SCHEME FOR STUDYING THE POSSIBLE CHANGES IN THE ECO-SYSTEM OF KUTTANAD CONSEQUENT ON THE CONSTRUCTION OF THANEERMUKKOM BARRIER

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PREFACE

The Thaneermukkom Barrage was partially commissioned during the year 1975-1976. Long before the commissioning the probable changes in the eco-system of Kuttanad and consequent effects that may adversely affect the present pattern of cropping and soil conditions etc. were under consideration by the Kerala Government. The Minister for Agriculture held discussion with the Vice-Chairman, Planning Board, Agricultural Project Commissioner and other officers as early as 8-5-1973 and directed the Agricultural University to conduct the necessary studies.

The Dean, Faculty of Agriculture, Kerala Agricultural University prepared a scheme for studies which was discussed in detail at a meeting presided over by the Vice-Chancellor, Agricultural University, on 12-2-1976. During the discussion it was pointed out that several aspects which are subject to changes due to change in eco-system of Kuttanad area have to be looked into in addition to what was highlithted in the Dean's report. For further study and report a committee was formed with representatives from all Government departments, Universitiesand other organisations connected with the problem. The list of members of the committee is given elsewhere.

The committee met several times and discussed all the aspects in detail and the present report was prepared.

Projects for seven disciplines have been formulated. Particular care has been taken to avoid overlapping of projects and application. In addition to the above, control of salvinia growth has to be studied. As there is a special State Level Committee constituted to look into this, this aspect has not been dealt with in detail here.

All the research projects are to be located at Monkompu, where there is already a research station. Facilities here will have to be increased and more space for laboratory provided. The scheme estimated provide for the glassware, chemicals etc. and separate provision has been made for buildings, furniture etc.

All the Research Projects will have to be Co-ordinated by a Project Co-ordinator who could be a competent Professor from the Agricultural College. He will be assisted by a skeleton staff for correspondanges, preparation of reports etc. Research scholars have been suggested for certain types of studies by which we expect very sincere and meticulous work will be possible.

The total cost of the scheme ie estimated to be Rs.30 lakhs for a period of five years. Studies, if any, to be continued can be done as research projects for post-graduate studies, and the University or Government can subsidise such projects.

In preparing this report valuable direction and guidance have been given by the Vice-chancellor of the Agricultural University, Shri N. Kaleeswaran, Dean of Agriculture, Dr.N.S. Money and Dr.R.Gopalakrishnan, Director of Research. The Committee is thankful to them.

In such a short time this report could not have been prepared

without the whole-hearted co-operation of the Committee members and their assistants. The burnt was borne by the Convenor Dr.M.M. Koshy himself and I have to record the appreciation for his work. Convenience for conducting the committee meeting was provided by the Agrl. College, Vellayani. For this kind gesture I record here by gratitude to the College Authorities.

Sd/-
M. MANGALABHANU
Chairman.

MEMBERS OF THE COMMITTEE

1. Shri M.Mangalabhanu, Adviser, Kerala Land Development Corporation. (CHAIRMAN)
2. Dr N.S.Money, Dean, Faculty of Agriculture, Kerala Agricultural University.
3. Dr N.Balakrishnan Nair, Dean, Faculty of Science and Head of the Dept. of Aquatic Biology and Fisheries, University of Kerala.
4. Shri V.C.Jacob, Senior Hydrogeologist, Central Ground Water Board, Trivandrum.
5. Shri J.J.Fenn, State Agricultural Engineer, Dept. of Agriculture, Trivandrum.
6. Shri S.Lekshminarayanan,Executive Engineer, Water Resources Division, Trichur.
7. Shri A.G.Vasavan, Joint Director of Fisheries, Trivandrum.
8. Shri V.Bhaskaran Nair, Soil Survey Officer, Trivandrum.
9. Shri T.V.Samuel, Asst. Commissioner, Land Use Board, Trivandrum.
10. Dr M.R.G.K.Nair, Professor of Agricultural Entomology, Kerala Agricultural University.
11. Dr M.Ramanatha Menon, Professor of Plant Pathology, Kerala Agricultural Universiy.
12. Dr (Smt) Mary K.George, Professor of Agricultural Botany, Kerala Agricultural University.
13. Dr N.Sadanandan, Professor of Agronomy, Kerala Agricultural University.
14. Dr M.M.Koshy, Profesor of Agricultural Chemistry, Kerala Agricultural University (CONVENOR)

Expenditure statement for the whole scheme for five years.
(Discipline-wise Abstract)

Discipline	Ist year	IInd year	IIIrd year	IVth year	Vth year	Total
	Rs	Rs.	Rs	Rs	Rs.	Rs.
1. Soil and water (Agrl. Chemistry)	67,685	59,925	61,410	62,660	64,350	3,16,030
2. Agronomy	82,685	69,925	71,410	72,660	74,350	3,71,030
3. Entomology and Rodent control	79,255	71,705	73,460	74,980	76,980	3,76,380
4. Agrl. Botany.	67,685	59,925	61,410	62,660	64,350	3,16,030
5. Microbiology & Plant Pathology	67,685	59,925	61,410	62,660	64,350	3,16,030
6. Aquatic Biology	1,67,200	1,01,200	83,200	--	--	3,62,600
7. Hydrology and Ground water	78,440	71,030	72,930	74,550	76,650	3,73,600
8. Head quarters.	3,07,170	53,169	54,168	53,167	54,166	5,21,840
Total.	9,28,805	5,46,804	5,39,398	4,63,337	4,75,196	29,53,540

Rounded as 30 lakhs

Expenditure Statement for the whole Scheme for five Years.

(Item-wise Abstract)

Item	Ist year Rs.	IInd year Rs.	IIIrd year Rs.	IVth year Rs.	Vth year Rs.	Total Rs.
1. Pay and allowances	3,42,805	3,54,804	3,65,398	3,31,337	3,43,196	17,37,540
2. Travelling allowance	49,000	49,000	49,000	44,000	44,000	2,35,000
3. Contingencies						
a) Office furniture & stationery	46,000	20,000	20,000	15,000	15,000	1,16,000
b) Books and periodicals	9,000	3,000	3,000	3,000	3,000	21,000
c) Lab equipment, chemicals, cost of cultivation etc.	2,32,000	1,20,000	1,02,000	70,000	70,000	5,94,000
	2,87,000	1,43,000	1,25,000	88,000	88,000	7,31,000
4. Building	2,50,000					2,50,000
T O T A L	9,28,805	5,46,804	5,39,398	4,63,337	4,75,196	29,53,540

(Rounded as 30 lakhs).

SCHEME FOR STUDYING THE POSSIBLE CHANGES IN THE ECO-SYSTEM OF KUTTANAD CONSEQUENT ON THE CONSTRUCTION OF THANEERMUKKOM BARRIER.

1 INTRODUCTION

1.1. The low lying area situated between the coastal belt and the uplands in Karthikappally, Mavelikara, Chengannur, Ambalapuzha, Kuttanad, Thiruvalla, Kottayam, Sherthala and Vaikom Taluks is generally known as Kuttanad.

