Thesis Component I

Unit - I

Genesis of the present analytical and experimental optimization Study

" We only think when we are confronted with a problem ".

- John Dewey.

I. Literature Screening :

After the conception of the idea to conduct investigatory and analytical studies in Rural Ecology, interest of the author in rural ecosystems was further enhanced, by discovering a distinct lacuna in our knowledge of rural ecosystems in India. There was no study available to form the basis on which further research programme could be planned. To make sure, a thorough literature review of ecological research in India was done. The author had to conclude on the basis of the literature review done at number of research centres in India including the ecology school of Varanasi that most of the studies in India were autecological in nature. However, it is not desirable to substantiate the review findings here due to the pressure of space as well as remote relevance to the present work. A number of Ph. D. theses have been submitted on the autecology of various plant species which have contributed significantly to our knowledge of the eco-behaviour of the component species in the ecosystem (Asana, 1950; Choudhary, 1967; Agarwal, 1970; Dwivedi, 1970; Chawan, 1971; Jain, 1971; Mall, 1971; Ambasht, 1972; Marwah, 1972; Nayar, 1972; Vyas, 1972; Kothari, 1973; Amritphale, 1976).

Some studies dealing with the forest ecosystem have also been done mainly on the aspects of energetics, mineral

circulation and production ecology (Misra, 1959; Misra, 1967; Singh, 1967; Misra, 1968; Misra, 1970; Chawan, 1971; Pandeya, 1971; Pandeya, 1972; Satyanarayan, 1972; Singh, 1972). Qualitative analysis and floristic aspects of forests have been worked out well by Sabnis (1967), Pathak (1975) and other workers. Grassland studies have also been done by various authors in Ujjain, Sagar, Varanasi and Rajkot (Agarwal, 1970; Gupta, 1971; Mall, 1971; Misra, 1971; Ambasht, 1972; Misra, 1972; Pandeya, 1972; Varsheney, 1972; Vyas, 1972; Misra, 1973; Misra, 1973; Pandeya, 1974; 1977). Crop ecology has received attention at some of the research centres (Asana, 1950, 1965; Dwivedi, 1970; Singh, 1971; Kothari, 1972; Misra, 1972, 1973, 1974; Singh, 1974; Amritphale, 1976; Lulla, 1976; Sen, 1976).

It is of interest to note that some of the Indian ecologists have now turned their attention to the studies on evaluation of human impact on forest ecosystem under the Man and Biosphere (MAB) Projects.

Recently Pandeya et al. (1977) made some attempts to study a semiarid village ecosystem in the systems' context. The study is very fascinating and deals with the quantitative data of a grazing land research plot in Khirasa village of Saurashtra. However, all the components and interactional processes are investigated in detail qualitatively and quantitatively, for grazing land ecosystem and environment.

The authors have attempted to present the functional model of the ecosystem. The study though quite informative deals with grazing land ecosystem analysis with emphasis on abiotic compartment of the ecosystem. There is no reported study dealing with the rural ecosystem with estuarine agricultural environment. It is necessary to point out here the poverty of Gujarat forests (only 4% of land area is under functional forest) for this reason almost all the rural ecosystems in the state are devoid of any forest cover and possess agricultural environment. However, scattered vegetational localities are encountered in many rural ecosystems in the state.

This lack of information and studies so evident from the screening of the literature prompted the author to undertake an analytical investigation of rural ecosystem with estuarine agricultural environment. As has been pointed out earlier that each of the rural ecosystem poses specific problems and potential for development and optimization - the research supervisor of this project suggested a 'micro-level' analysis of individual rural ecosystem as a 'unified' unit.

II. Micro-level analysis :

It is needless to emphasize again the necessity of the analytical studies of each of the rural ecosystem districtwise

due to the structural, functional and interactional specificities. Hence, it was decided to conduct the analysis of each component unit of the entire ecosystem chosen for the study. This type of analysis comes under the 'micro-level' analysis where in each component is subjected to all the analytical procedures (discussed in Thesis Component I - Unit II) and the data on that specific ecosystem is generated. Our concept of micro-analysis of rural ecosystem emerged after the survey of many rural ecosystem areas in Gujarat state in 1972-1973 period.

However, it is of interest to note that in the recommendations of the high level committee during 63rd Session of Indian Science Congress held at Waltair in 1976 which discussed the focal theme on 'Science and Integrated Rural Development' the need for micro-analysis of data regionwise has been quite well emphasized. The committee headed by Dr. Swaminathan, Director General, ICAR points that all the data available on climate, resources, health and nutrition are based on macro-level observations. The high level expert sub-committee on 'Science and Rural Development' has suggested that hereafter, the approach will have to be more intensive micro-level identification and analysis of rural areas and problems and potentials for optimization.

These recommendations of Indian Science Congress Association (1976) have substantiated our concept of micro-level-rural ecosystem analysis which had emerged as early as 1972-1973 during our intensive and extensive preliminary survey of rural ecosystem areas in Gujarat.

III. Grass-root level strategies of development and optimization :

Preliminary survey (1972-1973) revealed the fact that rural ecosystems have differential potential for optimization and development. Hence no central or regional planning done without any regard to the specific-rural ecosystem assets and environment both edapho-physical and economic can be useful. Any strategy to develop and optimize a particular rural ecosystem, must take into account in an extensively comprehensive manner the micro-level-analytical data to be viable in the ecological sense of the term. It seems imperative that any optimization approach or programme will have to be evolved at the grass-root level. These conceptual foundations of our preliminary survey are further substantiated by the reports of National Commission on Agriculture (Sud, 1977). An agro-ecosystem optimization case study was therefore, planned during the present investigation to indicate the utility of strategies developed at the 'grass-root' level.

IV. Selection Survey :

After completing the preliminary surveys of rural ecosystem areas in Gujarat, it was decided to make a selection survey of 'research rural ecosystem area' taking into considerations the resources available for the doctoral project at the Department of Botany and the practicability of conducting research. The considerations included the following major points :

(i) distance of selected rural ecosystem [illegible] (as there is no vehicle available and the dependence is solely on the State Transport),

(ii) nature of the rural ecosystem (developed or underdeveloped as decided by Taluka authorities),

(iii) whether the rural ecosystem has any specific problem areas that need attention?

(iv) whether the micro-level analysis and data generation will have any utility?

To begin with Survey of Baroda district rural ecosystem areas was made. After an extensive survey, finally the Estuarine Rural Ecosystem Complex at Chokari (Taluka Padra) was selected. The criteria of selection were :
(PLATE 2).

Plate - 2: Map of Taluka Padra indicating the geographical location of the estuarine rural ecosystem at Chokari which was selected for the present research investigations.

The hierarchical position of the ecosystem area is indicated by including the boundary maps of India, Gujarat, Baroda District and Taluka Padra.

