Report No. R-65.1

GIS METADATA FOR AN IRRIGATION SYSTEM

VOLUME I: CHISHTIAN SUB - DIVISION

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LAHORE

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FOREWORD

A numerous research studies had been carried out around the world, but, retrieving data from such studies by a third party is not always possible. More importantly, researchers in general do not make a concerted effort to make such a valuable resource available to other interested parties. Researchers at IMI Pakistan were not an exception to this until recently.

Mobin-ud-Din Ahmad, Samia Ali, Yann Chemin and Salman Asif have invested a considerable amount of time in producing this Metadata, on a compact disk (CD) and two volumes of these reports. Data presented in this CD relates to the Chistian Sub-division. It is described in the two volumes of reports. The first one provides sub-divisional level data, and the second one is a compilation of data from eight selected watercourses from the sub-division. The data were collected by a score of researchers associated with IIMI Pakistan, Punjab Irrigation and Power Department (PIPD), Soil Survey of Pakistan (SSP), Directorate of Land Reclamation (DLR), Water and Soil Investigation Division (WASID) WAPDA, SCARP Monitoring Organization (SMO) and Water Course Monitoring and Evaluation Directorate (WMED). Processing and compilation of data was carried by researchers at IIMI Pakistan, CEMAGREF France and WMED. By any possible measure, it reflects a genuine collaborative effort among National and International Agencies and the output is one that every one associated can be proud of.

The foreword will be incomplete, if Pierre Strosser's leadership and vision is not recognized. My commendations to Pierre and his team.

S. A. Prathapar
Research Coordinator
IIMI-Pakistan

ACKNOWLEDGEMENTS

The authors wish to acknowledge Dr. Pierre Strosser to continuous supervision and valuable guidance to the GIS/RS activities in Chishtian sub-division.

Most of our recognition goes to the field staff of Hasilpur and Bahawal Nagar field stations, for their constant and huge efforts to collect and to get in shape these data sets. Special thanks to Mr. Ghulam Rasool Shouq and Frank Schoenmaker for their accurate completion of the basic geographical data of this work, the watercourse coverage of Chishtian sub-division.

Authors wish to extend their thanks for the precious efforts and help of Gauhar Rehman, Asghar Hussain and SSP field staff for the development of the GIS database. Moreover, all collaborators from government agencies from where the secondary information has been obtained.

Authors appreciated the special editing care of Ms. Verenia Duke to bring this manuscript in the present form.

1 INTRODUCTION

This report describes *Metadata*[1] for different sets of information that have been collected in the Chishtian Sub-division to date, either by IIMI-Pakistan field staff or in collaboration with other organizations. Generally, *Metadata* is considered to be an extra and unnecessary task, but with long-term benefits. For example, if staff is substituted, new users could not exploit undocumented data, which may result to misleading conclusions.

This work is presented in two different volumes; the first pertains to *Metadata for the Chishtian Sub-division*, and the other, to *Metadata for Sample Watercourses*. Two main parts define its structures; an introductory explanation of the research's context, and the actual Metadata. These two volumes are complemented by one CDROM containing Metadata along with the GIS / digital database, available from the IIMI-Pakistan library.

1.1 Background

Research activities on the use of Geographical Information Systems (GIS) and Remote Sensing (RS) for irrigation management in the Chishtian Sub-division was initiated in 1995. With a gross command area of 75000 ha, it forms part of the Fordwah Eastern Sadiqia Irrigation System, which is confined by the Sutlej River in the northeast, the Indian border in the east, and the Cholistan Desert in the southeast (Figure 1).

These activities form part of the IIMI-Cemagref collaboration supported by the Government of France. In addition, these complement activities undertaken under other research programs and projects in the same area, such as *Managing Irrigation for Environmentally Sustainable Agriculture* funded by the Government of the Netherlands.

1.1.1 Research Activities

Research activities are organized around 4 different components, i.e.:

- Using GIS for spatial analysis of water supply performance;
- GIS and satellite imagery for the integrated approach;
- Satellite imagery for crop identification; and
- Satellite imagery and salinity monitoring.

These four components are described in further detail below.

[1] Generally speaking, *Metadata* refers the "data about data", describing the content, quality, condition, and other characteristics of data.

