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# THE ROLE OF SOIL SURVEYS IN AGRICULTURAL AND NON-AGRICULTURAL DEVELOPMENT IN PAKISTAN

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# THE ROLE OF SOIL SURVEYS IN AGRICULTURAL AND NON-AGRICULTURAL DEVELOPMENT IN PAKISTAN

Dr. M. Amjad Hassan*

## C O N T E N T S



* Director, Soil Survey Project, Government of Pakistan, Lahore.

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## I. INTRODUCTION

Before 1962 relatively little was known about the soils and soil resources of West Pakistan, apart from the experience gained in several centuries of grazing and irrigated and rainfed agriculture on a traditional pattern, and some sixty years of large scale canal irrigation development.

In the absence of modern soil surveys it was assumed that soils in the plains of West Pakistan were 'Alluvial' and genetically undeveloped; that texture was the single most important variable; and salinity was the only other important soil property. This concept was further strengthened in the report, "Landforms and Soils of Indus Plains" by Frazer et al 1957, published by the Government of Canada for the Government of Pakistan. In the early 'thirtees' the increasingly high water-table, and consequent water-logging as a result of extensive canal irrigation development, caught the attention of the Government in some areas. Also at about the same time, erosion in the foothills and rainfed uplands of West Pakistan was recognized as a danger. This resulted in the creation of two organizations, "Land Reclamation" and "Soil Conservation", for the control of the problems of soil salinity and soil erosion. The Land Reclamation Directorate carried out salinity surveys. Some soil surveys of small areas were carried out by the Soil Conservation Directorate.

Various kinds of surveys concerning land and soils, conducted in past by various agencies in selected areas, were single-value surveys meant to serve a limited purpose. Moreover, the information, for the most part even in local areas, was not available to other concerned agencies or departments as, in most cases, published reports were not produced. It was difficult to correlate the information as the methods used by various agencies were different. The Soil Survey Project of Pakistan was set up in 1962 in order to remove the aforementioned drawbacks and to provide, through regular basic soil survey operations, a comprehensive body of knowledge about the soils of Pakistan.

## II. NATURE OF SOIL SURVEYS

There is a general belief in our country that the main purpose of soil survey is to collect soil samples for laboratory analysis in order to assess their nutrient content and thereby make recommendations for the use of fertilizers. This is not correct. The purpose of soil survey is to describe, identify, classify and map soils, through airphoto interpretation, field work and soil profile examinations. The field work includes the study of soil profiles, the surface features, drainage, natural vegetation and the land use. As natural bodies the soils are classified into defined units: soil series, phases, great soil groups and subgroups. Soil maps and notes are subsequently processed to produce the soil survey report which contains the description of the soils and the maps. Soil samples are collected from representative sites of each soil and are analysed in the laboratory. The soil analyses data and the field data are used as complementary to each other for the description of the soils.

i. SPECIAL PURPOSE SURVEYS. Soil surveys are sometimes carried out for a special purpose and only those soil properties are noted which concern that purpose. The soil surveys carried out by the Directorate of Land Reclamation are of this type as these surveys were conducted for the purpose of investigating the extent of salinity problem and the soils were classified on the basis of texture and salt content. Similar surveys were carried out by the 'Water And Soil Investigation Division' of WAPDA. Such surveys are useful but only for the limited purpose. Additional field work is needed if the surveys are used for some other purpose.

ii. BASIC SOIL-SURVEYS. A basic soil survey envisages the collection of data on all the soil properties and classification of soils on the basis of all significant differences in properties. As it contains all the information about soil properties, it can be interpreted for many different purposes without any additional field work. Such soil surveys are now carried out in most of the advanced countries as they are more economical than the special purpose surveys in the long run.

iii. DETAIL OF MAPPING. With respect to the detail of soil mapping there are three main kinds of soil surveys, i.e. exploratory, reconnaissance and detailed. The exploratory soil survey is done to get a general idea about the soil resources of a large region or the whole country. It is used for project formulation in rural development. The reconnaissance survey is carried out where information is needed for planning of development projects. It gives complete information about the kinds of soils and their extent but the individual soils are not shown on the soil maps. The detailed soil survey is carried out for the execution of development projects. The detailed soil maps show the location and extent of individual soils.

iv. RECONNAISSANCE SOIL SURVEYS At present the Soil Survey Project of Pakistan is carrying out "reconnaissance" soil surveys. In this survey the individual soils are described and classified but they are mapped as soil associations which are groups of soils naturally occurring together in a distinct pattern. In the soil survey report the soil associations are described in terms of the component soils, their important properties, the relative proportion and the position in the landscape, together with their present land use, their limitations and specific improvements. Different soils have different potential for various uses. The reconnaissance soil survey reports and maps, when completed for whole of Pakistan, will serve as a comprehensive "INVENTORY OF THE SOIL RESOURCES" of the country in terms of potential for agricultural development. With accurate soil maps, and accompanying reports, the land users can make full use of the science and technology to realise the great potentialities of the soil for sustained production.

