimum 4 star rating) and Bureau of Indian Standards rated accessories Distribution Licensee, Department of Electrical Inspectorate and Agriculture Department must make necessary amendments to this effect in their relevant regulations and guidelines pertaining to granting permission for new agricultural connection and awarding financial grants and tariff concessions.
- The pump sets which are in use and not having four or five star rating must be replaced with new four or five Bureau of Energy Efficiency star labelled pump sets in a phased manned within three years as notified by Government of Kerala vide GO (P) No. 10/2014/PD dated 11-04-2014.
- In case the type and rating of pumps required are not covered under Star labelling programme, highest energy efficiency, Complying with relevant Bureau of India Standard must only be procured.

11.2 Guidelines for the Policy review for improving the energy efficiency in agriculture pumping sector

11.2.1 Create a data base of the existing eligible agriculture consumers with various parameters like pump type, age, size, make, rating, purpose, usage, water use, energy consumption, geographic/spatial deployment etc. in a pre-designed format.

11.2.2 Make statutory the purchase of star labeled agriculture pumps to avail subsidy for pump purchase cost.

11.2.3 Ensure that the installation of the pump sets is as per the guidelines of the agriculture department for bet operating efficiency and it should be certified by a competent person.

11.2.4 Any changes in the existing pumping system can be done only after getting prior approval from the concerned authority in a proper format.

11.2.5 An awareness on energy efficiency pumping operation may be given to officials of the agriculture departments as well as the consumers to ensure optimum operating efficiency.

11.3 Roles and responsibilities of various departments for improving Energy efficiency in agriculture pumping system

- A Proper documentation of the agriculture pump consumer should be created under each krishi bhavan with the collaborating with KSEBL.
- Create a data base of the existing eligible agriculture consumers with various parameters like pump type, age, size, make, rating, purpose, usage, water use, energy consumption, geographic/spatial deployment etc. in a pre-designed format by the Agriculture department.
- Department should prepare a standard protocol for the selection of the pump and the layout designing. The layout should also consider the water table variation by arranging a proper study by classifying the geographical area into different zones.
- The pump selection should be verified by the competent person which should be organized by the agriculture department. The pump selection should follow the G.O (P) No.21/2015/PD dated 11th June 2015
- Make statutory the purchase of star labeled agriculture pumps to avail subsidy for pump purchase cost and consumption cost. Agriculture department should ensure the proper purchase through local self-bodies.

- Ensure that the installation of the pump sets is as per the guidelines of the agriculture department for best operating efficiency and it should be certified by a competent person.
- Any changes in the existing pumping system can be done only after getting prior approval from the concerned authority in a proper format.
- Yearly updation of the details should be mandatorily followed by the agriculture department and so as the updation should be reflected in the primary data base.
- The Existing lower efficiency rated pumps should be mandatorily replaced either by ESCO or DISCOM model so as the sector should be operated at maximum efficiency pumps available in the market.
- The proper pump selection and layout design should be corrected along with the phase one.
- The agriculture department should monitor the consumption pattern of the agricultural pumps of the entire state.
- Irrigation Department should monitor the consumption of the irrigation pump sets.
- Irrigation department should conduct a separate study on each pump sets and identify the operating efficiency of the pumps throughout the year.
- Department should recognize the opportunity for replacing the old inefficient pump sets through ESCO/ DISCOM route.
- EMC should act as the monitoring agency verifying the consumption pattern, Efficiency improvement strategies adapted by the department through a competent agency.
- EMC should provide achievable targets to the Departments and should verify it annually with a competent agency.
- EMC should arrange necessary support to organize awareness program for the concerned staff and the consumers.

APPENDICIES

APPENDIX NO-2

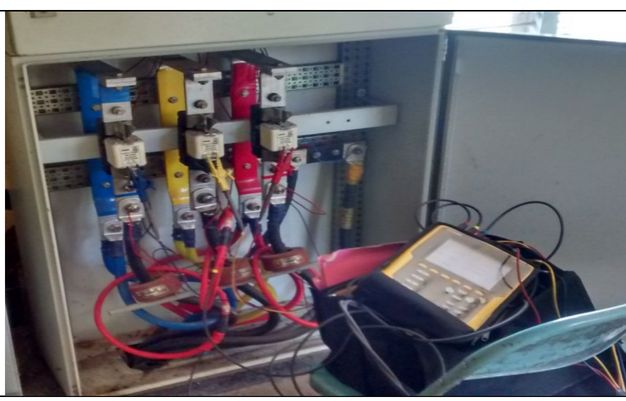
OVERVIEW OF STUDY CONDUCTED- PHOTOGRAPHS