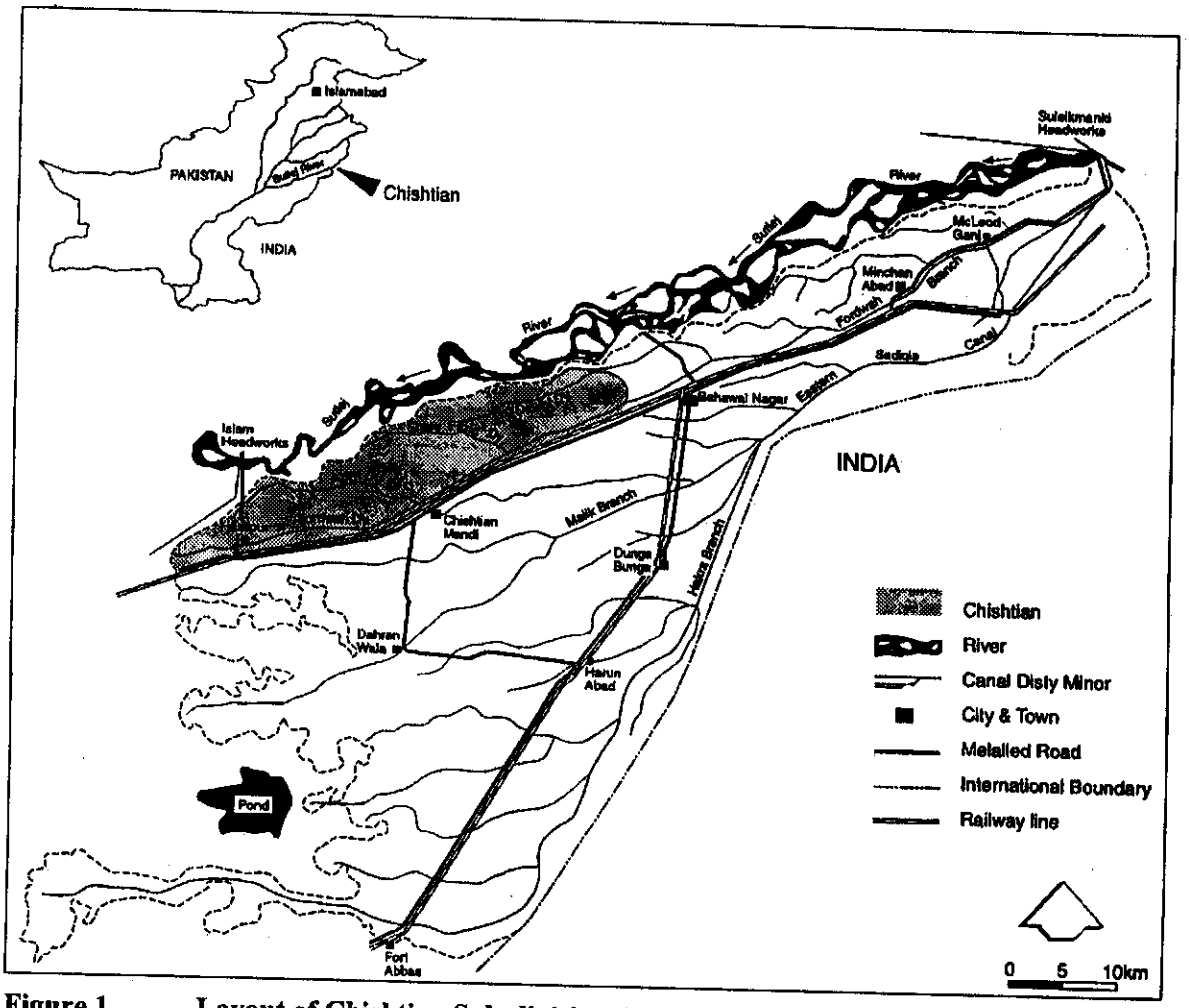


Figure 1. Layout of Chishtian Sub-division, Punjab.

1.1.2 Using GIS for Spatial Analysis of Water Supply Performance

The main objective of this research component is the analysis of irrigation system performance within the watercourse command area. The different variables integrated into the analysis include irrigation water supply (canal and tubewell), soil and salinity parameters, and agricultural production indicators (cropping patterns, yields, and gross margins). A sample of 8 watercourses along the Azim and Fordwah Distributaries has been selected for the analysis.

Allocation and distribution of canal water is analyzed at the plot, farm and landowner levels. Tubewell water supplies are then added to canal water supplies and compared to crop water requirements. Water stress and potential problems with the use of poor quality irrigation water are then spatially analyzed using GIS. Factors expected to influence water stress, crop production and salinity are included in the analysis. These factors include farm level characteristics (tubewell ownership, farm size, tenure status), physical factors (soil type), and spatial variables (such as distance from the head of the watercourse, or distance from tubewells).

1.1.3 GIS and Satellite Imagery in the Integrated Approach

In 1995, IIMI-Pakistan initiated an important research activity aimed at developing an integrated approach to assess the impact of changes in irrigation management on agricultural production, salinity and sodicity. This activity includes an analysis of the main physical and decision-making processes that take place within the irrigation system. Simulation and optimization models have been developed for the most important processes. The analysis of processes is coupled with the assessment of the present conditions in terms of physical characteristics (soils, groundwater quality, water-table depth), irrigation water supplies and agricultural production.

A large part of the efforts of this assessment was to develop a spatial database and an analysis of the spatial heterogeneity of the variables analyzed using GIS and statistical techniques. The information used for the analysis relates to different levels of the irrigation system (*killa*, farm, watercourse, soil unit, etc.) that are to be linked.

A watercourse-level database (520 watercourses) has been prepared to assess the present conditions. The database will be linked with simulation models to predict the impact of changes in irrigation management on agricultural production and salinity. The GIS is also used to present results of the simulations.

1.1.4 Satellite Imagery for Crop Identification

Although the potential for the use of satellite imagery in irrigation system management is often said to be large, so far, little has been tested in the field of irrigation in Pakistan. IIMI-Pakistan initiated activities on the use of satellite imagery for land use mapping and crop identification in 1995. The initial objectives were to test techniques applied elsewhere in the context of Pakistan, and also to train IIMI-Pakistan researchers in the use of hardware and software.

SPOT XS images were acquired for the Chishtian Sub-division in October 1994 and March 1995. Ground truth information was collected through a crop survey for 31 well-scattered watercourses. Supervised classification techniques were applied and land use classes obtained for the *Kharif* 1994 and *Rabi* 1994-95 seasons. Classification results permit the separation of cropped and non-cropped areas, but between crops, confusion still exists.

To date, the focus of the research has shifted from the application to the development of methodologies. The main question addressed during 1997-98, in the context of collaboration with the Watercourse Monitoring and Evaluation Directorate of WAPDA and Cemagref, relates to the identification of the appropriate methodology (satellite, frequency, ground truth information) to identify cropping intensity or cropping pattern at a given level of accuracy.

1.1.5 Satellite Imagery and Salinity Monitoring

Due to the size of the irrigation and drainage project currently undertaken in Pakistan, monitoring and evaluation of the impact of these projects on salinity is a difficult and time-consuming task. Often, it is difficult to attach any accuracy to the salinity indicators estimated from this information.