1.2. According to Geologists millions of years ago this lnd was dense forest. In succeeding geological ages the sea advanced and engulfed many places extending upto the foot of the Western Ghats, including this area. Several thousands years later the sea receded exposing part of the present midlands and the coastal region. During these Geological upheavals the entire forest areza was submerged far below the ground and thereafter silted upto varying levels.

1.3. The rivers Achancoil, Pampa, Manimala and Meenachil discharge their waters into Kuttanad region from the South east and east. These rivers on entering the area flow through a net work of channels leading to the Vembanad lake. The drainage area of these rivers is 51,00 sq. k. During South West monsoon ie. during June to September, the entire area will be submerged under flood waters. The flooded waters gradually drain through the water courses and Vembanad lake into the sea through the Cochin gut.

1.4 Geologically Kuttanad is an alluvial belt, the main formation being delta alluvium. This alluvium is essentially alternating layers of clay and sand of varying sizes and variable percentages of organic matter of vegetable and animal orgin. Clay is usually black blue or grey, while thesand is brown or yellow and is of fine to medium grains. These alluvial formations exist is layers varying upto 30 metres depth under-laid by sandstone and mottled clay of tertiary formations. On the eastern margin, the tertiary groups of rocks are exposed. The common outcrop is charnokite. The coastal belt on the west is covered by coastal alluvium composed of sand formed as sand bar.

1.5. The area is 870 sq.km. in extent of which 290 sqqkm is garden lands distributed widely rising one to two metres above sea level. The remaining area is below sea level and was once a watery waste. Of this, an area of 520 sq.k.m (52000 hectares of depth varying from 0.5 to 2.0 metres was progressively reclaimed by construction of bunds, leaving sufficient space for water course for drainage, navigation and irrigation. The area left unreclaimed is the present Vembanad lake. The Vembanad lake extends upto Cochin and there is connected to the sea.

1.6. Agriculture. The principal crop in kuttanad is paddy and coconut. Coconut is cultivated on the high ground and artificially formed bund s. There are three kinds of paddy fields viz.(i) karapadam, (ii) Kayal lands and (iii) Kari land s. Karapadams are in upper Kuttanad, in the east and South east, which are comparatively higher due to heavier silting from the rivers.The kayal land consists of area reclaimed from the lake. The kari-lands are located irregularly in different parts of the basin. These lands have vast organic deposits of fossils of timber and sea shellfish in varying depths reminiscent of submersion under for ages.

1.7. During the Monsoon period, ie. June to September, the entire area will be submerged. When the monsoon subsides by September-Oct. the water level drops and agricultural operations begin with the maintenance and repair of bunds around paddy fields. The water from the areas enclosed by bunds, known as padasekharams, is then pumped out, and theland is prepared b y ploughing and puddling. The paddy seeds are sown or seedlings transplanted around October-November. Harvesting is done during February-March.

1.8. Till the year 1915, in lower Kuttanad crop was raised only once in two years. The soil got enriched during the fallow period by deposition of silt and other natural processes. In the year 1916 an agricultural experiment station set up Kuppappuram studied the possibility of annual cropping and found it successful. Annual cropping became an established practice and the station was closed down in 1921.

1.9 The two major problems facing the cultivation in this area are (i) the damage caused by floods, and (ii) intrusion of salinity during the fag end of the crop period.

1.10. To protect the paddy fields from submergence due to floods and protect from salinity, the Government has formulated and implemented the Kuttanad Development Scheme. This consisted of the construction of a spillway at Thottappally to discharge the flood waters direct to sea at the South end ie. the upstream end of Kuttanad itself. This spillway id designed to discharge 64,000 cusees of water into the sea, which will bring the water levels within safe limits. The spill way consists of 40 shutterss each 25 feet wide and 9.25 feet deep.

1.11 To prevent instrusion of saline water the Thaneermukkom barrage is constructed. The barrage consists of 93 shutters of 40 feet span and 18 feet depth. Of these 62 are completed and the other portion closed with an earth bund forming part of the cofferdam.

1.12. To prevent entry of salt water from the Kayamkulam Kayal through the T.S. Canal a lock is constructed at Thrikkunnapuzha. Some of the minor water-ways are closed annually with temporary bunds.

1.13. The shutters of all the three structures, namely Thaneermukkom barrage, Thottappally spillway and Thrikkunnapuzha lock, are operated in such a way that flood waters are disposed off quickly and the salt water entry is stopped throughout the year. The net result of these operations is that the Kuttanad area will be having only sweet water all round the year.

1.14 Formerly, ie. before the construction of these structures, watercourses in Kuttanad were filled with sweet water from June to November and then due to tidal effect the water turned salty from December to June. In other words, for six months of the year the area was having fresh water and salt water for the other six months. Now the area is throughout the year having fresh water and this naturally will effect so many changes in the eco-system.

1.15. As early as 1973 Kerala Government was conscious of this matter and the Agricultural Planning Department directed the Agricultural University to have a detailed study of the possible changes in the eco-system due to the change from seasonal to permanent exclusion of salinity.

1.16. The present scheme, now formulated in this report is conceived with a view to having a systematic study of the various problems arising out of the new situation under the permanent influence of fresh water. The proposal is an inter disciplinary approach to the problem under the following subjects:

1. Soil and water (Agricultural Chemistry)
2. Agronomy.
3. Botany
4. Entomology and Rodent control
5. Microbiology and Plant Pathology
6. Aquatic Biology.
7. Hydrology and ground water.

Previous studies

2.1. In the year 1924 Shri.Parameswaran Pillai conducted a soil survey of the area. He carried out the chemical and mechanical analysis of a large number of soil samples. There was a research station located at Purakkad at that time. In 1928 Shri.Narayana Iyer continued the above work and determined the lime requirement, phosphoric-acid content and water soluble salts, especially in the soils of the Kari lands. He attributed the infertility of Kari land soils to deficiencies in lime and phosphoric acid, as well as to toxic concentrations of water soluble salts. Liberal application of lime and phosphate fertilizers after leaching with sweet water was the solution suggested.

2.2. In 1931 Sarvasree Narayana Pillai and Subramonian studied the origin and nature of peat soils. They found out the following: The brown aromatic oil extracted with petroleum ether was from the woody residues occurring in the soil. The presence of small quantities of resins in the soil exerted a marked influenc e in the moisture holding capacity of the soils. The mari soils contained large percentages of iron, aluminium and sulphur compounds, the latter in the form of mineral sulphates. The formation of free sulphuric acid and the sulphates of iron Calcium and Potassium were also detected.

2.3. In 1945 extensive studies on kari land soils from various parts of the State was conducted Dr. C.K.N. Nair. The nature and extent of organic matter in the soil was the prime object of the study. Decomposition studies with hydrogen peroxide revealed that the chemical nature of oxidisable complex in kari soils differed considerably from ordinary soils. Estimation of proximate chemical constituents showed the presence of large quantities of lignin, ether and alchohol-soluble substance , cellulose and polyuronides. Analysis and decomposition studies showed that the most resistant fraction was lignin with its complexes.