Water Flow measurements during the survey

Data Collection during the survey

Water Flow measurements during the survey

Data Collection during the survey



Power Measurement using Power Analyser

Site view at irrigation sector


Data Collection during the Survey


Pump Inspection during the Survey


Power Measurement during the survey


Field Interaction during the Survey


Site view during the Survey

Flow Measurement during the Survey

APPENDIX NO.3

MAJOR IS STANDARDS FOR THE PUMPS

IS No.	Description
IS:1520-1980	Horizontal pumps for clear, cold, fresh, water.
IS:1520-1977	Technical requirements for roto dynamic special purpose pumps.
IS:6595-1993	Horizontal centrifugal pumps for clear, cold, fresh water for agricultural purposes.
IS:8034-1989	Submersible pump sets for clear, cold, fresh water.
IS:8418-1977	Horizontal centrifugal self-priming pumps.
IS:8472-1977	Regenerative self-priming pumps for clear, cold, fresh water.
IS:9079-1989	Mono set pumps for clear, cold, fresh water for agricultural purposes.
IS:9137-1978	Code for acceptance tests for centrifugal mixed flow and axial pumps.
IS:9301-1984	Deep well hand pumps.
IS:9542-1980	Horizontal centrifugal mono set pumps for clear, cold, fresh water.
IS:9694-1980 (Pt I, II, III & IV)	Code of practice for the selection, installation, operation and maintenance of horizontal centrifugal pumps for agricultural applications: Part I selection
IS:9694-1980	Part II Installation.
IS:9694-1980	Part III Installation.
IS:9694-1980	Part IV Maintenance.
IS:10572-1983	Methods of sampling pumps.
IS:10804-1986	Recommended pumping system for agricultural purposes.
IS:10805-1986	Foot-valve, reflux valve or non-return valve and bore valve to be used in suction lines of agricultural pumps.
IS:10981-1983	Code of acceptance test for centrifugal mixed flow and axial pumps.
IS:11004-1985 (Pt I & II)	Code of practice for installation and maintenance of deep well hand pumps: Part I-Installation.
IS:11004-1985	Part II-Maintenance.
IS:11346-1985	Testing set up for agricultural pumps.
IS:11501-1986	Engine mono set pumps for clear, cold, fresh, water for agricultural pumps.
IS:12225-1987	Jet centrifugal pump combination.

APPENDIX NO. 4

BUREAU OF ENERGY EFFICIENCY STAR LABELLED SCHEME

Revision: 3

Date: 03rd November, 2015

Schedule No.: 7

Pump Set

Normative Reference

(i) The referred Indian Standards are IS 9079 : 2002 for Electric Mono set pumps for clear, cold water and water supply purposes, IS 8034: 2002 for Submersible pump sets, IS 14220: 1994 Open well submersible pump sets and IS 11346:2002 for testing purposes of the above mentioned pump sets.

(ii) The standard ratings covered under the energy labeling scheme are as follows:

Sl. No.	Product detail Electrical Pumps	Range kW	No. of Poles	Applicable IS
1.	3 Phase open well submersible pump sets	1.1kW, 1.5kW, 2.2kW, 3.0 kW, 3.7kW, 4.5kW, 5.5kW, 7.5kW, 9.3kW, 11kW, 13kW & 15kW	2 Pole	IS 14220:1994
2.	3 Phase submersible pump sets	1.1kW, 1.5kW, 2.2 kW, 3.0kW, 3.7 kW, 4.5KW, 5.5 kW, 7.5kW, 9.3kW, 11kW, 13kW, 15kW & up to 75kW	2 Pole	IS 8034:2002
3.	3 Phase Mono-set pumps	1.1kW, 1.5kW, 2.2kW, 3.7 kW & 5.5kW, 7.5kW, 9.3kW, 11kW & 15kW & up to 22kW	2 Pole	IS 9079:2002
4.	Single phase open well submersible	0.37kW to 2.2kW	2 Pole	IS 14220:1994
5.	Single phase submersible pump set	0.37kW to 2.2kW	2 Pole	IS 8034:2002
6.	Single phase mono set pumps	0.37kW to 2.2kW	2 Pole	IS 9079:2002

Terms and Definitions

i. Label means any written, printed, marked, stamped or graphic matter affixed to, or appearing upon the Pumps.