In this context, IIMI-Pakistan and Cemagref started activities on the use of satellite imagery for salinity monitoring in 1995. A classification procedure uses the vegetation and brightness indices derived from SPOT images (acquired in March 1995), and compares these values to levels of visual salinity collected through surveys.

With the classification obtained, highly saline areas are identified with good accuracy. However, results are less satisfying for cropped areas with low or medium salinity levels. In order to refine the analysis of the signal obtained from the satellite, a measurement campaign was organized in August 1997. Also, images from the Landsat satellite (with additional bands) were acquired. Final research results will be obtained in 1998 and compared to results of approaches developed by other organizations (e.g. Soil Survey of Pakistan, Directorate of Land Reclamation).

1.1.6 Collaborations

The research program on the use of GIS and remote sensing for irrigation management is jointly undertaken by the French research institute, Cemagref, with exchange information and results, visits, development of joint research studies, planning of research activities, etc..

More recently, efforts have focused on the development and strengthening of collaboration with Pakistani institutes. Organizations that have been associated with GIS / RS activities in the Chishtian Sub-division include; (i) SCARP Monitoring Organization (use of ground water data); (ii) Directorate of Land Reclamation (use of GIS for the development of reclamation programs); and, (iii) Soil Survey of Pakistan (soil mapping and salinity risk assessment).

Also, links have been established with the WAPDA Watercourse Monitoring and Evaluation Directorate (WMED). Technical assistance that IIMI-Pakistan has provided to WMED in the Fordwah / Eastern Sadiqia (South) Irrigation and Drainage Project includes joint activities initiated to develop an appropriate methodology to assess crop-related indicators at various levels of the irrigation system (from the pixel to the sub-division as a whole).

1.1.7 Training

CEMAGREF and IIMI-Pakistan researchers jointly developed training activities in France and Pakistan, respectively. Activities range from one week's training on the use of

the PC version of the Arc/Info software in Pakistan, to one month's training on the use of satellite imagery for crop classification in France.

Training has mainly been provided to IIMI-Pakistan researchers, WAPDA staff from the Watercourse Monitoring & Evaluation Directorate (WMED), staff from the Directorate of Land Reclamation, etc..

Training imparted to WMED staff, so far, has included:

(i) initial training in GIS concepts and digitizing techniques (1 year, on-the-job training);
(ii) one month's training, on the use of satellite imagery for crop identification, in France;
(iii) four months' training on the same subject, in Pakistan;
(iv) three weeks' training in the use of the PC Arc/Info software;
(v) one week's training on the use of satellite imagery for salinity monitoring; and
(vi) two days' theoretical introduction to remote sensing.

As there is a general increase in the demand for training in the use of (mainly) GIS and RS in Pakistan, one week's training on the *Use of GIS and RS for Irrigation Management* was organized by IIMI-Pakistan in 1997. Participants attending this training included staff from agencies and research institutes working in the fields of agriculture and water in Pakistan.

1.2 Metadata

Generally speaking, Metadata refers the "data about data", and describes the content, quality, condition, and other characteristics of data (FGDC, 1994). Metadata are comprehensive, systematic and deductive information about the content, the relationships, the representation, and the use context of the data stored in the underlying database (ESRI, 1995)[2]. Metadata is a toolbox containing geographical data that indicates if the data of one's interest is available and fit for use. But, it also provides a solution towards accessing and processing that data.

1.2.1 Why is Metadata so Strategic?

Metadata systems are application users-oriented; in a standard and concise form, it will provide the potential user with information about the adequacy of existing data to that of the actual need for study. Additional details about the data is not required, so that data pertaining to past projects do not lose its real value because of the absence of documentation (as frequently occurs in project-dependent organizations). With the passage of time, the lack of knowledge about existing data can lead to replication of studies.

[2] Endo, K., 1997. Metadata for a multi-disciplinary project. A case study in Alora, Spain. ITC. Wageningen, The Netherlands.