2.4. In the same year Dr.N.Subramoney carried out an extensive study on the causes of the infertility of Kari land soils. He established that the production of free sulphuric acid by the oxidation of sulphides present in the soil caused the high acidity and consequent infertility. Evidence was adduced of a Sulphur Cycle in these soils. During submergence when anaerobic conditions existed, normal sulphides and organic-sulphur compounds are reduced by sulphur-reducing bacteria and hydrogen sulphide is produced. Hydrogen sulphide reacts with bases in the soil and metallic sulphides are formed. When the soils are exposed and get dry, oxidation takes place resulting in the conversion of sulphides to sulphates and the formation of sulphuric acid. This cycle repeats with submergence and the exposure of the land.

2.5. In the mean time during 1940 considering the great damage caused by the rice swarming caterpillar the Travancore University had a research project working at Pallom till 1955. Later with the introduction of high yielding varieties and associated cultural practices the problem of pests was becoming more and more acute. Destructive pests other than rice swarming cater pillar, such as stem borer, rice leaf roller, rice gall midge, rice bug made their appearance shortly after. From 1973 onwards

brown hopper is the major menace. It was observed that pest infestation are likely to be of a higher magnitude if sowing is delayed due to some reason. Thereafter the Agriculture Department has been bestowing constant surveillance.

2.6. In the year 1958 Gopalaswamy made a comprehensive comparative study of Kuttanad soils, Soils of Sunderbans in West Bengal, and Bhuwaneswar in Orissa. He classified Kuttanad soils into three types viz.

1. Peaty marine clays.
2. Black humus sands.
3. Muck derived from young alluvium.

He attributes only medium status for Kuttanad soils as far as fertility is considered.

2.7. During 1962-1967 with ICAR assistance "Chemical microbiological and agronomic studies in soils of Kuttanad were conducted. Also " Studies in the acid soils of Kerala" and " Studies in reclamation of saline soils of Kerala" were two other schemes implemented during the same period, both with ICAR assistance. The results have been published as a Technical bulletin in 1973 by the Extension Education Department of Kerala Agricultural University.

3. SOIL AND WATER (AGRICULTURAL CHEMISTRY)

3.1. Life in any form depends directly in soil and water. When the chemical, physical and biological qualities of the soil and water change the living organisms, both primary and evolved, also change or some even perish. The change in the envirnnment directly causes changes in the properties of the soil and water. Investigations hitherto done show that the major soil problems in Kuttanad are high acidity and salinity. Now that salt water is completely cut off there will be drastic changes in the physico-chemical properties of the soil.

3.2. It is considered necessary to undertake a comprehensive soil survey of the area for detailed evaluation of the physico-chemical characters of the soils. Such a survey will also help to classify the soils in the area under well defined classificational units to ascertain the extent and distribution of various types of soils and to prepare detailed soil and land capability maps of the entire area. The soil studies will also enable in the formulation of soil amelioration measures suitable for the region.

3.3. With the above objectives in view a scheme for undertaking a comprehensive soil survey of Kuttanad was sanctioned by Government as per G.O.Rt. 2428/74/AD/dated 11--11-1974. Accordingly a reconnaissance soil survey was initiated in July 1975 which is now nearly complete. Detailed soil survey of the kayal lands has now been taken up and it is expected that the soil survey work covering the entire Kuttanad can be completed by the end of 1978.

3.4. The necessary staff and funds have been provided for the scheme already sanctioned and no additional funds are required.

3.5. As soil survey aims only at the classification and mapping of the soils it is necessary that a separate project be undertaken to investigate the changes that arelikely to occur consequent on the cutting away of the salt water.

Studies on soil-water relationships.

3.6 With the cutting away of the saline water, the physical, chemical and biochemical changes occurring in these soils are liable to considerably alterations. Further, the residues of poisonous plant protection chemicals are also likely to accumulate in the soil and water. Hence the following studies are contemplated with a view to tracing the changes that take place to the water, the soil and the soil flora and the extent to which pesticide residues are retained in the soil and water consequent on the prevention of the entry of salt water.

3.61. Project 1. Studies on surface waters. (1)

About 20 locations will be marked out by suitable means in the kayal, karapadom and kari areas at fairly equal distances. Surface waters will be collected from these locations at regular intervals and examined for the following:

a) pH
b) Chlorides, sulphates and other anions
c) Bases such as Na, K, Ca and Mg.
d) Iron and aluminium.

3.62 Project 2. Studies on ground water. (2)

Ground water samples will also be collected from the same areas as above at definite intervals. These will also be analysed for pH and the various anions and cations, iron, aluminium etc. and the correlations between the composition of the surface waters and the ground water worked out.

3.63. Project 3. Studies on soil profiles. (3)

Soil profiles will be collected from near the marked locations and samples from the different horizons will be examined for pH in the wet and dry conditions, total and available nutrients and also for the different forms of N, P, K, S, Fe and Al.

3.64. Project 4.Studies on soil solution. (4)

Soil samples will be collected from a large number of sites and their saturation extracts prepared. These extracts will be examined for the various anions and cations. Similar studies will be undertaken in soil profiles which will throw light on the variations in the anion and cation concentrations in the soils with depth. Correlations between changes in salinity and the soil constituents will also be worked out.

3.65. Project 5. Studies on soil structure. (5)

Soil structure is one of the properties which will be considerably affected by changes in the salinity of the soil water. The structure will be determined for the soils collected from various locations by the wet sieving method and correlated to salinity.

3.66 Project 6. Studies on Pesticides residues: (6)

The application of pesticides to the rice crop may result in the accumulation of poisonous chemicals in the soil and water. Hence studies will be undertaken to find out the extent to which plant protection chemicals are retained in the soil and water. For this soil and water samples will be collected from marked locations periodically and analysed for pesticide residues.

3.67. Project 7. Studies on soil physical properties. (7)

The non-entry of saline water will affect the state of dispersion and aggregation of the soil particles. This will indirectly influence soil physical properties such as water holding capacity, porespace, bulk density, plasticity, stickiness etc. Hence studies will be undertaken of the variations in these soil physical properties in the samples collected from different locations.

3.67. Location of the projects.

The projects mentioned above will be located at the Rice Res. Station, Monkompu. A full-fledged chemical laboratory with all modern facilities will have to be set upwt this station for carrying out the work envisaged.

3.8. Staff: For the successful implementation of the scheme the following staff structure is considered essential.

1. Assistant Professor (Rs.600-1200½ - 1
2. Instructors (Rs.510-995) - 2
3. Field Assistants. (Rs. 330-585) - 2

3.9 Expenditure statement (Soil and Water.

	1st year Rs.	2nd year Rs	3rd year Rs	4th year Rs	5th year Rs	Total Rs
I. Pay and allowances						
i. Assistant Professor (Rs.600-1200)1.	11,405	11,840	12,245	12,750	13,240	61,480
ii. Instructor Rs.510-995 (2)	19,210	20,305	21,115	22,090	22,980	1,05,700
iii. Field Assistant Rs.230-385 (2)	9,570	9,780	10,050	10,320	10,630	50,350
	40,185	41,925	43,410	45,160	46,850	2,17,530
II Travelling allowance	5,000	5,000	5,000	5,000	5,000	25,000
III. Contingencies						
a. Laboratory glassware and chemicals	10,000	5,000	5,000	5,000	5,000	30,000
b. Books and Periodicals	1,500	500	500	500	500	3,500
c. Office Furniture and stationery	6,000	2,500	2,500	2,500	2,000	15,000
d. Other contingencies.	5,000	5,000	5,000	5,000	5,000	25,000
	22,500	13,000	13,000	12,500	12,500	73,500
Total.	67,685	59,925	61,410	62,660	64,350	3,16,030

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4. AGRONOMY

4.1. Agronomy is the science dealing with cultivation practices, including management of the soil, water, and cultural treatments during the crop period. All agricultural operations connected with growth upto harvest of crop depend on the physical, chemical and biological conditions of the soil and soil moisture. When the eco-system changes the properties of the soil, soil moisture and allied reactions change. These changes will change the present balance of physical, chemical and biological activities in the soil and mois moisture. To adjust against such changes the cultivation practices also shall change. Hence the present practices will have to be modified to suit the changed conditions.