ii. Performance Factor means relative improvement of the pump efficiency with respect to BIS specified benchmark efficiency.

iii. Overall efficiency of the pump set is including the efficiency factor for induction motors. The overall efficiency is calculated as per IS 14220:1998, IS 8034:2002 and IS 9079: 2002 for pump sets and IS 12615: 2004, IS: 4029 – 1967, IS 325: 1996 for induction motors.

iv. NABL means National Accreditation Board For Testing And Calibration Laboratories

v. ILAC means International Laboratory Accreditation Cooperation

vi. APLAC means Asia Pacific Laboratory Accreditation Cooperation

Eligibility Criteria

- BIS License mark certification for the product is mandatory.
- Quality Certification such as ISO/BIS is mandatory.
- Only BIS/BIS approved lab/NABL/ILAC/APLAC approved lab test report is acceptable.

Testing Guideline

5.1. Method of Tests: The testing code and procedure for Electric Mono set pumps, Submersible pump sets and Open well submersible pump sets would be as per IS 11346: 2000 all amendments as on date.

5.2. Parameters to be tested: Parameters for check verification and challenge testing are guaranteed performance of nominal volume rate of flow, nominal head and overall efficiency of the pump set at the duty point.

a) The Open well submersible pump sets shall meet the requirements of performance in Clause 10.2 (10.21 through 10.23) of IS 14220: 1994.

b) The submersible pump sets shall meet the requirements of performance in Clause 15.2 (15.21 and 15.22) of IS 8034:2002.

c) The Electric Mono set pump shall meet the requirements of performance in Clause 13.2 (13.2.1 and 13.2.2) of IS9079:2002.

Energy Labeling Plan: The star rating plan for pump sets is as below:

Star Rating	Performance Factor of the Pump Set
1 Star	≥1.00 & <1.05
2 Star	≥1.05 & <1.10
3 Star	≥1.10 & <1.15
4 Star	≥1.15 & <1.20
5 Star	≥1.20

Manner of Display:

(i) The rating plate details will be as per the requirements of relevant Indian Standards with all its latest amendments.

(iii) The sample label on the name plate is as follows:

POWER CONSUMPTION STAR LABEL – ELECTRICAL PUMPS

ENERGY SAVINGS GUIDE

Overall Efficiency of the Pump set* :

SUBMERSIBLE PUMPSET

ENERGY IS LIFE
BEE
CONSERVE IT
BEE/XYZ/000

Manufacturers Logo if available

IS - 8034

TYPE		S.NO		Model No/ Year				kW/HP	
Del.SIZE mm		HEAD m		Dis. IPS		CAPACITY RANGE lps		IPkW	
rpm		OVERALL EFF. %		Operating Head Range m				Min.Sub m:	
V	+6% -15%	Hz		Min.Bore Size mm		No.of Stages		Max Current	
DUTY	S1	CONN		Phase		MONTH		YEAR	

Name of the manufacturer with complete address

*Under test conditions when tested in accordance with relevant IS No., the actual energy Consumption will depend on how the equipment is being used

*Aspect ratio of label shall remain same while printing

Note: Please fill Electric Submersible/ Open well Submersible/ Monoset Pumps and respective Indian standards as actual besides the star rating logo.

(iii) The label shall be applied on the front base of the equipment on the nameplate as shown above, so as to be prominently visible on the equipment.

(iv) Colour Scheme for Logo

BLUE –

Hue (H)-239^{o} Saturation(S):64% Brightness (B):59%

Luminance or lightness (L):28, chromatic components -a: 24 b: 54 Red(R):54 Green (G):55 Blue (B):151

Cyan(C):97% Magenta (M):95% Yellow(Y):6% Black (K):1% Web color code - #363797

GREEN –

Hue (H)-150o Saturation(S):10% Brightness (B):67%

Luminance or lightness (L):61, chromatic components -a: 53 b: 32 Red(R):0 Green (G):170 Blue (B):87

Cyan(C):81% Magenta (M):10% Yellow(Y):90%

Black (K):1% Web color code - #00AA56

Tolerances

The tolerance shall be as specified in IS 11346: 2002. However, there shall be no tolerance for star rating band, the average of products tested must be at par or better than the label threshold.