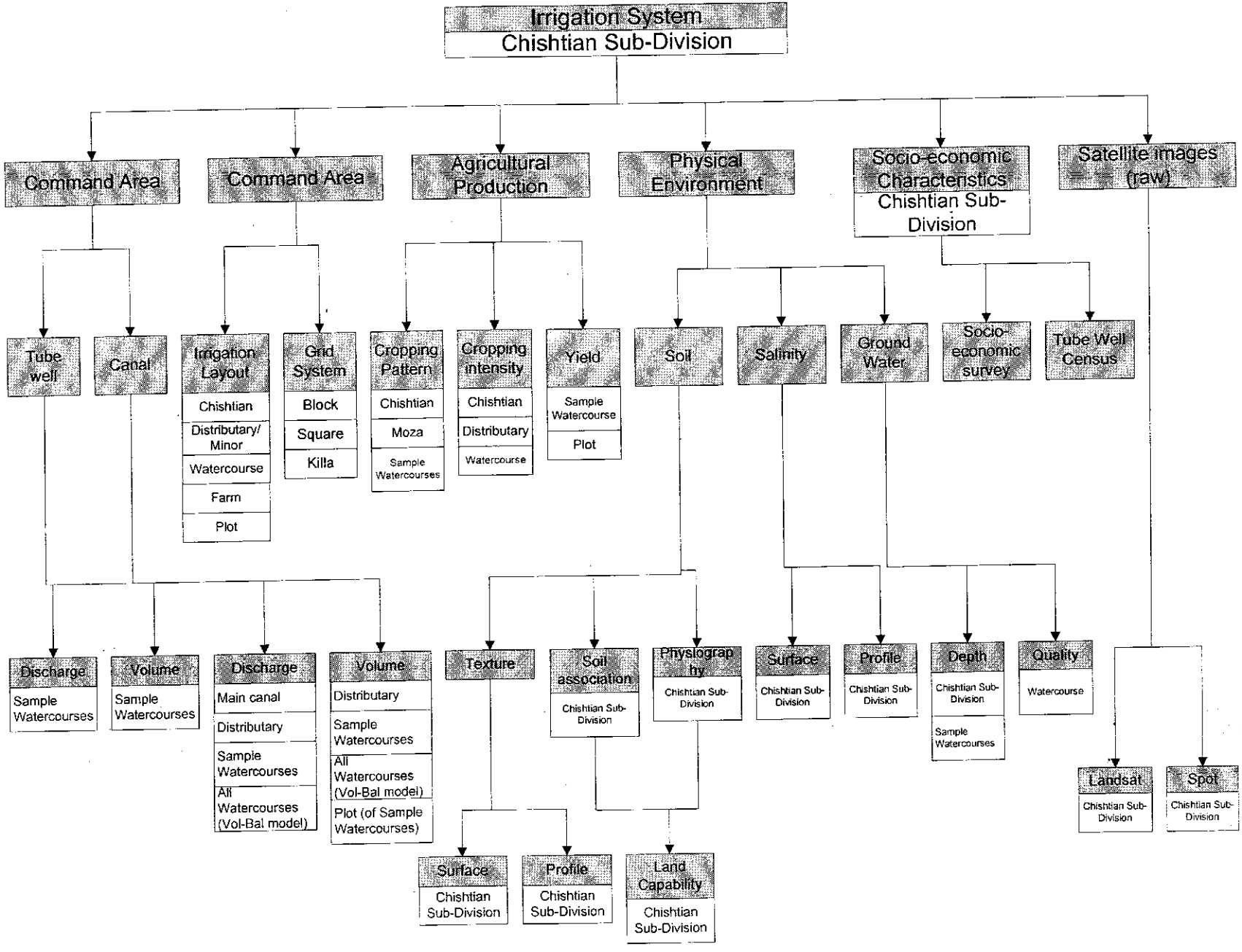
1.2.2 What Standard has been used?

The standard used has been referred to as Metadata developed in irrigation science. A comprehensive irrigation system geographical database developed in a study area in Spain is best suited to the present project in all aspects (data available, domain of activity and uses). However, the full Metadata is too developed for the real frame of applications in the Chishtian Sub-division, therefore, an effective and practical selection has been tailored to our requirements for future users.

1.3 Development of Metadata for the Chishtian Sub-division

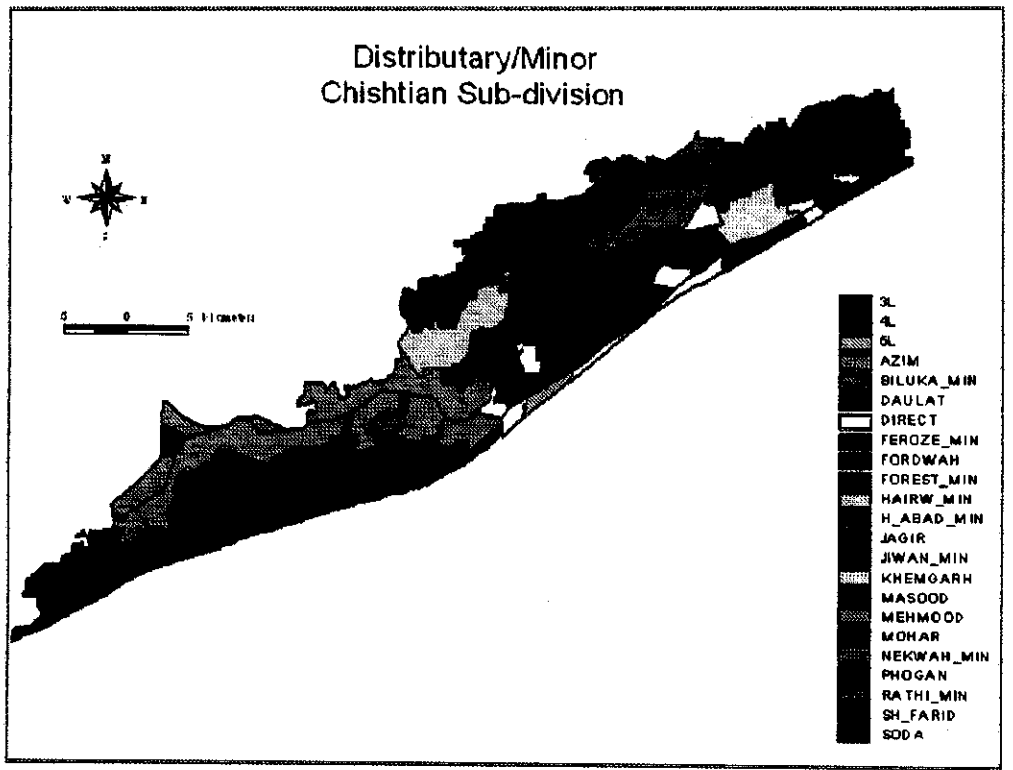
Considering the importance and utility of Metadata, it was decided to prepare a standard format of Metadata for IIMI-Pakistan, which would represent irrigation systems in Pakistan well. For information storage, two options, i.e. type and level, existed. Type of information refers to the physical environment, water supply, command area, agricultural production, socio-economic characteristics and satellite images. Whereas, level of information refers to irrigation sub-division, canal command, distributary, watercourse, field and / or block, square and *killa*. Finally, a structure, which takes both categories into account, has been developed (shown in the following flow chart). In this figure, shaded portions represent *type* of information, and white boxes, *level* of information.