4.2. Due to the prevention of entry of saline water into the area all the year round there will be fresh water. This change will not cause any sudden catastrophic effect which needs immediate attention. Only gradually the modification of soil conditions happen. Hence no immediate action is necessary. With the changed condition, perennial fresh water system and the construction of permanent bunds by the Kerala Land Development Corporation, two and occasionally three crops may be raised. Therefore there is urgent necessity to investigate the possibility of new cultivation practices as well as management and cropping patterns. With this object in view some suggestions are given below for detailed study in the field of Agronomy. The project may taken 5 years.

4.31. Experiments on Multiple cropping

Object: To assess the comparative efficiencies of some new cropping patterns and to select the best among them.

Technical programme.

Design RBD

Treatments: Seasons.

	Sept- Dec.	Dec-Feb.	March-May.
3.	Paddy	Paddy	..
4.	Paddy	Paddy	Soyabean
5.	Paddy	Paddy	Cowpea
6.	Paddy	Paddy	Green-Gram
7.	Paddy	Paddy	Black-gram
8.	Paddy	Paddy	Red-gram
9.	Paddy	Paddy	~~Red-gram~~ Groundnut
10.	Paddy	Paddy	~~Groundnut~~ Sweet potato
11.	Paddy	Paddy	~~Sweet-potato~~ Sunflower
			Paddy
			Sesamum.

Replications: 3

4.3.2. Experiment on Relay Cropping:

Object: To assess the possibility of relay cropping in Kuttanad area.

Lay out: RBD.

Treatments.

1. Rice - Rice + Cowpea.
2. Rice - Rice + Pellippessara.
3. Rice - Rice + Guar
4. Rice - Rice + Field beans
5. Rice - Rice + Sweet potato
6. Rice - Rice + Green gram.

Replications: 4.

~~4x33~~.

4.3.3 Production potential Trial with Rice.

Object: The object is to assess the possibilities of increasing the cropping intensity in rice for getting maximum production.

Treatments:-
1. 3 Short duration varieties.
2. 2 short duration + medium duration
3. 1 short duration + 2 medium duration.
4. 2 medium duration.
5. 1. short duration + 1 long duration
6. 2 long duration.

Replications: 4.

4.34. Experiments on the method of sowing:-

Object: To evaluate the different methods of sowing under the changing cropping patterns in Kuttanad.

Treatments: 1. Transplanting.
2. Transplanting - normal method with Dapog seedlings.
3. Broadcasting.
4. Line sowing.

Replications: 5.

4.4 Drainage requirement for coconut.

Object: To study the tolerance of coconuts to ground water table.

Treatments: 1 Maintaining the ground water level to the surface.
2. Maintaining the ground water level to 20 cm deep to 40 cm.
3. " 40 ~~60~~ cm "
4. " 60 ~~80~~ cm "
5. 80 cm "
6. " 100 cm "
7. " 120 cm "
8. " 140 cm "
9. " 160 cm "
10. " 180 cm "
11. " 200 cm. "

Replication: 4

4.5 Weed control

4.51. Survey, identification and classification of weed flora of kuttanad consequent on the expected changes in the eco-system.

The objective is to identify and classify the weeds of Kuttanad so as to suggest suitable control measures.

4.5.2 Studies on the weed infestation as influenced by cropping pattern under different methods of weed control.

Lay out: Split plot.

Major treatments:

1. Rice - Rice - Rice
2. Rice - Rice - Pulses
3. Rice - Rice - fallow
4. Rice - Rice - Sweet potato or groundnut.
5. Rice - (L.D) - (M.D) Rice (M.D.)
6. Rice (L.D) Rice (L.D.)

Replication: 4

(M.D. = Medium duration L.D = Long duration

4.5.3. Effect of variation in the depth of standing water on weed control:

Treatments:
1. 5 cm. standing water.
2. 10 cm ,,
3. 15 cm ,,
4. Hand weeding + 5 cm. standing water.
5. ,, +10 cm. ,,
6. ,, +15 cm ,,
7. Draining the Replication: 4 once in 7 days) + reflooding.

4.5.4. Effect of chemical weed control on the weed population and their residual effect on succeeding crops:-

Lay out: RBD.

Treatments:-

1. Chemical weed control for the first crop and its residual effect on the succeeding 2 crops.
2. Chemical weed control to the first 2 crops and their residual effect on the 3 crops.

The same treatments will be followed in the following cropping patterns.

1. Rice - Rice - Rice.
2. Rice - Rice - Cowpea.
3. Rice - Rice - Sweet potato.

Unweeded control will also be taken in all the above 3 cropping patterns.

4.6. Staff: The following staff is proposed. ✓

1. Assistant Professor	(Rs.600-1200)	- 1
2. Instructor	(Rs.510-995)	- 2
3. Field Assistants	(Rs.230-385)	- 2

4.7 Expenditure statement (Agronomy)

		Ist year Rs.	IInd year Rs.	IIIrd year Rs.	IVth year Rs.	Vth year Rs.	Total Rs.
I. Pay and allowances							
i. Assistant Professor(Rs.600-1200)	(1)	11,405	11,840	12,245	12,750	13,240	61,480
ii. Instructor(Rs.510-995)	2	19,210	20,305	21,115	22,090	22,980	1,05,700
iii. Field Assistant (Rs.230-385)	2	9.570	9,780	10,050	10,320	10,630	50,350
		40,185	41,925	43,410	45,160	46,850	2,17,530
II. Travelling allowance		5,000	5,000	5,000	5,000	5,000	25,000
III. Contingencies.							
a. Books and periodicals		1,500	500	500	500	500	3,500
b. Office furniture & Stationery		6,000	2,500	2,500	2,000	2,000	15,000
c. Other contingencies including cultivation expenses & equipment		30,000	20,000	20,000	20,000	20,000	1,10,000
		37,500	23,000	23,000	22,500	22,500	1,28,500
Grand total.		82,685	69,925	71,410	72,660	74,350	3,71,030

5. BOTANY:

5.1. Botany deals withthe scientific, systematic study of plants, their life cycle and characteristics.

5.2. As the properties of moisture on which the plants depends for their growth change, the growth of the various flora is modified to suit the changes. These modifications may be f avourable or unfaavourable to the cultivation. As thesoil characteristics also change, corresponding adjustments and modifications in the growth of plants are effected, as the soil and moisture are the too salient things which supply the nutrients to the plants for their growth.