The total area of West Pakistan (300,000 square miles) has been split up, for the purpose of reconnaissance soil survey, into two categories, 'A' and 'B', according to the suitability and importance for agricultural use. The category 'A' includes the agriculturally important area and comprises the Indus plain, including the Peshawar valley. It has been given priority for soil surveys and by the end of 1971, about 85,000 square miles (out of the total

120,000 square miles) have been surveyed. The survey reports have been published or they are under preparation (The areas surveyed are listed in the appendix). Each soil survey report contains the descriptions of the various soils of the survey area, their land capability classification and the present land use. Due to the reconnaissance nature of the survey the soil maps show the boundaries of soil associations which are groups of soils occurring, in a landscape, together in a certain definite pattern. In the report each soil association is described in terms of the component soils, their proportion, important properties, limitations and specific improvements which are needed to realise their potential. The position of each soil in the landscape is also indicated. The soil associations are interpreted into land capability associations for agricultural use and these are shown on separate maps accompanying the report. The land capability associations are described in terms of the component capability subclasses, their proportions, limitations and suggestions for improvement. The land capability data can be used for planning development projects. The soil survey report also contains the description of the present land use in terms of land use associations which are shown on a separate map. The suitability of each soil for various crops is also given in the reports. Thus the soil survey reports give information not only about the potential of the area but also about the present situation.

v. DETAILED SOIL SURVEYS. Whereas the reconnaissance soil surveys provide data for planning development projects, detailed soil surveys are needed for the execution of development projects and for the reorientation of agricultural research by soil types. The Soil Survey Project of Pakistan has carried out detailed soil surveys of the following agricultural research stations:

i. Punjab Agricultural Research Station, Lyallpur.
ii. Agricultural Research Station, Tandojam.
iii. Rice Research Station, Kala Shah Kaku.

Other research stations will also be surveyed. The detailed soil surveys of research stations show whether the soils are representative of that area or not. By reconnaissance surveys the major soils of these research stations are already known and the detailed surveys show whether their soils are representative of the major soils that occur in that area or not. For instance, the Rice Research Station, Kala Shah Kaku has been found to be located, as a result of detailed soil survey, on very unrepresentative soils and so the hard work of the research workers is not fully rewarded. To help in the execution of Shadab Pilot Project detailed soil surveys of model agricultural farms are being done.

## III. SOIL SURVEY INTERPRETATION

The reconnaissance soil survey has been completed for the major part of the agriculturally important areas of West Pakistan. Now the question arises - How to use this information? The answer is - Through interpretation of soil survey data. The reconnaissance soil survey reports contain basic data on soils - soil types, their properties, their relationship, the drainage and the climate. This

basic data can be interpreted for many uses. Land capability classification and crop suitability classification are the two interpretations given in the survey reports but many more interpretations can be made for various uses, as explained hereafter.

## IV. USE OF RECONNAISSANCE SOIL SURVEYS

The data provided by the reconnaissance soil survey is meant primarily for planning agricultural development at various levels - national, provincial, district, tehsil and development projects. The main uses of this survey are mentioned below:

1. Planning of Agricultural Development. In this regard soil survey data is interpreted to assess the land capability, and crop suitability of the soils. The area of various land capability subclasses in a province, district or project area can be worked out to find areas where development will be most rewarding and quick. Costly failure can thus be avoided. The survey data will help to find out the economic feasibility of a development project.

2. Planning for conservation of soil and water resources on the basis of land capability classification.

3. Planning of irrigation and reclamation projects. For centuries land settlement has been on a trial and error basis. This approach was successful in areas with high proportion of good land but it utterly failed in Kotri Barrage area where about 50 per cent land is unfit for agriculture.

4. Planning of towns and selection of sites for factories on land not suitable for agriculture, so that good agricultural land is saved.

5. Planning development of forest and range areas on land not suitable for agriculture. For example, the class IV and VI land in the subhumid areas and very sandy soils of riverain areas with sweet water at shallow depths can be used for forests.