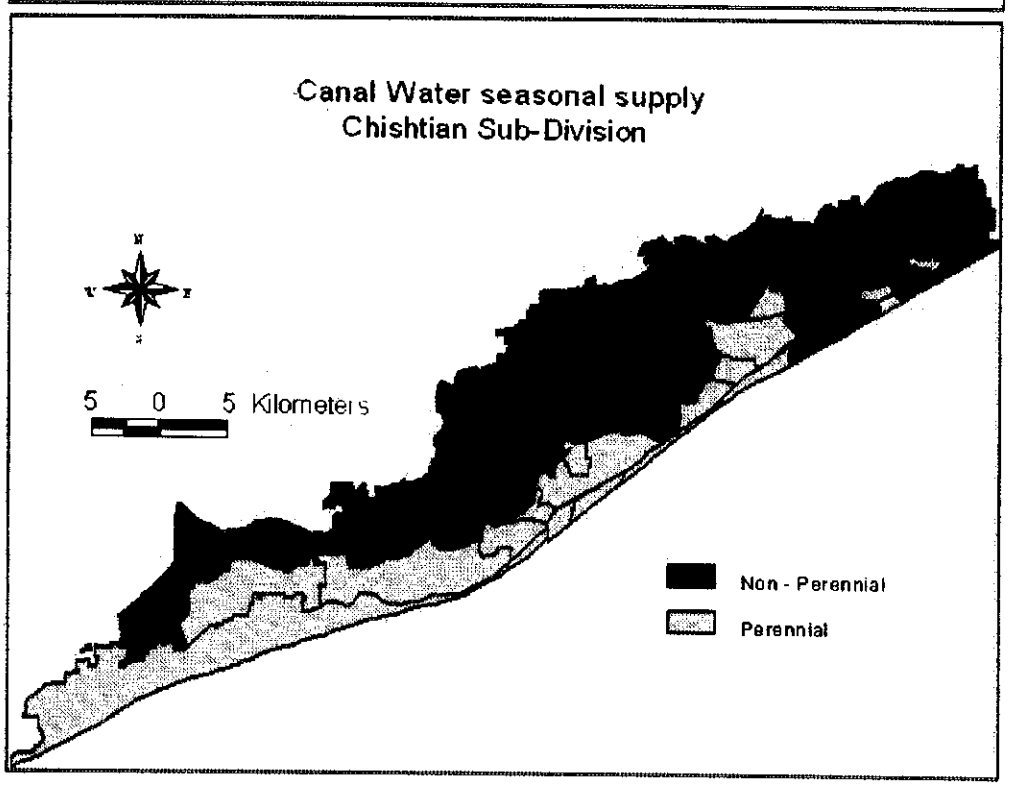
Once the overall structure was finalized, a proforma, comprising different components, i.e. data set identification, data set overview, data set quality information, object type, attribute type, organization and organization role, point of contact and point of contact role, distribution and Metadata reference, was developed. For now, as described in the Metadata, the following data is available.

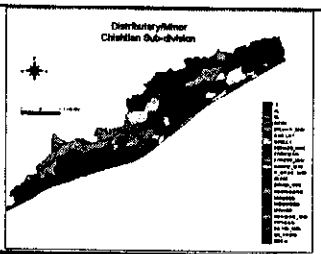

Irrigation System
Chishtian Sub-Division
Command Area
Command Area
Agricultural Production
Physical Environment
Socio-economic Characteristics
Chishtian Sub-Division
Satellite Images (raw)
Tube well
Canal
Irrigation Layout
Chishtian
Distributary/ Minor
Watercourse
Farm
Plot
Grid System
Block
Square
Killa
Cropping Pattern
Chishtian
Moza
Sample Watercourses
Cropping intensity
Chishtian
Distributary
Watercourse
Yield
Sample Watercourse
Plot
Soil
Salinity
Ground Water
Socio-economic survey
Tube Well Census
Discharge
Sample Watercourses
Volume
Sample Watercourses
Discharge
Main canal
Distributary
Sample Watercourses
All Watercourses (Vol-Bal model)
Volume
Distributary
Sample Watercourses
All Watercourses (Vol-Bal model)
Plot (of Sample Watercourses)
Texture
Soil association
Chishtian Sub-Division
Physiography
Chishtian Sub-Division
Surface
Chishtian Sub-Division
Profile
Chishtian Sub-Division
Depth
Chishtian Sub-Division
Sample Watercourses
Quality
Watercourse
Landsat
Chishtian Sub-Division
Spot
Chishtian Sub-Division
Surface
Chishtian Sub-Division
Profile
Chishtian Sub-Division
Land Capability
Chishtian Sub-Division

2 DISTRIBUTARY / MINOR

Chishtian Sub-division (Processed data)