5.3. The soil properties change with changes in the eco-system. The physical properties like temperature, annual silt deposits, amount of exposure to the submergence etc., influence the chemical and other activities in the soil. With the present changes in the environment no immediate catastrophic changes are expected, but gradual changes are anticipated. With the lowering of the water level in summer there will be visible changes in the perennial crops like coconut. It may be determental in the sense that the root system in the higher level are deprived of water, and beneficial as it is supplied with more soil air. So also the weeds that thrive in fresh water and perish in salt water may thrive well. High yielding varieties which could not thrive in saline soil could be cultivated with the change to non saline conditions.

5.4. To undertake studies on the above changes and other more detailed aspects research projects are formulated as below:-

5.5 Project. 1. Study of the flora of Kuttanad as influenced by the prevention of saline water ingression and tidal flow.

The technical programme includes:

a) Survey, collection and classification of the entire flora of Kuttanad and the preparation of a herbarium.

b) Study of the algal flora and other microflora of the paddy fields, their changing population, functions etc.

c) Ecological succession of the flora, their influx and dynamics of growth.

d) The gross physiological changes noticed in the case of coconut palms and other perennial crop plants due to lowering of the water table.

5.6. Project. II. Plant Breeding experiments.

a) To evolve high yielding varieties suitable for Kuttanad conditions. The trial projects, that they are underway at Monkompu have to be enlarged in scope and extent. In these new experiments, the specific problems such as

Seed dormancy,

Acid resistance.
Deep water and flood resistance.
Disease and pest resistance
Medium duration, semi tall and
non-lodging types

have to be be particularly taken into account.

b) Segregating populations of paddy and other crops from other research stations will be tested for adaptability and yield.

c) Screening of high yielding varieties produced in other stations including other states for adaptability and yield.

d) Surveillance study in the quality of seed material to ensure that genetically pure seeds are cultivated by the farmers.

5.7. Project III. To study the growth and production of paddy as influenced by environmental conditions.

The objective is to study the physiology of the paddy plant under changing environmental conditions and to see how such changes affect the gross growth and production.

Paddy will be sown in test plots according to the cropping plan in Kuttanad and experiments will be repeated, at four different areas of the region. The high yielding varieties popular in Kuttanad will be used as the test varieties.

The following characters will be studied by the collection of data at an interval of ten days from sowing.

1. Root growth: Weight and length of the root system.
2. Leaf: Number, area, weight.
3. Leaf Area Index.
4. Tillers: Number, Type
5. Flag Leaf: Area.
6. Panicle: Time of formation of the primordium and emergence, spikelet number, sterility, grain number and weight.
7. 1000 grain weight.
8. Total grains.
9. Total straw.

The conditions of the fields, soil analyses, water, aeration, pH etc. will be ascertained.

5.8. The other environmental factors like precipitation, humidity, wind velocity, temperature, photoperiod, intensity of sunlight, etc. also will be measured.

5.9. Facilities required:

Land: Main stations - 1.5 ha
3 sub-stations - 0.5 ha } 3 ha.

Laboratory:

A complete laboratory with facilities for conducting plant breeding work and plant physiolog y and systematic botanywork is essential. Equipment like microscopes, microtomes, pH metres, incubators, ovens, flame photometers, spectrophotometre, digestive chambers, water still, deionizer, chromatograph, warburg apparatus etc. are required. A complete meterological station will be established at the main station with facilities for weather forest for farmers.

5.10. Staff: The following staff is required for the implementation of the projects.

1. Assistant Professor (Rs.600-1200) - 1
2. Instructors (Rs.510-995) - 2
3. Field Assistants (Rs.230-385) - 2

5.11 Expenditure Statement (Botany)

	Ist Year Rs.	IInd year Rs.	IIIrd year Rs.	IVth year Rs.	Vth year Rs.	Total Rs.
I. Pay and allowances						
(i) Asst. Professor (Rs.600-1200)-1	11,405	11,840	12,245	12,750	13,240	61,480
(ii) Instructor (Rs.510-995) - 2	19,210	20,305	21,115	22,090	22,980	1,05,700
(iii) Field Assistants (Rs.230-385)-2	9,570	9,780	10,050	10,320	10,630	50,350
	40,185	41,925	43,410	45,160	46,850	2,17,530
II. Travelling allowance	5,000	5,000	5,000	5,000	5,000	25,000
III. CONTINGENCIES						
(a) Laboratory equipment	10,000	5,000	5,000	5,000	5,000	30,000
(b) Books and Periodicals	1,500	500	500	500	500	3,500
(c) Office furniture and stationery	6,000	2,500	2,500	2,000	2,000	15,000
(d) Other contengencies	5,000	5,000	5,000	5,000	5,000	25,000
	22,500	13,000	13,000	12,500	12,500	73,500
Total	67,685	59,925	61,410	62,660	64,350	3,16,030

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6. ENTOMOLOGY AND RODENT CONTROL

61. This subject deals with the study of control of diseases and damages caused by insects, rats etc. Due to the changes in the natural conditions like continuous availability of fresh water more exposure of the soil surface and change in the cropping pattern there will be consequent changes in the habits, life cycle, multiplication rates, infestation pattern and food habits of insects and rodents. The changes in the flora and the pattern of growth of the flora will directly modify the habits of the fauna also. Due to the lowering of the water level the bunds get exposed more and this will lead to rapid multiplication of rodents and this needs immediate attention.

6.2. Rodents form an important class of pests in Kuttanad. The Indian mole rat or the lesser bandicoot, Bandicoota bengalensis appears to be the main species infesting the paddy fields of Kuttanad. Elsewhere in other parts of the country this rat is observed to cause damage to rice at all stages of its growth. This damage is done to the shoots in the beginning, then to the milky pulp of the earhead, and finally to the ripened earhead. It makes burrows in the field mostly in the bunds and these burrows are extensive going to the depth of about one metre. It also forms distinct run-ways through densely growing paddy. It is possible that other species of rats also damage crops in these areas. As the change in the present eco-system is going to be a permanent feature in Kuttanad it is necessary to undertake some advance studies to understand properly the rodent problem in Kuttanad in general and its control.

6.3. Objectives: Control of pests is a major problem facing rice cultivation in Kuttanad. Even on the single crop which is mostly being raised at present the incidence of pests is of a high order. There are also indications of the possibility of the acceleration of this problem with the adoption of multiple crop patterns. The present proposal is for studying the changes in the patterns of pest infestations which will take place with the changes in the cropping patterns envisaged under the land development programme for Kuttanad and to evolve suitable pest management systems.

It will also be necessary to conduct studies on two more connected aspects, viz.

(a) Control of the crop pests involving the minimum use of pesticides, and

(b) Role of pesticides in the environmental pollution in Kuttanad.

For the first aspects, an operational research programme sponsored by the I.C.A.R. has already started functioning in Kuttanad. Studies on the second aspect is to be taken up by the Department of Agricultural Chemistry.