6. Providing information for engineering purposes, e.g. alignment of roads, location of construction material (sand, gravel, clay etc.) and location of airports and buildings.

7. Providing basis for the suitable location of agricultural research stations. Recently the soil survey information was used for locating the suitable sites for tea research trials in West Pakistan.

8. Providing teaching material for courses in Soil Science, Pedology, Soil Morphology, Soil Genesis, Soil Classification,

Geography etc. in education institutions of the country.

9. Providing a framework for detailed soil surveys which are needed for planning at individual farm level.

## V. PRACTICAL EXAMPLES OF VARIOUS USES OF SOIL SURVEY IN WEST PAKISTAN

As a result of the activities of Soil Survey Project many aspects of soils and soil resources in West Pakistan have become much better understood than before and the soil survey data have been actually used by various organizations in many different ways. These uses were, however, possible by interpretation of the soil survey data by the staff of the Soil Survey Project. These are just few examples to show the utility of soil survey data in the development of the country. Nevertheless, they show that the scientific soils information leads to considerable economy of capital investment and help to avoid the costly failures.

1. Planning of Agricultural Development Projects. The Shadab Project which is a pilot project of integrated rural development, is using the soil survey data for planning the development programme. The survey data has been interpreted to suit the requirements of the project. Also, detailed soil surveys are being carried out for the preparation of farm plans of Model Farms within the Shadab Project.

The reconnaissance soil survey data is being used for planning of agricultural development of the riverain areas in Sind. The development is being planned by installation of tubewells and the plan is being prepared by the Project Planning Directorate, Southern Zone, WAPDA.

2. Planning of salinity control and reclamation projects. The detailed study of the genesis of saline-alkali soils, during the soil survey operations, revealed that saline-alkali soils are of two main kinds i.e. (i) porous and (ii) dense or without porosity. The dense saline-alkali soils are not economically reclaimable because in the absence of porosity the permeability of these soils is very low, almost zero, and the water either does not move down or move so slowly that the reclamation process is very slow and uneconomic. Unmindful of this problem, the WAPDA planners considered all saline-alkali soils as economically reclaimable but now the dense saline-alkali soils are discounted from the area to be reclaimed. The new salinity control and reclamation projects are being planned on the basis of soil survey data (Example: SCARP-5-Lahore district).

3. Reclamation experiments. In Khairpur area experiments on reclamation of various kinds of saline and saline-alkali soils were conducted by the Reclamation Expert, SCARP - Khairpur, using the soil survey data. The results of these experiments confirmed the findings of the Soil Survey Project of Pakistan and helped to refine the limit of the economically reclaimable soils. This is the first time that [1/]

1/ de Vos, J.F. Reclamation Report 1969-71, SCARP, Khairpur.

the reclamation experiments on saline soils were conducted by kinds of soils in West Pakistan. Now that the area of various kinds of soils is known through soil surveys, the results of these experiments can be applied with great certainty of success.

4. Planning of irrigation projects. An exploratory soil survey of the Hab Dam Irrigation Project area was made by the Soil Survey Project at the request of the Agricultural Development Corporation. The survey showed that half of the area, planned to be irrigated, comprised poor land with very shallow soils underlain by gravel or rock. The smooth surface of the land was deceptive for the engineers and planners. The timely soil survey helped to avoid the wastage of millions of rupees: equivalent to about five years budget of the Soil Survey Project.

The Agricultural Development Corporation planned to irrigate an area near Karachi by constructing a high level canal from the Kotri Barrage and the water was to be lifted by about 50 feet. A timely exploratory soil survey showed that the area to be irrigated was mostly unfit for irrigated agriculture due to very shallow soils; hardly one-third area had suitable soils. The wastage of millions of rupees was thus avoided.

5. Suitability of agricultural research stations. The detailed soil survey of Kala Shah Kaku Rice Research Station has been shown that almost whole of its area has unrepresentative soil. Only a very small area has representative rice soil. The major area has a reclaimed phase of a very bad saline-alkali soil and has at present 8 to 15 inches of reclaimed surface soil underlain by impervious saline-alkali layers. Thus the hard work of the research scientists working there is not fully rewarded. The Secretary of Agriculture, Punjab has taken note of this and a substation on the representative soil is being planned.