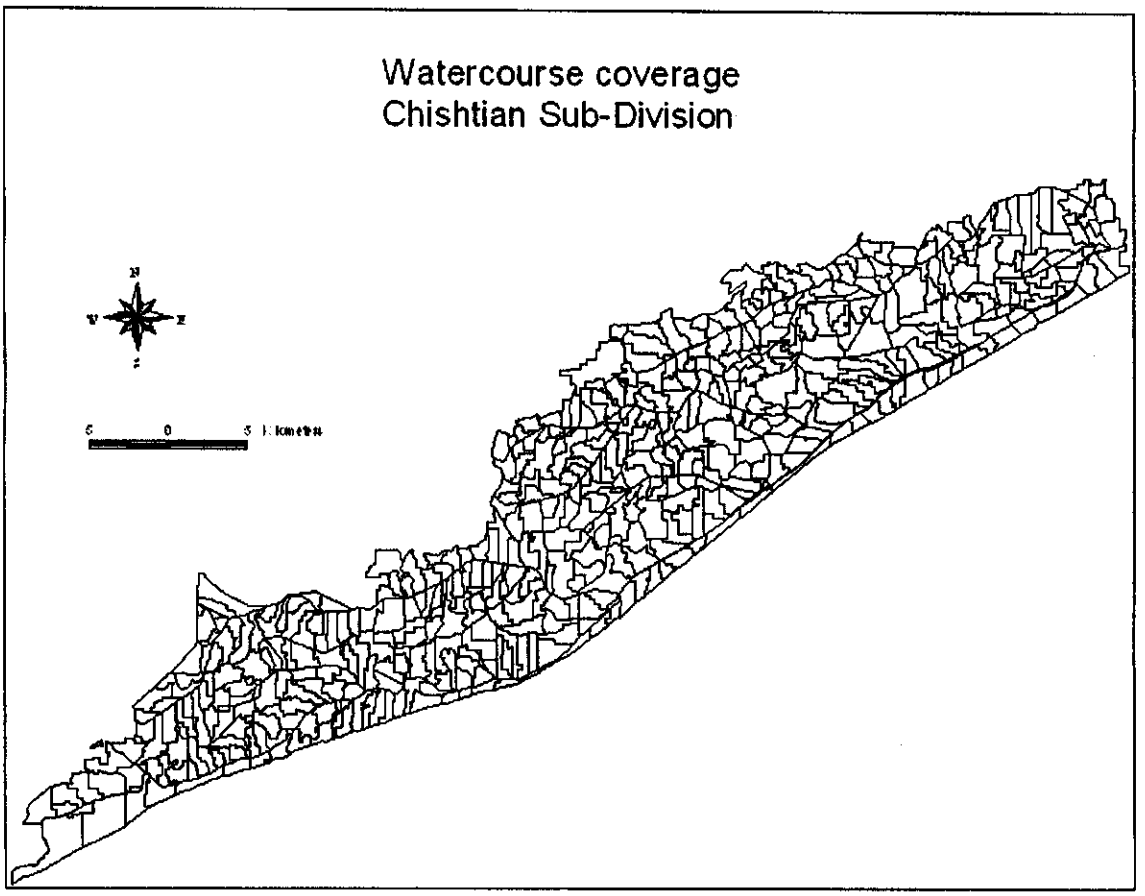
Metadata	Description
2.1 Data set identification	
Data set title	Distributary / Minor coverage of Chishtian
Physical name	\DB-chishtian\Command area\Irrigation layout\Distributary-Minor └── \covs └── \chtdst
Format	PC Arc/Info coverage
2.2 Data set overview	
Abstract	This data set is the secondary level irrigation unit (distributary/minor) aggregation coverage for the Chishtian Sub-division. Irrigation canals have been indicated in the coverage.
Purpose of production	All studies at the secondary level of information for the Chishtian Sub-division, in cases of spatial data sets, have been using this coverage.
Usage	Used by Frank Schoenmaker, Marcel Kuper, Pierre Strosser Period: 1995 to 1998 This spatial database is prepared by Salman Asif and Frank Schoenmaker.
Geographical extent	Chishtian Sub-division irrigation system
Temporal extent	
From date	April 16, 1996
To date	October 12, 1996
Output document	Pierre Strosser: "Integrated Approach for Management of Irrigation Systems" Reference of raw information: Data sources are canal command maps from the Punjab Irrigation Department.
Document reference	
Sample	
2.3 Data set quality indicators	
Process history	• **DATA ENTRY:** Data has been digitised and checked from canal command maps of the Punjab Irrigation Department by IIMI-Pakistan staff. **DATA PROCESSING:** Data has been extracted from the Chishtian Watercourse Coverage to ascertain the distributary / minor boundaries.
Overall positional accuracy	Geo-referencing, according to the Chishtian Watercourse Coverage (reference coverage for Chishtian).
Overall thematic accuracy	Positive identification of the distributary names, for

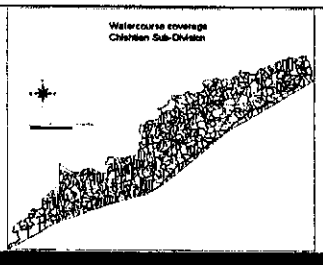
	accuracy, has been checked from the field.
Overall temporal accuracy	The validity of the secondary units' boundaries has good stability over one or two decades, even if the riverbank has variations. Indeed, floods change the shape of the river's meanders, which can enter the irrigation system.
Overall completeness	Available for the whole Chishtian Sub-division.
2.4 Object type	Geographical object
Object type name	Boundary of the distributary and minors for the Chishtian Sub-division.
Object type definition	Boundary of the secondary irrigation units (distributary and minors) for the Chishtian Sub-division irrigation system.
Object type code	Chtdst
2.5 Attribute type	DBF fields
Attribute type name	DISTY
Attribute type definition	Names of distributary and minor
Attribute type code	3L (distributary) 4L (distributary) 5L (distributary) AZIM (distributary) BILUKA_MIN (minor) DAULAT (distributary) DIRECT (distributary) FEROZE_MIN (minor) FORDWAH (distributary) FOREST_MIN (minor) H_ABAD_MIN (Hussain Abad Minor) HAIRW_MIN (Hairwah Minor) JAGIR (distributary) JIWAN_MIN (minor) KHEMGARH (distributary) MASOOD (distributary) MEHMOOD (distributary) MOHAR (distributary) NEKWAH_MIN (minor) PHOGAN (distributary) RATHI_MIN (minor) SH_FARID (Shahar Farid Distributary) SODA (distributary)
Thematic accuracy	Thematic accuracy for attributes is good.
2.6 Organization and organization role	Data collection
Organization name	Punjab Irrigation and Power Department
Organization abbreviation name	ID
Organization address	Head Office Secretary, Punjab Irrigation and Power Department Irrigation Secretariat Old Anarkali Lahore Phone: (92 42) 7354993 / 7354165 Fax: (92 42) 7323897
Organization role	PID staff has made and updated the maps every five years.
Function of the organization	The Irrigation and Power Department has been assigned the following major functions: • Maintaining and operating irrigation systems