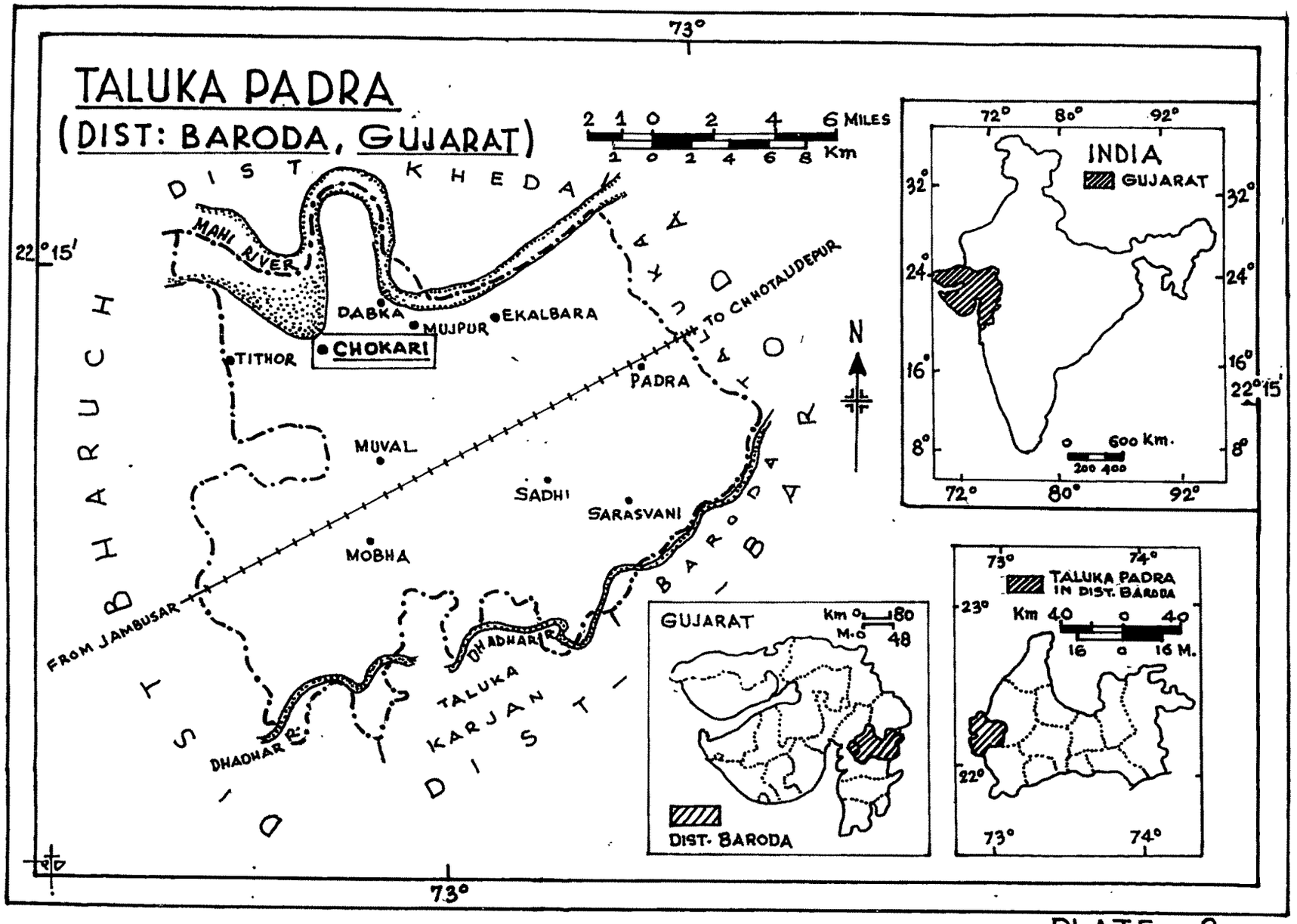

TALUKA PADRA
(DIST: BARODA, GUJARAT)
73°
2 1 0 2 4 6 MILES
1 0 2 4 6 8 Km
DIST KHEDA
MAHI RIVER
22°15'
DABKA
MUJPUR
EKALBARA
CHOKARI
TITHOR
TO CHHOTAUDEPUR
PADRA
MUVAL
SADHI
SARASVANI
MOBHA
FROM JAMBUSAR
DHADHAR R.
TALUKA KARJAN
DIST BARODA
DIST BHARUCH
N
INDIA
GUJARAT
72° 80° 92°
32° 24° 16° 8°
0 600 Km.
200 400
GUJARAT
Km 0 180
M. 0 48
DIST. BARODA
TALUKA PADRA IN DIST. BARODA
73° 74°
23° 22°
Km 40 0 40
16 0 16 M.

PLATE - 2

(i) Chokari ecosystem area is underdeveloped and neglected ecosystem area according to the taluka authorities.

(ii) The ecosystem area can be reached by State Transport in all seasons (though the frequency of services is poor) except in monsoon season when the author had to go from Majatan (a nearby village) on foot.

(iii) The Chokari rural ecosystem area presented two distinct ecological zones for comparison. One of the zones was plain natural zone like all other rural ecosystems of the taluka. The other zone had saline edaphic complexes. This was the problem zone in need of optimization strategies.

(iv) One of the ecological zones of rural ecosystem presented fluctuating estuarine environment. No work has so far been done in India on the optimization estuarine agro-ecosystems which face salinity problems in edaphic complexes.

(v) There is agricultural environment as there is no forest subsystem in this rural ecosystem (which did not add to the complexity of the rural ecosystem for analytical purposes.)

(vi) The officials of the village panchayat, gram sevak,

and sarpanch were very cooperative (this being very essential in ecosystem studies).

(vii) There is no information scattered or compiled available on Chokari ecosystem area and hence the data generated during this project would prove useful not only for the ecological research work but also for Taluka Development Officials and the State Governmental Officials in the Departments of Agriculture, Revenue, Land Development and Public Welfare.

A general account of the estuarine rural ecosystem with agricultural environment and saline edaphic zones is presented in the Thesis Component I - Unit 3.

V. Challenge (Approaches for the present work):

As there was no study of this kind in Rural Ecology available in India and the other developing countries (a few preliminary accounts of Otto Somoerwotto (1974) and a case study of Pandeya et al. (1977) are now available) at the time of the genesis of the present work, the author was faced with a challange to develop the approaches for qualitative analysis of the rural

ecosystem areas. The generation of Ecosystem Analytical Description Inventory - a tool generated and assembled by the author has been discussed in Thesis Component I - Unit II.

Thesis Component I

Unit - II.

Approaches used in the present work :

(A) Approaches pertaining to Ecosystem Analysis.

(B) Approaches pertaining to Ecosystem Optimization.

" Our Age of Anxiety is, in great part, the result of trying to do today's job with yesterday's tools - with yesterday's concepts".

- M. McLuhan.

(A) Approaches pertaining to Ecosystem Analysis

I. Analytical Ecology :

A Clapham Concept :

Professor A. R. Clapham (1965) the noted British ecologist and thinker has pointed out that the ecologists of the future will have to concern themselves with the basic issues of finding methodology to optimize the efficiency of land utilization for raising plants and animals for food as well as other purposes. He terms this approach 'Analytical Ecology' - wherein the qualitative and quantitative analysis is to be incorporated. This concept of 'Analytical Ecology' is equivalent to the concept of 'Systems Ecology' using 'systems' approach to ecological studies (Nelson, 1966). The concept of 'Analytical' ecology involving the qualitative and quantitative analysis as proposed by Clapham (1965) has been the basis of the present work. The integrative and segregative (i.e. holological and merological) approaches have been also highlighted for creating a proper perspective of evaluation of the approaches and the methodology used in the present investigation.

I. 1. The holistic (holological) Concepts and Ecosystem Analysis :

The ecosystem is the central theme and most important

concept of ecology (Odum, 1971). This is only the practicable unit of study of the complex biosphere. The study of ecosystem is complex and multifactorial. To really comprehend the complexity of any ecological system, the necessity of making an inventory of the 'entire' ecosystem hardly needs any emphasis. The ecosystem has to be studied as a 'unified whole'. There is however, another approach put forth by Stephen Forbes (1887) as quoted by Odum (1971) in which the parts of the system are considered and then a "unified picture" of the whole is built from the parts. This is merological approach. Odum (1971) however advocates the integration of two approaches viz. the holological approach and the merological approach. It is here that the 'system' approach becomes essential. In this connection Watt (1966) says if we are to study an ecosystem as a 'whole' system and not just collection of fragments, we must by strategy of research, which at every step is redesigned in terms of the problem fitting, integrate all the fragments together correctly at the end of research programme. Thus it is evident that there is need of holistic approach for analysis of complex interactions of the ecosystem. It may be pointed out that some or all aspects of an ecosystem might have been earlier worked out separately and vast literature might be existing, but then, as clearly stated by Glass (1964) "the vastness of scientific literature makes

the research for general comprehension and perception of new relationships and possibilities every day more arduous".