APPENDIX NO. 5

The List of BEE Star Labelled Manufactures –Mono set pumps

SL. No	Brand Name	Model Number	Pump set Rating (kW)	Overall efficiency (%)	Valid Till Date	Phase
1	AQUATEX	AMH-2	2.2	51.5	20-07-2020	Three Phase
2		AMH-8	5.5	61.5	14-09-2020	Three Phase
3		AMH-6	3.7	60	14-09-2020	Three Phase
4		AMH-29	1.5	55.5	12-02-2021	Three Phase
5		AMH-15	7.5	69.5	05-07-2021	Three Phase
6	BINDHU PUMPS	BEHH3	0.37	27.5	18-03-2021	Single Phase
7		BEHH1	0.75	32.6	18-03-2021	Single Phase
8	CETO	CCM85	0.75	31.8	13-03-2021	Single Phase
9		CCMS50	0.37	27.3	13-03-2021	Single Phase
10	CRI	ACM A15	1.1	38	18-09-2019	Single Phase
11		5H1-N2	3.7	57	19-01-2020	Three Phase
12		7.5H3-N2	5.5	61.5	19-01-2020	Three Phase
13		10H4-N2	7.5	62.5	19-01-2020	Three Phase
14		T/ACM29	2.2	56	29-12-2019	Three Phase
15		ACM A6	0.75	46.5	20-07-2020	Single Phase
16	CROMPTON	MBS10.2	7.5	63	13-06-2019	Three Phase
17		MBM12(1PH)	0.75	45.7	07-08-2019	Single Phase
18		MBS52	3.7	68.5	27-04-2020	Three Phase
19		MBK1.52(1Ph)	1.1	48.5	08-10-2020	Single Phase
20		MBG12(1PH)-21	0.75	35	27-02-2021	Single Phase
21		MBK22	1.5	51	27-02-2021	Three Phase
22		MBP12.52-45	9.3	61.7	27-02-2021	Three Phase
23		MBS15.2	11	65	25-12-2020	Three Phase
24	ELEEN LAXMI	LNH II B	0.37	28	12-04-2021	Single Phase
25	ELLAII LAXMI	MPVI / SR	0.75	42.4	08-08-2020	Single Phase
26		MPIII / SR	1.1	44.9	08-08-2020	Single Phase
27		MP VL SR	0.37	29	13-03-2021	Single Phase
28	HARSH	1/HH 8 Plus	1.5	53	02-04-2021	Single Phase
29		1/HH 14 Plus	2.2	58	02-04-2021	Single Phase
30	JAI	VCTBNS 050075	3.7	60.5	28-03-2019	Three Phase

31	KALPA PUMPS	VCTBNS 030065	2.2	52.45	28-08-2019	Three Phase
32		5 STAR KERA 052525L.	0.37	28.6	19-12-2020	Single Phase
33		5 STAR KERA 104040.	0.75	38.6	19-12-2020	Single Phase
34		5 STAR KERA 155040.	1.1	45.7	19-12-2020	Single Phase
35	KERA PUMPS	5 STAR KERA 052525L	0.37	28.6	26-01-2020	Single Phase
36		5 STAR KERA 104040	0.75	38.6	26-01-2020	Single Phase
37		5 STAR KERA 155040	1.1	45.7	26-01-2020	Single Phase
38	KIRLOSKAR	KDS-515E	3.7	62.6	20-07-2020	Three Phase
39		KDS-1.514++	1.1	48.5	14-09-2020	Single Phase
40		KDS-325F	2.2	57	19-12-2020	Three Phase
41		KDS-1331F	9.3	66.6	12-02-2021	Three Phase
42		KDS-1537F	11.2	66.1	19-12-2020	Three Phase
43		KDS-822F	5.5	64.5	23-05-2021	Three Phase
44		KDS-1030F	7.5	65.3	23-05-2021	Three Phase
45		KDS-1555F		58.5	23-05-2021	Three Phase
46		KDS-2050F		64.8	23-05-2021	Three Phase
47		KDS-0510+	0.37	37	25-09-2021	Single Phase
48		KDS-116++	0.75	43.5	25-09-2021	Single Phase
49		KDS-527S	3.7	55	01-11-2021	Three Phase
50		KDS-216F	1.5	55.1	18-01-2022	Three Phase
51	LAURA	LMB-1S	0.37	27.3	27-02-2021	Single Phase
52		LMB-3S	0.75	31.8	27-02-2021	Single Phase
53	LUBI	LBH-29AA	15	64.95	06-11-2019	Three Phase
54		LBI-15A	3.7	58.78	23-05-2020	Three Phase
55		MDH-12SV	0.37	27.3	20-07-2020	Single Phase
56		LBI-27H	5.5	58.08	20-07-2020	Three Phase
57		LBH-12AR	7.5	66.85	20-07-2020	Three Phase
58		LBH-21AR	9.3	66.35	20-07-2020	Three Phase
59		LBH-29BR	11	65.9	20-07-2020	Three Phase
60		MDH-21S	1.5	59	12-02-2022	Single Phase
61		MDH-17S	0.75	48	12-02-2022	Single Phase
62		MDH-20S	1.1	50	12-02-2022	Single Phase
63	MAHENDRA	JR60	1.1	51.5	18-01-2020	Single Phase
64		JR50	0.75	48	18-01-2020	Single Phase
65		JR3+		34	18-01-2020	Single Phase
66		MCH80	0.55	34	18-01-2020	Single Phase
67		CHV1HH	0.37	39	18-01-2020	Single Phase