	• Operation and management of SCARPs, improvement / maintenance of drainage systems, land reclamation, etc. • Flood control and flood protection measures • Regulation of river flows and hydrological observation • Administration of Electricity Act, 1910, Electricity Rules, 1937, and other related matters
Organization and organization role	Data entry and analysis
Organization name	International Irrigation Management Institute
Organization abbreviation name	IIMI-Pakistan
Organization address	12 km Multan Road Lahore, 53700 Phone: (042) 541-0050-53 Fax: (042) 541-0054 E-mail: iimi-pak@cgiar.org
Organization role	IIMI-Pakistan staff entered and analyzed the data.
Function of the organization	IIMI-Pakistan's mission is to improve food security and the lives of poor people by fostering sustainable increases in the productivity of water used in agriculture through better management of irrigation and water basin systems.
2.7 Point of contact and point of contact role	
Point of contact name	Director
Point of contact address	12 km Multan Road Lahore, 53700 Phone: (042) 541-0050-53 Fax: (042) 541-0054 E-mail: iimi-pak@cgiar.org
Point of contact role	Director, IIMI-Pakistan
2.8 Distribution	
Restrictions on use	Prior permission from the Director, IIMI-Pakistan, and acknowledgements in the published document.
Copyright owners	IIMI-Pakistan
Media	Hard and soft copies; whole data set on CD-ROM.
Formats	Arc/Info Coverage
Order	Request to the Director, IIMI-Pakistan
Support services	Not available at the moment.
2.9 Metadata reference	
Entry date	November 21, 1997
Last check date	November 21, 1997
Last update date	November 21, 1997

3 WATERCOURSES

Chishtian Sub-division



Metadata	Description
3.1 Data set identification	
Data set title	Watercourse coverage of the Chishtian Sub-division
Physical name	\DB-chishtian\Command area\Irrigation layout\Watercourse └── \covs └── \chtwc
Format	PC Arc/Info coverage
3.2 Data set overview	
Abstract	This data set is the tertiary level irrigation unit (watercourse) aggregation coverage for the Chishtian Sub-division. Irrigation canals have been indicated in the coverage. This coverage is the reference coverage for the geographical position of the geo-referenced database.
Purpose of production	All the studies at the secondary and tertiary levels of information for the Chishtian Sub-division, in the case of spatial data sets are using this coverage.
Usage	Everybody conducting spatial analysis on the Chishtian Sub-division irrigation system. Period: 1995 to 1998 This spatial database is prepared by Frank Schoenmaker, Salman Asif, Mobin-ud-Din Ahmad and Asghar Hussain.
Geographical extent	The Chishtian Sub-division irrigation system.
Temporal extent	
From date	April 16, 1996
To date	October 15, 1996
Output document	All output documents of the database have been using this coverage.
Document reference	
Sample	
3.3 Data set quality indicators	
Process history	• **DATA ENTRY:** Data has been digitised from Irrigation Department canal command maps, and watercourse boundaries have been checked from the field by IIMI-Pakistan staff. The correction of the Irrigation Department map for each watercourse took a very long time; the names had been checked and corrected several times, until accuracy had been achieved. • **DATA PROCESSING:** Geo-referencing has been performed from the Spot images of March 1995.