According to Dale (1970) 'System Approach' and 'System Analysis' is the use of scientific method with conscious regard for the complexity of the objective study as the system is a collection of interacting entities. Watt (1966) points out that system simulation, system optimization and system measurement are other facets of this approach. It is necessary to stress here that analytical modelling of ecosystem becomes essential when the systems approach is to be used in studies of Complex interacting entities (Watt, 1966).

II. The nature of Analytical Ecological Models :

The process of translating physical or biological concepts about any system into a set of mathematical relationships is the basis of systems quantitative analysis (Odum, 1971).

However, the extensive use of 'verbal' or 'picture' models is done in ecological research (Odum, 1971). The ecological model is built by the mathematical approaches for the quantitative vectorial analysis (Holling, 1966).

It is to be stressed here that the information about the

qualitative aspects of ecosystem is a pre-requisite before dynamic quantitative modelling can be attempted.

II. 1. Generating an Analytical Qualitative Model (AQM) :

To establish any qualitative model is basic step in ecological modelling for further ecosystem analysis. This has been done by the following four processes :

(1) hierarchical analysis of ecosystem (Simon, 1973)

(2) compartmentalization of ecosystem (Odum, 1971)

(3) Qualitative Compartmental Analysis (Otto Somoerwotto,1974)

(4) Model Synthesis (Patten, 1966; Watt, 1966; Odum, 1971; Simon, 1973).

According to Odum (1971) the ability to describe and predict the behaviour of ecological systems by the use of models depends largely on a principle of all systems : that of hierarchical organization or the principle of integrative levels. The importance of component analysis, however, cannot be minimized (Clapham, 1965). The compartmentalization of the systems is essential to obtain data on the component parts that contribute to the functioning of the 'unified' whole.

The qualitative analysis of each of the components of the compartments is essential before model could be finally synthesized.

As it is necessary to have the complete information and data on all the constituent components of ecosystem an attempt has been made to develop an ecosystem analytical description inventory. It is needless to state here that all the ecosystems can be first put into qualitative 'descriptive model before making even an attempt to quantify the same'. (Clampham, 1965).

II.2. Developing Ecosystem Analytical Description Inventory (EADI)

Back drop :

According to Odum (1971) any ecological statement is an analytical descriptive model (word model) of complex ecosystem interaction. It is needless to point out the fact that quantitative mathematical modelling is subsequent outcome of the analytical descriptive model. To study any ecosystem from systems analysis point of view, the knowledge of its qualitative compartments and composition is essential.

Considering the above conceptual frame work, it was

decided to construct an analytical description questionnaire for ecosystem analysis for the present study which involves ecosystem analysis of rural milieu.

Otto Somoerwotto (1974) one of the pioneer workers of the Institute of Ecology Indonesia has developed a descriptive qualitative model for rural eco-complexes in Java. No such attempt has ever been made in India. To the best of the knowledge of the investigator, this is the first attempt in India to study a rural ecosystem as a unified whole from analytical point of view. Some attempts have been made by Pandeya et al. (1977) to study the village ecosystem in systems' context. However, the studies dominate abiotic and resource variables. The qualitative aspect and Human as well as biotically significant interactions have not received adequate attention.

Otto Somoerwotto (1974) has based his qualitative model on his observations and documentation services of the governmental structure.

To achieve a higher degree of objectivity, the author in the present study has attempted to generate an ecosystem analytical description inventory (EADI) which can be a useful tool in rural ecosystem analysis.

Man and Biosphere (MAB) Report No. 17 (UNESCO-1974) advocates the integration of the social sciences and survey methods for the analysis of ecosystem as a unified whole. The present analytical description inventory represents such an integration - as will be seen from the stages given below :

Sequential stages during the development of the Inventory :

I. Compartmentalization of Ecosystem.

II. Component - break up of Compartments.

III. Component Analysis methodology.

IV. Component information data sheet.

These four sequential stages are discussed below with reference to rural ecosystem at Chokari.

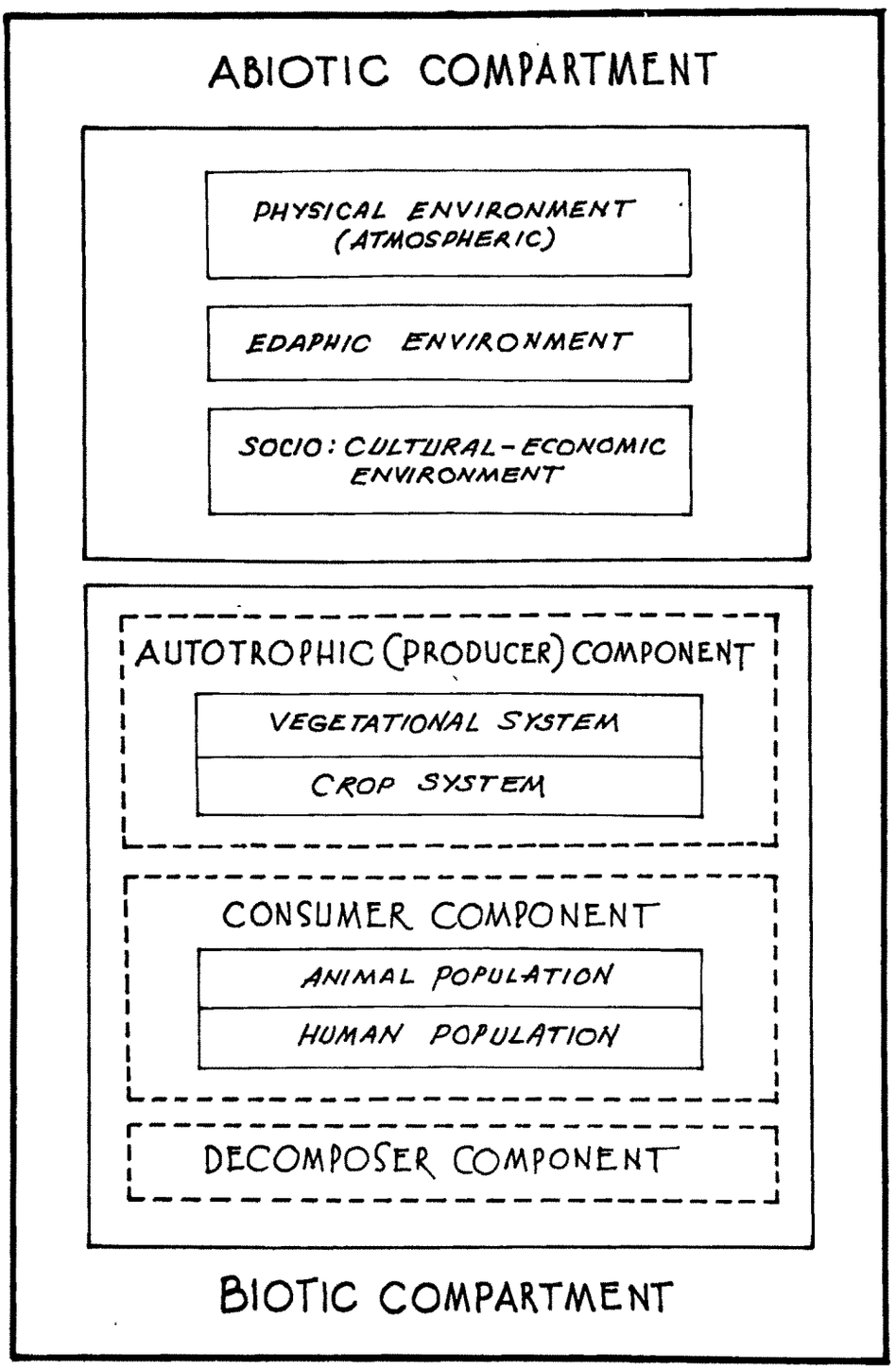
I. Compartmentalization of Ecosystem :

Any rural ecosystem, like all other ecosystem complexes can be compartmentalized into two main compartments : (PLATE 3)

(i) Abiotic Compartment,

(ii) Biotic Compartment.