68	PSG	EHN58	3.7	59.1	22-08-2019	Three Phase
69	SHAKTI	SMB32-160-323	2.2	52.2	08-01-2020	Three Phase
70		SMB32-160-535	3.7	54	08-01-2020	Three Phase
71		SMB32-160-841	5.5	55.5	08-01-2020	Three Phase
72	TARO	HCS 3025-R	0.37	30.5	21-01-2021	Single Phase
73		HCS 7030-R	0.75	37	21-01-2021	Single Phase
74	TEXMO	HCS 1575 NR	1.5	55	15-06-2020	Single Phase
75		TMH 12	2.2	56.1	25-12-2020	Three Phase
76		TMH 13	5.5	64.4	08-08-2020	Three Phase
77		TMH 37	3.7	62.6	08-08-2020	Three Phase
78		HCS 8050 F	1.1	50	03-01-2021	Single Phase
79		TMH 22	9.3	61	27-02-2021	Three Phase
80		TMH 15 Q	7.5	64.3	30-07-2021	Three Phase
81		TMH 54 MQ	15	62.1	28-01-2022	Three Phase
82	V-GUARD	VCTBNS 030065	2.2	52.45	06-11-2019	Three Phase
83		VCTBNS 050075	3.7	60.5	20-03-2019	Three Phase
84		VCTBNS 015080	1.1	47	20-03-2019	Three Phase
85		VCS-F80	0.75	26	19-09-2020	Single Phase
86		VCT 0245	1.5	50.65	07-03-2021	Three Phase

APPENDIX NO. 6

The List of BEE Star Labelled Manufactures –Open Well Submersible				
Activa Submersible Pump	Duke	Jalkranti	Orcal	Skylegend
Aden Submersible Pump Set	Eleen Laxmi	Jaystar Submersible Pump	Oriant	Splendor Pumps
Agronomy	Ellaii Laxmi	Jeet	Parth	Standard
Agrosun	Falcon	Kalpa Pumps	Patal	Star Gold
Ajanta	Fidel	Kalsi	Penguin	Sterling
Allison	Fieldmarshal	Karvel	Pew	Swastik
Amco	Figo	Kelvin	Point	Target
Angel	Filltop	Kera Pumps	Poonam	Taro
Aquapower	Fine Alpha	Kirloskar	Prayag	Techno
Aquatex	Fitwell	Kripa Pumps	Pro Sumo	Texmo
Arjun	Flamingo	Krishna Submersible	Proton	Topland
Arun Pumps	Flotech	Ksb	Raiyaraj	Trishul
Aryenvarsha	Flowone	Ktc	Ratna	U-Neel
Au Perfect	Flowvil	Lakhi	Rclassic	Universale Pump
Axel	Fusion	Landmark	Rikin	Unnati
Besten	Gangotri	Lanzer	Rotec	Vaigai Pumps
Bindhu Pumps	Garvel	Laura	Sabar	Varuna
Bluestar	Geeco	Laxmi	Sagun	V-Guard
Celvin	Gforce	Lubi	Samrat Pumps	Vikram
Ceto	Goldstar	Mahendra	Samurai	Vishal
Cri	Harsh	Mak	Sanjivani Pumps	Waterman
Crompton	Hi Flow	Meghana	Seeco	Zmr
Damini	Icon	Meghdoot	Selon	
Deccan	Jagdish	Messey Super	Shayona	
Devganga	Jai Jansi Hi Floow Pumps	M-Tech Pump	Silicon	
Dmf	Jaldeep	Niraj	Silver	

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