The reconnaissance soil survey shows that some agricultural research stations are located on unrepresentative soils. Agricultural Research Station, Rawalpindi is one example as it represents a soil which occurs only in the vicinity of Rawalpindi. So a new research station near Rewat or Gojar Khan and an additional station near Pindi Gheb are needed. The research station near Chakwal is not representative as it is in the transitional zone between subhumid and semiarid climate. No research station is located in the main arid zone, from Multan to Nawab Shah. At Multan and Khanpur stations research is conducted only on cotton and fruits. So new research stations are needed in the following areas:-

- Rewat or Gujar Khan, Rawalpindi district.
- Pindi Gheb, Campbellpur district.
- Sukkur district or Khairpur district.
- Khanpur station needs extension of research on all crops.
- Indus delta area.

6. Fertilizer experiments. Soil fertility trials on farmer's fields have been carried out throughout West Pakistan for many years, but without regard to soils. No recommendations could, therefore, be given for specific soils and only general fertilizer recommendations

are made for a region. Being averages these recommendations hold good for few soils but on others they do not give the desired results; in some cases they produce even negative response. For example, in Hazara district the fertilizer application reduced the crop yield in one field experiment. The field assistant was dismissed on this account. Later, it was found out by soil survey that the cause of the failure of the experiment was poor soil - one foot of soil underlain by gravel.

Recently, the Soil Survey Project has started identification of soils of the fields in which the Soil Fertility Directorate staff conducts fertilizer experiments. The soil survey information is also used to select experimental fields so that the experiments are done on main soils and the results are applicable on large areas. Specific recommendations for each kind of soil will now be available, making it possible to realise the full capacity of each soil and also to avoid failures.

7. Irrigation planning. To date, development and allocation of irrigation water have been planned on the basis of projected average cropping intensities and average yields, without considering the variability of soils. The Soil Survey Project of Pakistan have now produced land capability classification on a uniform standard for nearly whole of the Indus plains. This shows that: (i) generally the proportion of very good and good irrigated and irrigable land in the Indus plains is quite high but its full capacity for crop production is not being realized due to shortage of water (ii) the proportion of very good, good moderate and poor land varies a great deal between canal commands: for example, Thal and Kotri Barrage commands contain much lower proportion of very good and good land than other canal commands. This information will help in the allocation of new irrigation water between canal commands, so that water is first allocated to meet the demands of very good and good land on which it gives much higher return than the moderate or poor land. If water is surplus, then it may be allocated to the moderate land. The poor land gives so low return that the scarce water should not be wasted on it and no surplus water will be available for it even after completion of Tarbela dam. It may be mentioned that most of the poor land within the canal command areas is lying barren at present.

In view of the shortage of irrigation water, extension of cultivation on to the poor land should be discouraged and we should try to increase production per unit of water instead of per unit of land. The farmer should be encouraged to concentrate on good land instead of spreading his limited water supply to all his land.

8. Problems of the Indus Delta area. The soils of Indus delta (the Kotri barrage command) have formed under conditions quite different from the other parts of the Indus plains, and so they present unique problems. Large areas of extremely silty soils formed by massive spills of the river under the influence of sea tides have low clay content but very high percentage of silt, resulting in very high capillary porosity favouring upward movement of water from more than ten feet. In these soils the water moves down through them only when water is standing on the surface. So the downward movement of water takes place only during the irrigation, for a few hours, and then the

moisture moves upward under the influence of capillary pull created by evaporation. There is a severe salinity problem which cannot be solved unless the water-table is lowered to more than twelve feet - an impossible task.

The good soils of the Indus delta are clayey and have good porosity created by grasses. Their pores are such that the downward movement of water and salts predominates over the upward movement. So once reclaimed, these soils remain nonsaline if the water-table is kept below three feet. When the drainage network is completed in the area, these soils will form good irrigated land and give high net returns. But these soils cover only about half of the delta area. The remainder, covered by very silty soils, should not be brought under cultivation.

The substratum of the clayey soils is also very silty with very slow permeability. The drains should therefore be placed in clayey layer above the silty substratum. It is expected that mole drains made at short intervals will be most useful. Drainage by tubewells has failed because perched water-table remains above the impervious silty layer.

9. Problems of Pothowar Uplands. The soil survey has shown that there are two climatic zones in the Pothowar uplands - one is subhumid with rainfall of more than 20 inches and the other is semiarid with rainfall of less than 20 inches. (For different soils the limit is different - 16 inches for loamy soils, 20 inches for silty soils and 22 inches for clayey soils). The best soils in the subhumid area form class III land (moderate agricultural land) and the best soils in the semiarid zone form class IV land (poor agricultural land). It may be mentioned that the class I and class II lands occur only under irrigation in West Pakistan. The class IV is economically marginal land on which agriculture is barely profitable.