Plate - 3 : Compartmentalization of the ecosystem and the hierarchical break up of component units of each of the compartment of ecosystem at Chokari.



ESTUARINE RURAL ECOSYSTEM – CHOKARI

PLATE - 3

II. Component break up of Compartments :

Further to the compartment classification, each compartment of the rural ecosystem can be further categorized into its constituent components :

ABIOTIC COMPARTMENT COMPONENTS

- Physical Environment (Atmosphere) Climate
- Edaphic Environment
- Socio - cultural - economic Environment

BIOTIC COMPARTMENT COMPONENTS

- Autotrophic (Producers) Component
  - Vegetational Systems.
  - Crop Systems.
- Heterotrophic Consumer Component
  - Animal Population.
  - Human Population.
- Decomposer Component.

III. Component Analysis methodology :

It is evident that the rural ecosystem is composed of very

diversified units in each of its components. Hence, the analysis of each of the component warrants distinctly different methodology and tools to obtain information of that particular component. The methodology followed for obtaining the information about the various components of Chokari rural ecosystem is discussed here. (PLATE 4).

It may be again recalled here that each ecosystem has its specific component constituents and therefore, needs the redesigned methodology in terms of the problem fitting (Watt,1966).

COMPONENT WISE METHODOLOGY DESCRIPTION :

Abiotic Compartment Components

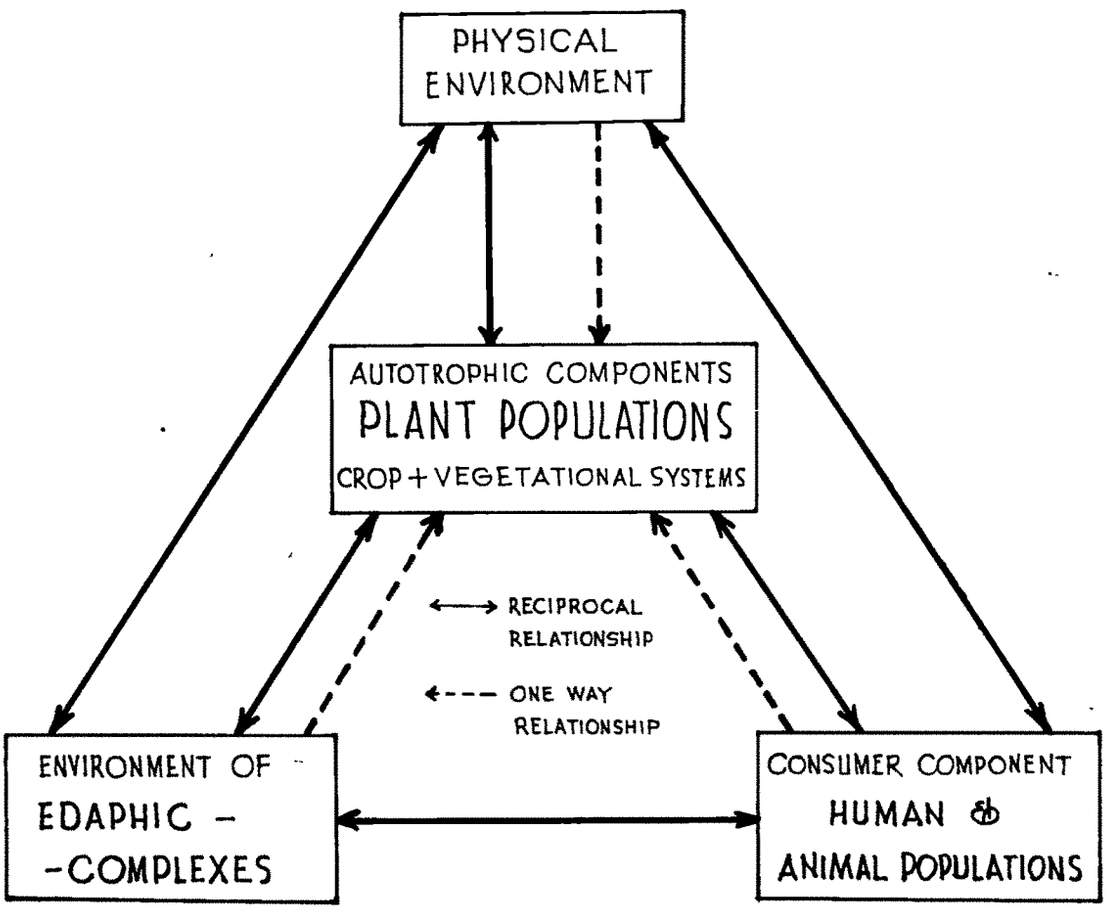
(1) Physical (Atmosphere) Environment :

The analysis of physical environment was carried out by the following two methods :

(a) Documented Record Analysis : The regional and district meteorological observatories were contacted to obtain the data on the macro-physical environment. The records were checked. Verified and then means of the requisite parameters

Plate - 4 : The eco-theoretical assessment of :

- the components of rural ecosystem at Chokari,
- the possible interactions (⟶) and impact relationship (- - - -→) between the components,
- this assessment was done at the time of conception of the present investigation.
- Plant populations are shown in centre due to their ecological status as 'Primary Producers'.



ECOSYSTEM COMPONENTS AT CHOKARI (INDIA)

PLATE - 4

were computed. The data collected in this way was verified with the reports of meteorological department.

(b) Instrumentation Analysis : The data on the micro-physical environment at taluka level and village level was collected by using the following instruments :

	Instrument	Parameter measured and method used
(1)	Centigrade Thermometer	Temperature (Weaver and Clements, 1928).
(2)	Thermograph	Temperature (Weaver and Clements, 1928).
(3)	Hair Hygrograph	Humidity (Weaver and Clements, 1928).

The standard methods of recording and observation were followed (Weaver and Clements, 1928). The agricultural department of the Government of Gujarat has an experimental station at Chokari ecosystem complex. The instruments of meteorological observation are kept in their enclosed plot. The data was analysed and computed for presentation as micro-physical environment.

(2) Edaphic environment :

(a) Instrumentation - Chemical Analysis :

The analysis of abiotic edaphic environment was carried out using standard methods of soil chemical analysis (Piper, 1944; Jackson, 1967; Misra, 1968; Pandeya, et al., 1968). As there is no soil testing laboratory in the Department of Botany or in any other department of the University, the soil samples were analyzed by the author in the PWD Soil Survey Laboratory Baroda.

Edaphic environment parameter	Method used
1) Moisture content	Oven dry wt. basis (Misra, 1968; Pandeya et al. 1968).
2) pH	Elect. pH meter (Misra, 1968).
3) Exchange capacity	Chemical analysis (Jackson, 1967).
4) Exchangeable Ca	Chemical analysis (Jackson,1967).
5) Exchangeable Mg-Mn	Chemical analysis (Jackson,1967).
6) Exchangeable K	Chemical analysis (Jackson,1967).
7) Total Soluble Salts (elect. conductivity)	Conductivity Bridge (Jackson, 1967).
8) SiO_2, Al_2O_3, Fe_2O_3	Flame Photometer (Jackson, 1967).

(b) Edaphic environment fluctuation Inventory :

There is no documented record of the changes in the edaphic complexes of the Chokari ecosystem. Raychoudhuri et al. (1963) have recorded the saline patches of taluka wherein the edaphic complexes of Chokari ecosystem area are included. The interview schedules (MAB 1974 Report; Smith, 1975; Chung, 1977) with farmers were held and identical set of questions were asked and their responses were recorded in the data sheet. This enabled the author to a certain extent to get the crude idea of fluctuating estuarine edaphic environment.