6.4 Technical programme

6.4.1. (1) Assessment of the pest populations in crops raised in different seasons in different parts of Kuttanad

Pest counts will be made at weekly intervals on crops in three areas in Kuttanad representing the upper, middle and lower Kuttanad regions. Light traps will be used for rice stem borer, gall midge and Brown Plant Hopper. Sweeping nests will be used to take counts of such pests as leave hoppers, swarming caterpillars, hispa, case worm etc. Counts in sampled areas of paddy fields will be undertaken for four years continuously. Analysis of the data with respect to the region, season, crop stage, climate etc. will be made during the 5th year.

6.4.2. (ii) Studies on the rodent population and control

(a) Survey and identification: Rats will be collected from different parts of Kuttanad at different periodsof the year and got identified at the Zoological Survey of India, Calcutta.

(b) Population fluctuations: The population fluctuations of rats in the fields during different periods of the year will be studied by catching the rats in traps.

(c) Biology and habits: These will be studied in rat cages and ratteries constructed for the purpose.

(d) Control: Use of traps, poison baits and burrow fumigation for controlling the rats will be ascertained by field trials. The use of stepped down electric current for controlling rat population will also be tried.

6.5. Location

The work can be undertaken at the Rice Research Station, Monkompu for which additional facilities are to be provided.

6.6. Staff: The following staff is necessary for the successful implementation of these projects.

1. Assistant Professor (Rs.600-1200) - 1
2. Instructors (Rs.510-995) - 2
3. Field Assistants (Rs.230-385) - 4

6.7. Expenditure Statement (Entomology and Rodent Control)

	Ist year Rs.	IInd year Rs.	IIIrd year Rs.	IVth year Rs.	Vth year Rs.	Total Rs.
I. Pay and allowances						
(i) Asst.Professor(Rs.600-1200)-1	11,405	11,840	12,245	12,750	13,240	61,480
(ii) Instructor (Rs.510-995)-2	19,210	20,305	21,115	22,090	22,980	1,05,700
(iii)Field Assistants (Rs.230-385)-4	19,140	19,560	20,100	20,640	21,260	1,00,700
	49,755	51,705	53,460	55,480	57,480	2,67,880
II. Travelling allowance	7,000	7,000	7,000	7,000	7,000	35,000
III. Contingencies						
(a) Laboratory equipment & chemicals	10,000	5,000	5,000	5,000	5,000	30,000
(b) Books and periodicals	1,500	500	500	500	500	3,500
(c) Office furniture & stationery	6,000	2,500	2,500	2,000	2,000	15,000
(d) Other contingencies	5,000	5,000	5,000	5,000	5,000	25,000
	22,500	13,000	13,000	12,500	12,500	73,500
Total	79,255	71,705	73,460	74,980	76,980	3,76,380

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7. MICROBIOLOGY AND PLANT PATHOLOGY

7.1 The science dealing with biological activities of microbes as applied to agriculture is known as, microbiology. Plant Pathology deals with study of diseases in plants caused by microorganisms.

7.2. The change in ecosystem changes the environmental conditions of the soil like submergence, exposure, chemical and physical properties of soil. These changes will modify the type and quantity of the microbes in the soil. These changes may modify the flora. The change in the flora may stimulate development of new and uncommon varieties of pathogenic microbes, which in turn may cause a variety of diseases now not prevalent in the area. It will not be possible to predict the exact impact on non-saline conditions. The change may be gradual and no immediate flaring up of diseases can be expected. However microbiological investigations of these soils periodically over a few years will help to throw light on the nature of changes undergone by the organisms as a result of the changes undergone by the soil during the same period. For a study of such changes the following projects in microbiology are suggested.

7.3. Study of the microbial population of the soil and water in relation to the crops grown

In future attempts will be made to grow two crops of paddy and a third crop of legume in the Kuttanad area. It is well-known that the crops grown will have their effect on the microbial population of the soil. Hence areas representing the karapadam, kayal and kari lands will be marked out and soil and water samples collected at regular intervals. Qualitative and quantitative estimates of the organisms in these soils and water will then be carried out. The effect of soil depth and the fluctuations in water table will also be studied. Further, studies will also be made of the rhizosphere and phyllosphere organisms.

7.4. Study of nitrogen-fixing organisms in Kuttanad

There are several species of organisms including bacteria, as well as algae, which enrich the soil by the fixation of nitrogen from the atmosphere. Some of these organisms can function only under aerobic conditions, while others can thriveeven under anaerobic conditions. Some require a nearly neutral soil reaction whereas some others can live and function even under conditions of high acidity. Hence it is considered desirable and necessary to carry out a systematic study of these useful organisms. For this, soil samples will be collected periodically from representative areas and nitrogen fixing organisms such as the azotobacter spp. isolated. Detailed studies of their morphological and physiological characters will be made. Attempts will also be made to prepare cultures of the more promising strains for the purpose of inoculating soils which are devoid of such bacteria.

7.5 Study of the effect of pesticide and weedicide residues on the soil microflora

It is obvious that the pesticide and weedicide residues in the soil will have an adverse effect on the soil microflora. Experiments will therefore be conducted to study the effect of the application of pesticides and weedicides on the organisms in the soil and the water. The studies will be undertaken in farmers' fields in which different plots will be treated with different plant protection chemicals, as well as weedicides. Soil and water samples will be collected periodically from the treated and the untreated (control) plots. Comparative studies of the microbial population of these different plots will throw light on the effect of pesticides and weedicides on their life and activity.

7.6. Duration: The studies will be initially for a period of five years.

7.7. Staff: The following staff structure is necessary for carrying out this study.

1.	Assistant Professor -	(600-1200)	- 1
2.	Instructors	(510-995)	- 2
3.	Fieldman/Lab.Assistant	(230-385)	- 2

Expenditure statement (Microbiology and Plant Pathology)

		1st year Rs.	2nd year Rs.	3rd year Rs.	4th year Rs.	5th year Rs.	Total Rs.
I. Pay and allowances							
1. Assistant Professor (Rs.600-1200)	1	11,405	11,840	12,245	12,750	13,240	61,480
2. Instructor (Rs.510-995)	2	19,210	20,305	21,115	22,090	22,980	1,05,700
3. Field Assistant (Rs.230-385)	2	9.570	9,780	10,050	10,320	10,630	50,350
		40,185	41,925	43,400	45,160	46,850	2,17,530
II. Travelling allowances		5,000	51,000	5,000	5,000	5,000	25,000
III, Contingencies							
1. Laboratory equipment		10,000	5,000	5,000	5,000	5,000	30,000
2. Books and periodicals		1,500	500	500	500	500	3,500
3. Office furniture & Stationery		6,000	2,500	2,500	2,000	2,000	15,000
4. Other contingencies		5,000	5,000	5,000	5,000	5,000	25,000
Total		22,500	13,000	13,000	12,500	12,500	73,500
Grand total		67,685	59,925	61,410	62,660	64,350	3,16,030

8. AQUATIC BIOLOGY

8.1 Aquatic Biology is the science dealing with the study of animal and vegetable life including micro-organisms in the water.