Land levelling by bull-dozers is being done in the semiarid zone to create more class IV land. It has been estimated that this land is open to danger of being washed away in about 5 years on average. Since the cultivation of such land is barely profitable the farmer cannot pay back the cost of land levelling in 5 years.

It has been found by soil surveys that there is an area of about 1,163,000 acres of class III land on which improvements are quite feasible and economic. This should receive prime attention in the development programme. The class IV land comprising about 273,900 acres and already under cultivation should be improved next.

Soil erosion is a problem on about 5% in Rawalpindi and Jhelum districts, 28% in Campbellpur district and in areas falling in Gujrat district on about 20 per cent of the cultivated land, the rest being almost free of erosion hazard. Erosion problem is being increased by bulldozers by disturbing the sloping land. The problem of soil erosion is of different magnitude on different soils. For example, the silty soils are much more vulnerable to erosion than the loamy soils. The major cause of soil erosion is the practice of leaving the land vacant during summer and emphasis on wheat production. Cultivation of groundnuts on loamy soils and sorghum on clayey soils

would help to check soil erosion but this is possible only if wheat supply is assured from the irrigated areas.

The reconnaissance soil survey shows areas of different types of soils and land capability classes and subclasses. Now the foremost need is to evolve suitable cropping patterns for various land subclasses so that maximum potential of the land is realized and soil erosion is kept under check. The suitable erosion control practices can also be evolved for various types of land.

10. Deep ploughing and levelling. Deep ploughing has been found to increase crop yields in some soils but on the Kala Shah Kaku Rice Research Station it has resulted in total crop failure. The soil survey information shows that the soil has only about 10 inches thick good surface layer underlain by strongly alkaline layers. The deep ploughing mixed the bad subsoil layer with the good surface layer which had been created by reclamation and cropping for 50 years.

Deep ploughing gave good results during the first year at Lyallpur but later the water intake rate decreased. A look at the soil layers showed that deep ploughing had destroyed the natural porosity. It has been found that some soils have impervious and dense layer below the plough layer (at 4 to 10 inches depth). Deep ploughing is useful only in such cases and the depth of ploughing should be enough only to break the dense layer.

For land levelling also the soil survey information is necessary. Shallow soils over sand or gravel or rock may be destroyed by levelling in the absence of such information.

11. Alignment of roads. On the basis of soils data, the alignment of the following roads was proposed to the Highways Departments.

i) Road between Ahmadpur East and Feroza in Bahawalpur circle. The road section between Chani Goth and Feroza was previously located in an area with very high water-table caused by the seepage from the Panjnad Main Canal. Realignment of this road in the light of the soil survey information solved this problem.

ii) Road between D.G.Khan and Loralai. The help of the Soil Survey Project in the alignment of this road not only helped in avoiding sharp bends, steep slopes and higher elevation spots, but also reduced the length of the road as much as by 40 miles.

iii) Road between Kharian-Jalalpur Jattan. The existing road is unmetalled and crosses a number of streams coming from the adjoining hills. Help was rendered in selecting the suitable sites for bridges on the streams in order to reduce the cost of bridges, and to avoid the road bends.

iv) Road between Muridke and Qila Suba Singh. According to the first plan the road was located on very good agricultural land. The road alignment was shifted to the dense saline-alkali land which is worthless for agricultural use.

v) Road between Qila Suba Singh and Narowal and between Badiana and Zafarwal. These roads had problems of failure in certain sections. The soil survey data showed that these points were the areas of seasonally wet and swelling clays. In new alignments of these roads the trouble spots were avoided.

12. Town planning. All the cities and towns are rapidly expanding. The soil surveys show that in most cases very good agricultural land is being used up for the purpose and lost for ever. There are areas of poor land which has no economic potential for irrigated agriculture and at many places they are not very far from the cities and towns. The expansion of Lahore, for example, is using up very good agricultural land on the southern side. The very good land is the only land that can be used to produce fresh vegetable, fruit and milk, and can also form a green belt around the city. The Directorate of Town Planning, Lahore was apprised of this situation and was helped in reviewing the Township Scheme. It has been shown that it is better to expand the city on poor land along the Shahdara-Sheikhupura road on the north. With proper integrated planning on the basis of the soil survey data, the city of Lahore could be transformed into a city of gardens with intensive cultivation of vegetables and fruits on good land to the south-east, south and west.