(3) Socio-cultural-economic Environment Inventory :

The socio-cultural-economic environment was measured by employing the scale prepared by the noted Indian social scientist Udai Pareek (1970). Socio-economic status scale for rural areas is constructed and standardized for Indian rural areas. It is widely used in the social sciences. The scale was obtained from the Centre of Advanced Study in Education, M. S. University of Baroda and administered to the human component of the Chokari rural ecosystem. The responses were scored and categorized and on the basis of the categories the

environment is described. This scale has been given in the Appendix.

Biotic Compartment Components

(1) Autotrophic (Producer) Component :

1 a. Vegetational System :

The vegetational system was analyzed according to Oosting (1958), Cain (1959), Misra (1968).

(i) Floristic analysis was carried out by the standard methods of identification using Hooker's Flora of British India as reference source.

(ii) Phenological analysis was done according to Singh (1967) and Daubenmire (1968).

(iii) Growth form and growth period analysis was done according to Cain (1959) and Misra (1968).

(iv) Collection and identification methodology :

Visits were made to the zones of vegetational systems and field observations on the phenology seasonal changes, vegetational and floristic composition were made. In the field, plants were collected and packed

in polythene bags. The 'on the spot' notes regarding the plant habit, flower colour, plant size, plant morphological peculiarities, gross abundance and associational stands were made. Identification was confirmed by means of Flora and the plant list was arranged according to Bentham and Hooker's System of Classification.

1 b. Crop Systems
(Agro-ecosystem)
(i) Phenological Crop system analysis :

The analysis of Crop Systems was done by phenological observations of agro-ecosystems during the study period. These observations were correlated with the documentation analysis of the agricultural yield records of the village panchayat office and taluka panchayat office.

(ii) Documented Record Analysis : (Otto Somoerwotto, 1974; Lulla, 1976).

The agricultural output records were obtained from village and panchayat office and data was analyzed. The inter as well

as intra organizational check was done by studying yield records - fiscal records and the progress reports of the two offices.

(iii) Interview Schedules :

Participation of large number of farmers in the interview schedule enabled the author to gather relevant data about cropping and harvesting patterns. The identical questions were put to the farmers and their response was recorded in data sheet which was then analyzed for reporting (MAB, 1974; Smith, 1975; Chung, 1977).

(2) Consumer Component :

2 a. Animal Populations :

The analysis of animal populations was done with help of official form of animal survey (Pashudhan Form) published by the Government of Gujarat. The records of surveys conducted by the taluka authorities were also analyzed. The grazing animal populations were only included in the present survey. No inventory of Birds and rodents was made. (District Panchayat - Baroda, Report Government of Gujarat 1971-73, 1973-75).

2 b. Human Population :

The population survey was made with the help of official

demographic form (Vasti ganatari Form) published by the Government of India. The taluka and village panchayat survey figures were also analyzed with the help of statistician of the Taluka Panchayat. The survey figures were checked by inter and intra organizational check and analysis (District Panchayat - Baroda, Report Government of Gujarat 1971-73, 1973-75).

Special inventory consisting of identical questions was constructed to obtain data on energy utilization patterns of the human component ecosystem (Smith, 1975).

The dwelling structure was analyzed by the analysis of revenue records of the village panchayat.

The analysis of human environment was done by the interview schedules according to Smith (1975).

(3) Decomposer Component :

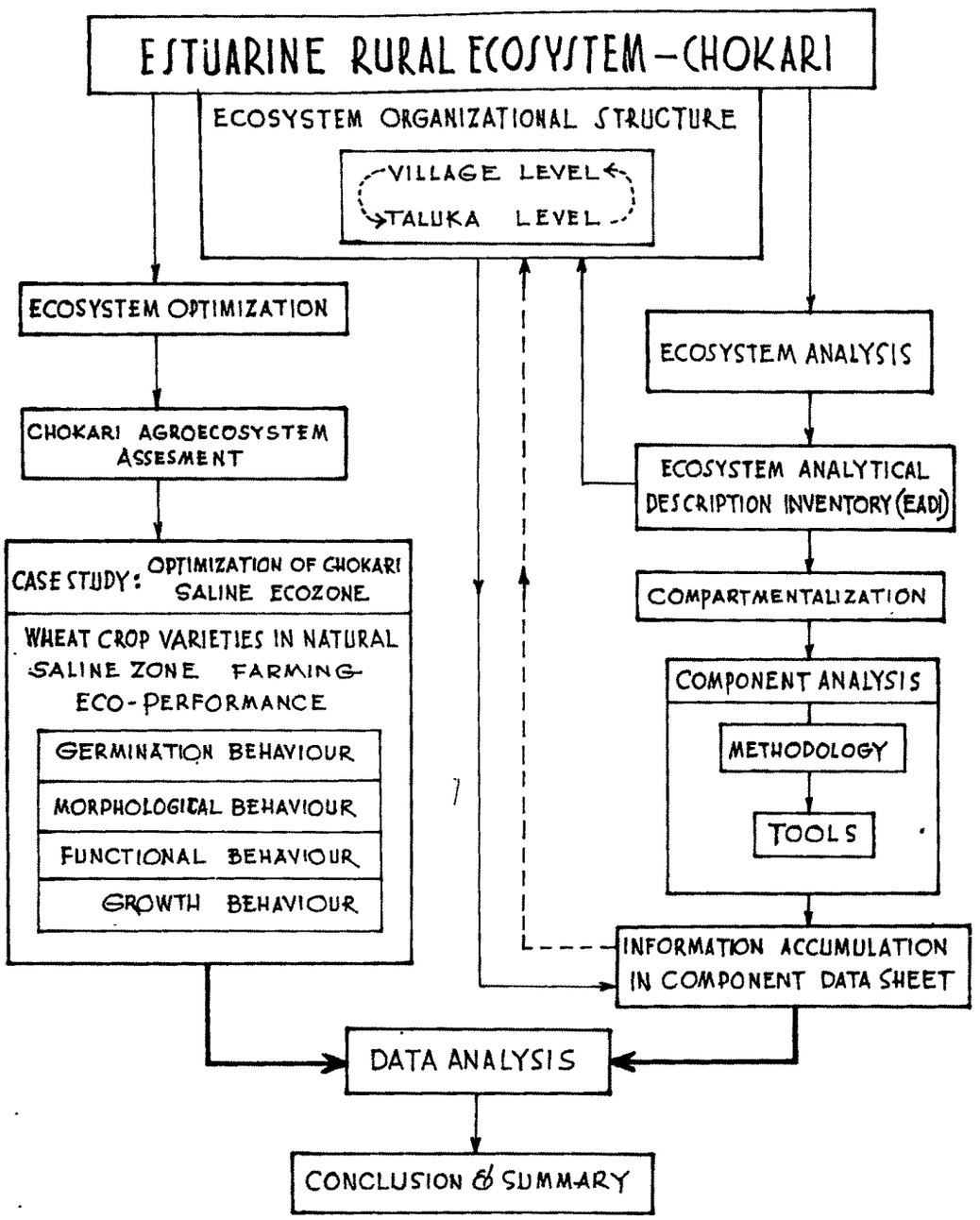
The fungi and Actinomycetes in general, were assessed in terms of number of colonies by plate count method (Flynn, 1966). This work was done with the assistance of Soil Microbiologist of Engineering Research Institute, Race Course, Baroda. The Department of Botany does not have any facilities for micro-biological work.

III. Component Information Data Sheets :

The analytical approaches and methodological strategies generated information which was classified and analyzed and recorded in Component Information Data Sheets (PLATE 5).

The descriptions of the component units are based on the data sheet of each of the component.