8.2 When the flow of sea water is prevented by the barrage the upper reaches will become a fresh water area and the whole environment changes. This will have a marked difference in the flora and fauna of the area. Migratory aquatic fauna is prevented from entry and exit into or from the area. The closure of barrage causes stagnation of the water and fauna and flora which depend on moving water for their requirements for growth will be adversely affected.

8.3 The future of migratory fish, crustaceans especially prawns are in danger in the area for which, as well as other changes, detailed investigations on a long range programme are essential.

8.4 The shutting off of the saline water will flare up the growth of the salvinia weed. Lack of movement of water increases the toxic concentration due to insecticides especially those in soluble pellet from, which may exterminate the fauna in the narrower channels.

The following studies are proposed.

8.5 Hydrographical studies in the Kuttanad region in relation to incidence and seasonal abundance of plankton

8.5.1 Six stations north of Thanneermukkom bund and six stations south of it will be selected for collection of water samples and plankton. Bimonthly collections will be taken from each station Surface temperature will be recorded and if possible, reversing water bottle will also be used for collection of water at different depths and for recording bottom temperature. The water samples collected will be analysed for the determination of salinity, oxygen content, pH, and nutrients such as phosphates, nitrates and silicates. A study of the plankton in relation to the physico-chemical properties of the water for three years will form data for arriving at possible correlation on physico-chemical factors in relation to plankton.

8.5.2 The investigation will be carried out by the Senior Research fellow with the help of a Junior Research Fellow (Chemist), the technical assistants and fieldmen.

8.6 Investigations on crustaceans of the Kuttanad region

8.6.1 The prawn or 'Chemmeen' caught in large numbers in the back waters represents certain stages in the

'Kadal Konju'. Though called marine prawns, they migrate into the lakes temporarily for short seasons and the prawns which are found in the Kuttanad back waters are the submature adults of the marine prawns. They breed in the sea and move along the coast to enter the back-waters where they scatter in search of shallow regions, which are used for Punja cultivation of paddy. The inward migration of the young prawns is concurrent with the breaching of the bunds of the paddy fields, so that with energy flow tide the prawns enter these fields in large numbers. They feed on the decaying stumps of harvested paddy, other organic debrics and small aquatic weeds.

8.6.1 By the end of May, when the fresh water from the flooded rivers reduces the salinity of the lake water considerably, the small prawns move away from the shallower parts. Their reproductive organs also show signs of development and this physiological change stimulates an inner urge towards the sea, After an absence of some 9 months the outward migration towards the sea begins. The maximum intensity of this migration is observed during October and November. Subsequently the shoals become smaller and smaller and cease altogether by the middle of April. In the sea they grow rapidly till they reach a length of six to seven inches.

8.6.2 From the above it is clear that there should be no barrier in the lake for the uninterrupted migration of prawn larvae into the back water and the migration of the maturing prawns from the backwaters into the sea for breeding. The effect of the Thanneermukkom bund on the biology of these crustaceans will have to be examined with a view to finding ways and means of conservation and management of this fishery which brings in considerable foreign exchange.

8.6.3 One Junior Research Fellow will carry out the investigation assisted by the fieldmen.

8.7 Survey of fish and fisheries of the Kuttanad region

8.7.1 Kuttanad possessed excellent fisheries nearly a decade ago, but year by year they have declined and important food fishes which were at one time found in plenty have almost disappeared. The ruin of the Kuttanad fisheries is largely due to: (1) the catching of fish during the breeding and migrating seasons; (2) the destruction of the spawning grounds, (3) the destruction caused by 'madavalas' during the dewatering of paddy fields and (4) the destruction of eggs and larvae and perhaps also due to other manmade changes especially pollution. Twenty seven species of fishes have been recorded from the Kuttanad region by the Department during a survey of the backwaters but as yet we do not have detailed accounts of their distribution, feeding habits and spawning behaviour and their reactions to the altered conditions consequent on the construction of the bund. Exotic fresh water fish will be introduced after careful study of

the ecology. (Eg. Carps, Catla, Rohu) The possibilities of using the insect pests as useful food for frogs and fishes in special farms will also be tried. Experimental fish and frog ponds will be formed in selected areas in paddy fields with suitable light traps for insects which will form the food of frogs and fish. The possibility of raising frogs and fish in this way will be tried-

8.7.2 One Junior Research Fellow will investigate into this aspect and he will be assisted by the Technical Assistants and fieldmen

8.8 Study of the benthos of the Kuttanad region

8.8.1 The study of the benthos (the flora and fauna of lake bed) of Kuttanad which represents the secondary production and an important link in the food chain of the Kuttanad area will be examined in relation to the general tropic picture of the back-water ecosystem. This study is of great importance in relation to the food of both prawns and fishes.

8.8.2 Monthly collections of bottom fauna and bottom deposits will be taken from all the 12 stations selected for hydrological and plankton studies. In all cases the bottom deposits will be graded with the help of international sieves and the calcium carbonate content and other nutrient components will be examined in relation to grain size of the substratum. The bottom fauna will be collected from each of the stations with a beam trawl and dredge. Special emphasis will be given for a survey of the lime shell resources of Kuttanad region. The stoppage of the free flow of salt water into the lake will have a marked influence on the breeding of Veloritta, Meretrix, Arca, Ostrea and Cynena and ways and means of reviving the lime shell industry will be chalked out.

8.8.3. This scheme will be carried out by 2 Junior Research Fellows assistee by the fieldmen.

8.9 The problem of salvinia

8.9.1 Salvinia, the exotic aquatic fern accidentally introduced into this State, has of late, become a very serious menace paralysing water transport, hampering fishing and shell collection, preventing agricultural operations and choking the turbines of generators in hydro-electric projects. Drawing up all available nourishment from the water in which they live, these weeds have laid waste vast areas of excellent fishing grounds and paddy fields. This weed is in fact threatening the very means of livelihood and the basis of economy of several areas of south and central Kerala. A large number of organisms is closely associated with this floating fern community including several species of fish which use them as food.

8.9.2 It is therefore contemplated to examine the various organisms which feed on this weed and also the various conditions under which it lives. A detailed study will be undertaken to study the effects of chemicals, pesticides and salt water on the biology of this fern.

8.10 Staff

This problem will be worked out by a Junior Research Fellow (Botany) assisted by the Technical Assistants and fieldmen

8.11. Expenditure statement

Purpose	1st year	2nd year	3rd year	Total
1. One Senior Research Fellow @ Rs.600/-p.m	7,200	7,200	7,200	21,600
2. Six Junior Research Fellow @ Rs.400/-p.m	28,800	28,800	28,800	86,400
3. Two Technical Assistants @ Rs.250/-p.m	6,000	6,000	6,000	18,000
4. Two Fieldmen @ Rs.175/-p.m.	4,200	4,200	4,200	12,600
5. Hydrographic equipment, dredgers, trawlers and 6 Nos.microscopes.	1,10,000	25,000	7,000	1,32,000
6. Chemicals and glassware	10,000	10,000	10,000	30,000
7. Collection charges including hire charges of boat	12,000	10,000	10,000	32,000
8. Travelling allowande	5,000	5,000	5,000	15,000
9. Unforeseen contingencies	5,000	5,000	5,000	15,000
	1,78,200	1,01,200	83,200	3,62,600

9. HYDROLOGY AND GROUND WATER

9.1. This subject deals with study of surface and ground waters.

9.2 The availability of water of proper qualities in proper quantities at the proper time is essential for the proper growth of the plants. The soil shall contain water in optimum quantities for utilisation by the plants. If the water level in the soil is too low or too high the plants may wither or decay as the case may be

9.3 When the water level in the water courses changes due to the changed conditions the availability of water for the root to get at the water may be difficult or may be submerged. In both cases the plants may be adversely affected and damages will be caused in the whole area.