13. Forestry planning. The soil survey shows that the irrigated forest plantations are located mostly on very good agricultural land. It has been estimated that the net returns from the land under these forest plantations is about one-third to one half of what it would be under agriculture. Good forest can be grown even on poor land with very sandy soils (example: forest plantation a few miles north of Sargodha). So in future the poor land with very sandy soils occurring in riverain areas and having sweet ground was with 10 to 15 feet depth can be utilized for forest plantations. In such areas irrigation will be needed only for the first few years and later the trees will thrive on the ground moisture.

14. Miscellaneous. A light weight concrete made by firing of balls made from certain clayey soils is used in special building structure. The Soil Survey Project provided samples of various clayey soils to a foreign expert of engineering for this purpose. It was found that one clayey soil which is useless for agriculture, is good for making light weight concrete. The total area of this soil is also known through soil survey.

# APPENDIX

## LIST OF PUBLICATIONS

### A. SURVEY REPORTS

| S.No. | Survey area | Square miles | Million acres | Survey completed | Report issued |
|---|---|---|---|---|---|
| | **RECONNAISSANCE SOIL SURVEY REPORTS** | | | | |
| 1. | Peshawar Vale | 3 440 | 2.20 | 1967 | 1967 |
| 2. | Lyallpur | 3 420 | 2.19 | 1967 | 1967 |
| 3. | Rawalpindi | 3 642 | 2.33 | 1967 | 1967 |
| 4. | Gujrat | 2 264 | 1.44 | 1967 | 1967 |
| 5. | Gujranwala and Sialkot | 4 379 | 2.80 | 1965 | 1968 |
| 6. | Sheikhupura | 2 381 | 1.52 | 1968 | 1968 |
| 7. | Lahore | 2 216 | 1.41 | 1968 | 1968 |
| 8. | Jhang | 3 236 | 2.07 | 1968 | 1968 |
| 9. | Sahiwal | 4 224 | 2.70 | 1968 | 1968 |
| 10. | Thal North | 4 250 | 3.93 | 1968 | 1968 |
| 11. | Thal South | 3 822 | 2.44 | 1968 | 1968 |
| 12. | Thatta East | 3 388 | 2.17 | 1969 | 1969 |
| 13. | Sargodha, 2d ed. | 2 290 | 1.47 | 1966 | 1969 |
| 14. | Multan South | 3 035 | 1.85 | 1969 | 1969 |
| 15. | Multan North | 2 686 | 1.73 | 1969 | 1969 |
| 16. | D.I.Khan | 3 765 | 2.30 | 1969 | 1969 |
| 17. | Jacobabad | 2 273 | 1.47 | 1969 | 1970 |
| 18. | Ghotki | 2 818 | 1.49 | 1969 | 1970 |
| 19. | Muzaffargarh | 1 614 | 1.03 | 1970 | 1971 |
| 20. | Khairpur | 2 119 | 1.36 | 1970 | 1971 |
| 21. | Hyderabad | 1 624 | 1.04 | 1970 | 1971 |
| 22. | Badin | 3 480 | 2.23 | 1970 | 1971 |
| 23. | Campbellpur | 4 131 | 2.64 | 1970 | 1971 |
| 24. | Bahawalpur | 4 300 | 2.75 | 1971 | 1972 |
| 25. | Bahawal Nagar | 3 184 | 2.04 | 1971 | 1972 |
| 26. | Nawab Shah | 3 347 | 2.14 | 1971 | 1972 |
| 27. | Sanghar | 3 207 | 2.05 | 1971 | 1972 |
| | **REPORTS ON AGRICULTURAL DEVELOPMENT POSSIBILITIES** | | | | |
| 1. | Thatta West | 1 994 | 1.28 | 1970 | 1970 |
| 2. | Ghotki | 2 326 | 1.49 | 1969 | 1971 |
| 3. | Chaj doab | 5 644 | 3.61 | 1965, 1968 | in press |
| | **INTEGRATED REPORTS, SOILS AND VEGETATION** | | | | |
| 10+11 | Thal | 9 965 | 6.38 | 1968 | 1970 |
| | **DETAILED SOIL SURVEY REPORTS** | | | | |
| 1. | Kala Shah Kaku Rice Research Station. | acres 1 238 | | 1970 | 1970 |
| 2. | Agricultural Research Institute, Tandojam. | 1 000 | | 1971 | 1971 |
| 3. | The Punjab Agricultural Research Institute, Lyallpur. | 2 600 | | 1971 | in press |

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