Plate - 5 : The flow chart for the approaches used in the present investigation showing the 'modus operandi' of the present research project.



APPROACH FLOW CHART

PLATE - 5

(B) Approaches pertaining to Ecosystem Optimization :

(a) Conceptual Frame work :

Ecosystem optimizationc can be viewed from multi-dimensional out look. The basic issue is that of optimization of primary production of the agricultural crops to feed the enormously growing population of human component of the biosphere (Van Overbeek, 1976). One of the approaches to the optimization is to select a proper variety which would give better yield under the given conditions of environment both edapho-physical and economic. The evaluation of eco-behaviour of varieties during early growth is essential as the standing crop and harvest yield are entirely dependent upon this phenophase of the varietal growth. With this conceptual frame work in view, the following approaches were planned and experimentally executed.

(b) Approaches for Chokari Rural Ecosystem :

The problems of ecosystem optimization at Chokari rural ecosystem area can be divided into two major areas :

(a) Energy subsidy needs : In Chokari non-saline as well as saline farming ecozones the optimization can be achieved by

more input of energy-produced fertilizers and pesticides. This problem has been correlated to the economic environment of the cultivators in question.

(b) Saline Farming Systems : In these farming systems the problems of salinity gradient limit agricultural output. It is here that the practical problem of optimization has to be attacked from an altogether different point of view. The agroclimatological land use has to be established by selection of proper varieties of different crop plants for cultivation in different season.

(c) Case Study :

Optimization of agricultural (wheat crop) output of saline edaphic complexes at Chokari by evaluation of eco-behaviour or by the assessment ofthe halophytic potential.

Evaluation of eco-behaviour was done experimentally by studying the following :

(a) Germination behaviour
(b) Morphological behaviour
(c) Functional behaviour
(d) Growth behaviour.

Material :

The authentic germplasm samples of the four varieties of

wheat were obtained from Gujarat Agricultural University Anand Campus, Anand, and from the Wheat Breeder, Wheat Research Station, Vijapur, Mehsana.

Agro-genetic history :

The varietal information of each of the variety used in the investigation is summarized in the chart given below :-

Agro-Genetic Characteristics of Wheat Varieties*

Sr. No.	Characteristics	Kalyansona	Sonalika	J-40	J-24
1.	Parents	(Fn x k. 58-n thx N10 B) Gb-55.	(II-53-588 x An) Yt 54 x N10 B)	LR	(5.308 x WS-110)
2.	Sowing time	second half of November	December	Second half of November	Second half of November
3.	Sowing distance	———	23 cms between rows		———
4.	Fertilizer doses	——100 kg N : 60 Kg P_2O_5 : 40 Kg P_2O_5/hect——			
5.	Average height	80-90 cm	90-100 cm	75-80 cm	105-110 cm
6.	Maturity days	110-115	100-105	108-112	105-110
7.	Yield/hectare	4000 kg	3500 kg	4000 kg	4200 kg
8.	Grain colour	Amber	Amber	Amber	Amber
9.	1000 grain weight	36-38 gm	50-52 gm	42-45 gm	50-52 gm
10.	Protein %	14.2%	14.3%	-	14.3%

* (Source : Wheat Research Station, Report - Vijapur - Mehsana -1970-71).

Methodology :

(a) Germination behaviour and percentage seedling mortality :

(i) Percentage Germination :

The germination count was made after 48 hours of sowing and the emergence of plumule above the soil level was taken as the standard to obtain the total germination count (Misra, 1968). The percentage calculations were done based upon the following formula :

$$\frac{\text{Seeds germinated (count)}}{\text{Total seeds sown}} \times 100.$$

(ii) Percentage Mortality :

The percentage mortality was calculated according to the formula (Misra, 1968) :

$$\frac{\text{No. of seedlings dead}}{\text{(No. of seedlings survived + No. of seedlings newly established)}} \times 100.$$

(b) Morphological behaviour :

(i) Root Length, Shoot Length and Root : Shoot Ratio (cm :

Root length and shoot length was measured with standard

scale as variation was expected. The root to shoot ratio was then computed (Singh, 1974).

(ii) Leaf Area (Cm^2) :

The leaf lamina samples were collected and drawn on a graph paper and the area was measured with the help of planimeter (Singh, 1974; Misra et al. 1970) (The sheathing leaf base is not included in this measurement).

(c) Functional behaviour :

(i) Phytomass (Total and Compartmental) :

Phytomass (expressed as mg $plant^{-1}$) has been obtained by determining dry weight of plant(measured by single pan Mettler balance.)

The plant samples were dried in oven at 80°C for 24 hours. Compartmental phytomass estimated by separating plant parts into root and shoot and weighed as shown above (Singh, 1974).

(ii) Root:Shoot Phytomass Ratio :

The ratio was calculated using the data of compartmental phytomass. (Wahi, 1976).

(iii) Net Primary Productivity :

The root and shoot net primary production was computed by

the following formula : (Misra, 1968; Odum, 1971).

Net Primary productivity (Mg plant^{-1} day^{-1})

$$= \frac{W_2 - W_1}{t_2 - t_1}$$

where W_2 = final dry weight

W_1 = initial dry weight

t_2 = harvest time

t_1 = initial observation time.

Odum (1971) refers this as short term harvest method.

(iv) Leaf Weight Ratio (LWR), Shoot Weight Ratio (SWR) Root Weight Ratio (RWR) :

The LWR, SWR and RWR were computed using following formula : (Singh, 1974; Wahi, 1976).

$$\frac{\text{Dry weight of component part}}{\text{Dry weight of total parts}}$$

(d) Growth behaviour :

The following parameters were calculated according to Fisher (1921), Gregory (1926), Radford (1967) and Blackman (1968), Golley (1960).

$$\text{RGR (mg mg}^{-1}\ \text{day}^{-1}) = \frac{\text{In } W_2 - \text{In } W_1}{t_2 - t_1}$$

$$\text{NAR (mg cm}^{-2}\text{ day}^{-1}) = \frac{\text{In } A_2 - \text{In } A_1}{A_2 - A_1} \times \frac{W_2 - W_1}{t_2 - t_1}$$

$$\text{LAR (cm}^2\text{ mg}^{-1}) = \frac{A_2 - A_1}{\text{In } A_2 - \text{In } A_1} \times \frac{\text{In } W_2 - \text{In } W_1}{W_2 - W_1}$$

where

W_2 = Final reading of dry weight

W_1 = initial reading of dry weight

t_2 = time of final reading

t_1 = time of initial reading

A_2 = leaf area at final observation time

A_1 = leaf area at initial observation.

$$\text{Specific leaf weight (SLW) (mg cm}^{-2}) = \frac{\text{Leaf Weight}}{\text{Leaf area}}$$

$$\text{Specific leaf area (SLA) (cm}^2\text{ mg}^{-1}) = \frac{\text{Leaf area}}{\text{Leaf weight}}$$

Statistical treatment

The statistical treatment in terms of test of significance was done wherever possible according to Snedecor and Cochran (1967).

Agronomic and Cropping Patterns :

(i) Field Research Sites :

The research plots for the present optimization investigation were scattered in the saline ecozone of Chokari Ecosystem Complex. Research plots of 0.2 hectares were used in three different gradients of salinity.

Plot	Salinity gradient in millimhos/cm
I	1.8 - 3.5
II	3.5 - 4.5
III	4.5 - 5.0

(ii) Cropping history :

Mixed cropping practices are in vogue in this ecozone. The crops are influenced by environmental parameters. The saline ecozone was a 'salt' manufacturing bed about 1000 or 2000 years ago - due to high sea water ingress frequency (old farmer's Report). The estuarine accumulation of 'soil' due to 'river' ecosystem made the zone partly worth cultivation of some crop varieties. Agriculture on the research sites is in practice since long as this zone is saline but quite away from coastal area of the river where periodic sea water ingress increases salinity to a considerable extent.