9.4 By the lowering of water level due to the absence of in-flow both from the upstream and from down stream, drought conditions may prevail which has to be immediately rectified by finding alternate arrangement for in-flow of water into the area to raise the water level. During 1975-76 the Thanneermukkom bund was closed during the crop season. The in-flow from the rivers dwindled during summer. So also the inflow due to tides also was completely cut off, so much so the evaporation and evapo-transpiration from the water-surface and field could not be compensated. As such the water level had gone down considerably. The adverse effects observed and possible are:-

9.4.1 Lowering of water level in the water courses to such an extent that nagigation of country boats in the smaller water courses were rendered impossible.

9.4.2 The movement of water was completely stopped. This caused the salvinia and other aquatic plants to remain in one place and multiply fast rendering chocking up of the narrower canals.

9.4.3 The usual practice in Kuttanad is to dump wastes into the water courses. Human refuses (sewage) and other waste materials when deposited into the water courses remained there itself polluting the area and atmosphere. So also the water containing dissolved insecticides when pumped out or drained into the water courses remained stagnant and increased the pollution. The reduced quantity of water due to lowering of water level also increased the concentration. The local people who were using this surface water for bathing washing etc. found it difficult to live with it. It is reported that in some places fish also died in large numbers due to the toxicity.

9.4.4 The water in surface wells also may get polluted due to the pollution of the water.

9.4.5 The lowering of water levels will lower the water levels in surface wells which may, due to higher concentration of salt in lower layers, render the well water more saltish.

9.4.6 The sub soil water level in the elevated land in Kuttanad and upper Kuttanad will go down affecting the perennial and seasonal crops. In some of the padasekharams it was not possible to let in irrigation water by gravity, instead had to be lifted by some methods. In Upper Kuttanad, due to lowering of subsoil water, the plants may not get get water in their root zone. This may necessitate alternate irrigation facilities.

9.4.7 Due to stagnation fine sediments may settle down and siltation of water courses is possible. But the rate will be very slow to affect the navigation etc.

9.4.8 There may be other effects due to the change in the hydrological aspects due to the changed conditions. There is a proposal to direct water from Movattupuzha river during summer to Kuttanad area through Vadayar and Puthenthodu. This will help to regulate the water level in Kuttanad.

9.5 All the above aspects require detailed study.

The studies can be broadly classified as:

1. Water level variations
2. Quantity of water to be diverted from Moovattupuzha river
3. Ground water changes in higher ground in and around Kuttanad.
4. Other connected matters.

9.6 The studies shall be conducted continuously for at least five consecutive years and later continued in some aspects. There is already some data being collected by the Irrigation wing of the P.W.D.

9.7 Staff and equipment

The Executive Engineer, Irrigation Division, Alleppey may direct the studies. Following additional staff may have to be posted to assist him.

1.	Assistant Engineer (Rs.560-1100)	- 1
2.	Junior Engineer (Rs.465-775)	- 2
3.	Overseer, Gr.II (Rs.255-455)	- 2
4.	Lascars (Rs.196-265)	- 4

Self recording guage (25 Nos) will have to be installed in the Kuttanad area.

Hydrology

9.8 Expenditure Statement (Hydrology and Ground water)

Items	Ist year Rs.	IInd year Rs.	IIIrd year Rs.	IVth year Rs.	Vth year Rs.	Total Rs.
I. Pay and allowances						
(i) Assistant Engineer (Rs.560-1100) - 1	10,600	11,030	11,530	12,000	12,550	57,710
(ii) Junior Engineer (Rs.465-775) - 2	17,600	18,350	19,100	20,050	20,800	95,900
(iii) Overseer, Gr.II (Rs.255-455) - 2	12,300	13,000	13,400	13,900	14,500	67,100
(iv) Lascar (Rs.196-265) - 4	13,440	13,650	13,900	14,100	14,300	69,390
	53,940	56,030	57,930	60,050	62,150	2,90,100
II. Travelling allowances	7,000	7,000	7,000	7,000	7,000	35,000
III. Contingencies						
(a) Books and Periodicals	1,500	500	500	500	500	3,500
(b) Office furniture and stationery	6,000	2,500	2,500	2,000	2,000	15,000
(c) Other contingencies including cost of equipment	10,000	5,000	5,000	5,000	5,000	30,000
	17,500	8,000	8,000	7,500	7,500	48,500
T O T A L	78,440	71,030	72,930	74,550	76,650	3,73,600

10. CONCLUSION

10.1 Detailed research programmes for the study of changes effected by the change in eco-system, and to evolve remedies for the adverse effects if any have been formulated and explained in the preceeding portions of the report. The research programmes have to be located at Moncompu, where there is a research cum experiment station under the Kerala Agricultural University. Additional facilities will be provided in this station for the efficient research worksto be done as per this report.

10.2 The works done by scholars in each discipline shall not be a waste, and shall not overlap. To avoid such things and to give proper direction and guidance a Coordinator for the research programme is essential. A person which technical excellence and administrative experience and maturity will be most suitable. I suggest that a Senior Professor with an inquisitive mind and capacity to do hard work will be suitable. A Professor is suggested because the Professor will give technical guidance and direct the research.

10.3 To assist the Professor a small staff, say Stenographer, a Clerk and a peon will suffice. There should also be an Advisory Committee consisting of experts from all disciplines to advise him. The success of the scheme will depend on the ability of the Coordinator.

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10.4. Expenditure Statement (Head Quarters)

Items	Ist year Rs.	IInd year Rs.	IIIrd year Rs.	IVth year Rs.	Vth year Rs.	Total Rs.
A. Recurring						
I. Pay and allowances						
(a) Project Co-ordinator (Rs.1100-1600).	19,480	20,155	20,830	21,505	22,180	1,04,150
(b) Stenographer (Rs.230-385) - 1	4,455	4,590	4,725	4,860	4,995	23,625
(c) Clerk (Rs.230-385) - 1	4,455	4,590	4,725	4,860	4,995	23,625
(d) Peon (Rs.156-265) - 1	3,780	3,834	3,888	3,942	3,996	19,440
	32,170	33,169	34,168	35,167	36,166	1,70,840
II. Travelling Allowance	10,000	10,000	10,000	10,000	10,000	50,000
III. Contingencies						
(a) Office furniture and stationery	10,000	5,000	5,000	3,000	3,000	26,000
(b) Other contingencies	5,000	5,000	5,000	5,000	5,000	25,000
Total recurring	57,170	53,169	54,168	53,167	54,166	2,71,840
B. Non-recurring						
Building	2,50,000	-	-	-	-	-
T O T A L	3,07,170	53,169	54,168	53,167	54,166	5,21,840