(iii) Agronomic operations during Research period :

Like the Chokari cultivator research was also conducted under 'Natural' or "organic" or "Biological" system of farming.

The two operations were performed - that of sowing and harvesting. However, occasional weeding (once in study period) was done.

(iv) Irrigation and Fertilization :

Irrigation is "natural" as the saline ecozone is near the river ecosystem. Water percolates into edaphic sub-layers and soil moisture is maintained. It is also rainfed area. There are no irrigation facilities. The 'Kyara' are built to store rain water which is used for irrigation. Fertilizer input is also very negligible. Only "green" or "organic" or "biological" fertilizer is used as per the conventional methods.(PLATE 6).

Plant Sampling :

Plant sampling was done at the interval of 10, 20, 30 days in the three growing seasons and at each sampling period 15 to 20 plants were randomly sampled from each of the research plots. For each observation minimum three replicates were studied.

Plate - 6 : Storage of rain water in the traditional 'Kyara' dug near the border of the crop field in saline edaphic zone for the purposes of irrigation. No artificial irrigation facilities are available.


PLATE- 6

Root studies sampling :

Sampling for root studies was done in the same manner as described above using Monolith method (Pandeya et al., 1968). Monolith of 15 x 15 x 30 cm were dug from each of the plot and each of the replicate sample. Soil adhering root was washed carefully by gentle water current in the sink avoiding the loss of rootlets as far as practicable. Excess moisture was blotted off and further studies were conducted.

Moisture content studies :

Plant samples were separated into root and shoot and dried in oven at 80°C for 24 hours (Misra, 1968).

$$\text{Moisture content of plant part} = \frac{\text{Fresh weight - dry weight}}{\text{Fresh weight}} \times 100.$$

Informative note :

All the methods were standardized, and used in the investigations. The values in the tables represent the average of the minimum three replicates of each experimental parameter examined during the study period. The research farm plots used in the present work are under the management of Deepak Sahakari Mandali (Deepak Cooperative Farming Society) Chokari and Dabka villages of Padra Taluka in District of Baroda.

Thesis Component I

Unit - III

The estuarine rural ecosystem with agricultural environment and saline adaphic zone at Chokari

(a general account : assessment before initiation of Research work).

I. Location :

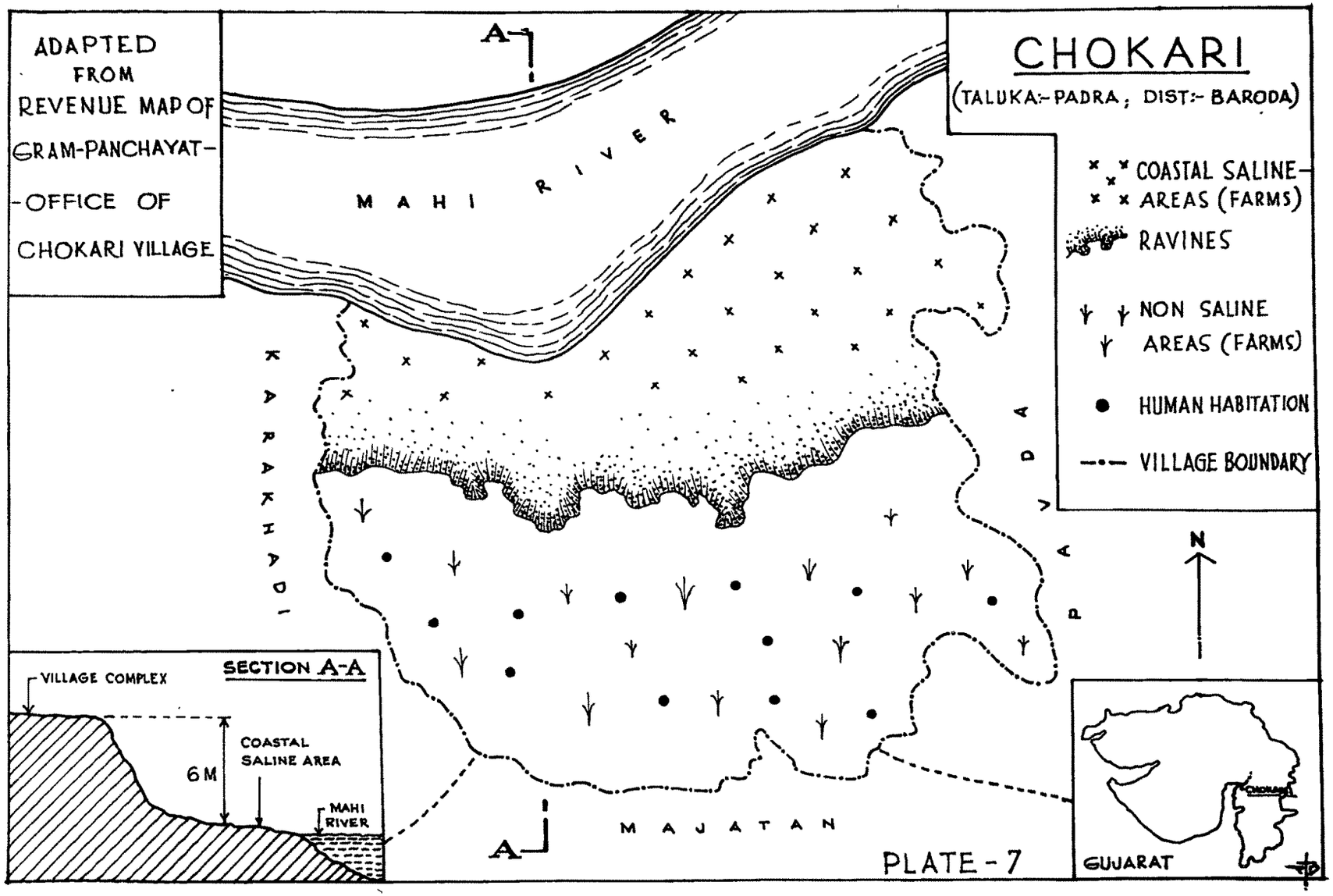
The estuarine rural ecosystem located at Chokari forms a constituent part of the Padra taluka and Baroda district from hierarchical point of view. It is 48.5 km. away from Baroda urban ecosystem and 49.2 km. from the University complex.

The ecosystem area is approachable from Dabka - a slightly bigger village - through a katcha road running into ravines of Mahi River. Another approach which is also called the 'Monsoon' approach is from Kareli and Majatan. The buses of State Transport (during monsoon) go only upto Kareli - and the population of Chokari has to walk 18-19 km. to reach the village complex. (PLATE 7).

II. Agricultural Environment :

Chokari ecosystem complex is devoid of industrialization urbanization or other resource development projects which keeps the environment purely agricultural. There is no cottage industry - no economic activity worth the mention in terms of shops etc. One can observe the cluster of human settlements and the agro-ecosystems i.e. farmfields and their associated flora and fauna. There are no other means of employment. The environment of the ecosystem area is dominated by the natural

Plate - 7 : The map of 'Chokari area' representing the entire estuarine rural ecosystem and indicating the natural zonation of the ecosystem area into non-saline and saline areas separated by the ravines.


ADAPTED FROM REVENUE MAP OF GRAM-PANCHAYAT-OFFICE OF CHOKARI VILLAGE
CHOKARI
(TALUKA:- PADRA ; DIST:- BARODA)
COASTAL SALINE AREAS (FARMS)
RAVINES
NON SALINE AREAS (FARMS)
HUMAN HABITATION
VILLAGE BOUNDARY
MAHI RIVER
A
A
N
SECTION A-A
VILLAGE COMPLEX
6 M
COASTAL SALINE AREA
MAHI RIVER
MAJATAN
GUJARAT
PLATE - 7

settings and random 'habitation' spots distributed all over. The farm fields are comparatively small and meagre in appearance. The signs of fragmentation are evident in agricultural zones.

III. Natural Zonation :

The entire ecosystem shows natural zonation into the three parts. The zone of plain land which is in continuation with other taluka units and has non-saline soils. This zone appears raised by 6-8 meters from the other two zones. The other zone is the ravinous one which is a sort of natural separation between the saline and non-saline zones. The third zone is that of large area of saline soils which end into the saline coastal belts of the River Mahi. (PLATES 7 and 8).

IV. The River Mahi :

It is away from the main village complex at a distance of 8-9 km. the river flows from the north side of the ecosystem area and touches Dabka before widening its course as it passes through this area. The river ultimately takes its course to the gulf of Khambhat. Chokari ecosystem coastal area is the initiation of the widening of the mouth of the river hence constitutes the estuarine environment. (PLATE 9).

Plate - 8 : The natural zonation at Chokari ecosystem area is clearly visible from the habitation structures of the non-saline area, the ravinous area and the beginning of the saline area.

PLATE- 8

Plate - 9 : The river Mahi and the estuarine settings in the saline area of the Chokari rural ecosystem.

PLATE-9

V. The Estuarine settings :

'An estuary is a semi-enclosed coastal body of water having a free connection with the open sea-area and containing a measurable quantity of sea salt' (Pitchard, 1952). There are a complex interplay of ever-changing river and tidal flows complicated by the effects of topography (Green, 1971). From the aquatic environment point of view Hedgpeth (1967) offered the definition that the estuarine ecosystem is a mixing region between sea and inland water of such shape and depth that the net resident time of suspended materials exceeds the flushing. This makes it evident that interactional zone of edaphic complexes with this tidal mouth of the river tends to remain saline due to salt suspension and deposition which exceed flushing. This saline zone of soils is the problem area of the ecosystem due to its fluctuating nature.

Eco-history of estuarine complex :

Due to the prevalent fluctuations in the estuarine ecosystem environment the author tried to know the ecological history of the area. In absence of any documented 'micro-eco-history' of the area which forms but a very small part of the taluka, the author arranged for the interview of the oldest farmer and a group of old farmers from this area as well as

nearby village ecosystems to know eco-history which is passed on from generation to generation. It was reported (authencity of the reports are not at all claimed) that the area in question was a 'salt manufacturing' bed some 1000 or 1500 to 2000 years back due to higher quantity and frequency of the ingress of sea water which had rendered the area totally saline. Then gradually the sedimentation and deposition of 'good' soil occurred and the area partly could be brought under cultivation. These facts are crudely confirmed by the two observations. Firstly the ecosystem shows 'Ravines' and a plain land before the actual coastal zone. The history of flood of Mahi is well known in Gujarat. These ravines are indicative of the changes in the topography due to River ecosystem fluctuations. Secondly the recent major floods in 1970 and 1973 as well as the minor floods in 1976 had considerably altered the edaphic status according to the soil experts of agriculture departments. The dry conditions of 1974 had worsened the situation. So it is clear that the estuarine environment is highly fluctuating. The problems of salinity in this zone of ecosystem always remain - the shift is always in quantity and not that in quality. (PLATES 10 and 11).

VI. The 'Man' in Estuarine Rural Ecosystem :

The 'Man' in Chokari has meagre look and evident backward

Plate - 10 : A magnified view of the coastal edaphic systems in constant interaction with the river ecosystem in the estuarine settings.

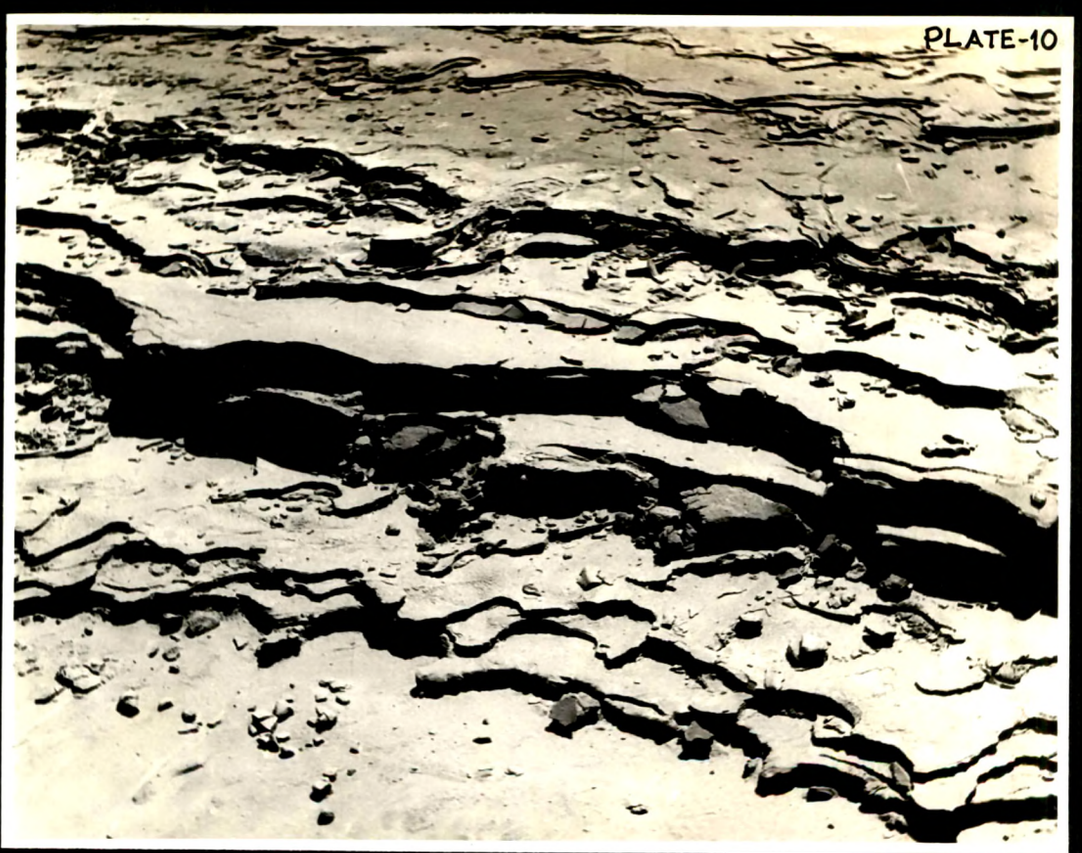


PLATE-10

Plate - 11 : The zone of periodic sea water ingress rendering the 'soils' saline. The salinity gradient of this zone is high. The photograph shows the zone after 'saline' water has receded.

PLATE-11

background. The major portion of population is illiterate, socially and culturally underdeveloped. The activities of man are confined to the cultivation and agricultural labour. The environmental impact is evident. The system of exploitation of land is a peasant system directed by legally monogamous head of the household. An average household consists of 5-8 members. Women are also very active in farming operations. Fragmentation of land as well as families is common through the pattern of family life is joint. Unemployment is tremendous. 'Marginal' farming and 'subsistence economy' is not able to sustain the population which is below the poverty line (BPL). Traditional rural socio-religious beliefs prevail even now. The people though backward are in general vegetarian and peace-loving.

VII. The 'Nature' in ecosystem area :

There is no 'natural' or 'artificial' forest or plantations in a unit area. No development of forests is also being done. The vegetation is supported by grazing and waste lands. It is typical semi-arid zone vegetation with differential floristic patterns in all the three natural zones of the ecosystem area.

There is no 'wild' life in the ecological sense. However, Bird life is evidently as good as other rural ecosystems. The precipitation and temperature patterns are of semi-arid nature.

There is no exploitation of estuarine aquatic biota by the population of this rural complex.

These general observations were made before the analytical and optimization investigations were undertaken.