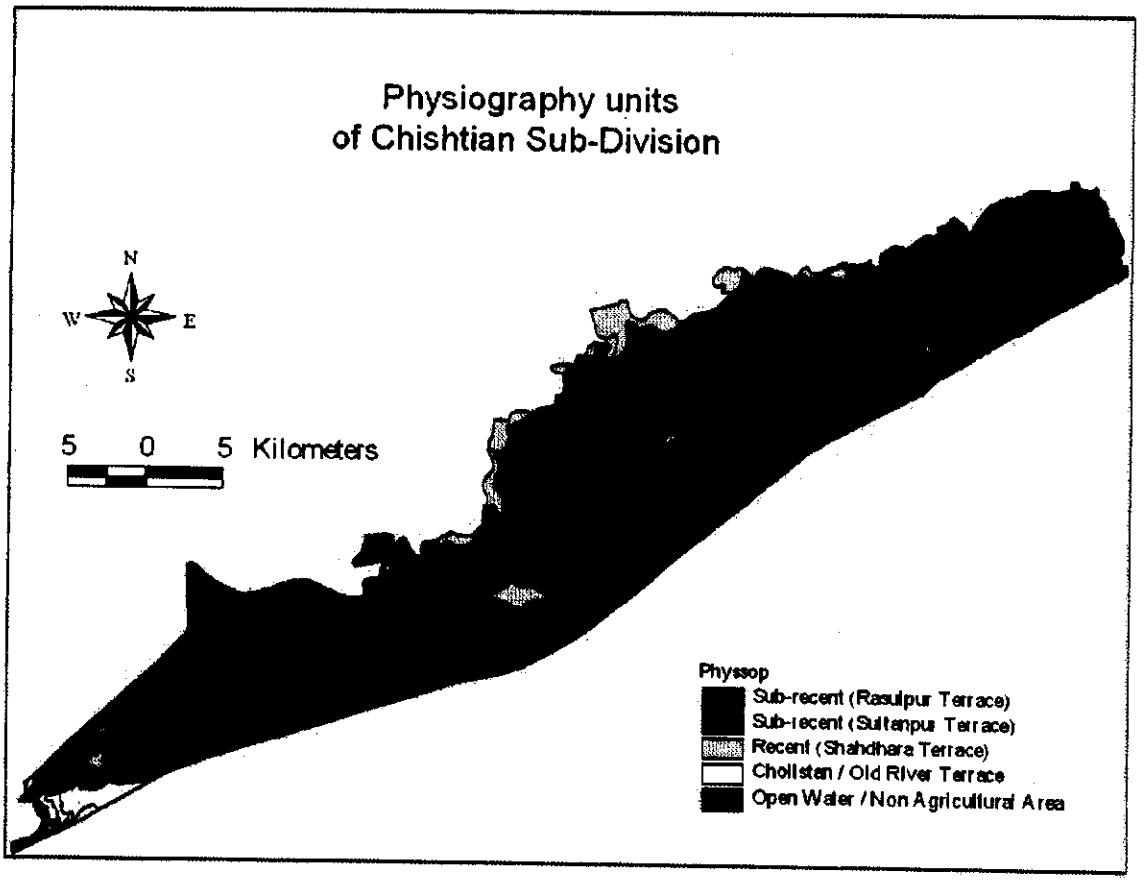
Overall positional accuracy	Geo-referencing according to the SPOT satellite imagery. The accuracy is improving from southwest up to northeast. The major inaccuracy is well observed on the Forest Minor and its surrounds, mainly attributed to repositioning digitized coverage from maps to the satellite image.
Overall thematic accuracy	The names of the watercourses (the abbreviated name of the distributary, followed by the outlet number) have been checked several times; the accuracy is satisfactory. Right, "R", or left, "L", indicates the side of the canal on which the watercourse is located. This has been checked thoroughly, and is satisfactory.
Overall temporal accuracy	Valid for the season during which the survey was conducted (*Kharif* 1996). Watercourses have moving boundaries and outlet names also change with time. Therefore, it is difficult to expand the life span of this coverage for data encompassing several years. Safe use would be for ± 3 seasons.
Overall completeness	Available for the whole Chishtian Sub-division.
3.4 Object type	Geographical object
Object type name	Watercourses of the Chishtian Sub-division.
Object type definition	Tertiary units of the Chishtian Sub-Division's irrigation system.
Object type code	Chtwc
3.5 Attribute type	DBF fields
Attribute type name	Watercourse identification
Attribute type definition	To positively identify watercourses by different indicators, as well as the ability to aggregate these watercourses by different indicators easily, without too much time spent on spreadsheet recalculation.
Attribute type code	1)*OUTLET:* 01234 Y **01234** = Distance in feet between the outlet and the head of the canal where the outlet takes water in. **Y** = Canal side where the watercourse takes water in. • **Y:** C = Center (also F = front) L = Left R = Right T = Tail 2)*DISTRIBUTARY:* 3L (distributary) 4L (distributary) 5L (distributary) AZIM (distributary) BILUKA_MIN (minor) DAULAT (distributary) DIRECT (distributary) FEROZE_MIN (minor) FORDWAH (distributary) FOREST_MIN (minor) H_ABAD_MIN (Hussain Abad Minor) HAIRW_MIN (Hairwah Minor) JAGIR (distributary) JIWAN_MIN (minor)

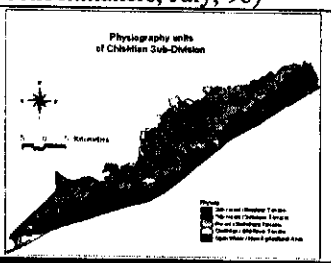
	KHEMGARH (distributary) MASOOD (distributary) MEHMOOD (distributary) MOHAR (distributary) NEKWAH_MIN (minor) PHOGAN (distributary) RATHI_MIN (minor) SH_FARID (Shahar Farid Distributary) SODA (distributary) *3)DISTRIBUTARY_NUMBER:* Color code for visualization of the distributary with hidden minors. *4)DISTRIBUTARY MINOR:* Color code for visualization of the distributary and minors. *5)CODE:* Abbreviated name of the Distributary / Minor: 3L = 3L 4L = 4L 5L = 5L AZ = Azim BK = Biloka Minor DO = Direct Outlet DT = Daulat FD = Fordwah FS = Forest Minor FZ = Feroze Minor HA = Hussain Abad Minor HW = Heerwah Minor JG = Jagir JW = Jiwan Minor KG = Khem Garh MH = Mohar MM = Mahmood MS = Masood NK = Naikwah Minor PG = Phogan RT = Rathi Minor SD = Soda SF = Shahar Farid 6)LINK: Universal link following the "**XX 01234 Y**" format: **XX** = Distributary abbreviation, see 5 CODE **01234** = see 1)OUTLET **Y** = see 1)OUTLET
Thematic accuracy	Data has been checked sufficiently to ascertain its accuracy.
3.6 Organization and organization role	Data collection
Organization name	International Irrigation Management Institute
Organization abbreviation name	IIMI-Pakistan
Organization address	12 km Multan Road Lahore, 53700

	Phone: (042) 541-0050-53 Fax: (042) 541-0054 E-mail: iimi-pak@cgiar.org
Organization role	IIMI-Pakistan entered and analyzed the data.
Function of the organization	IIMI-Pakistan's mission is to improve food security and the lives of poor people by fostering sustainable increases in the productivity of water used in agriculture through better management of irrigation and water basin systems.
Organization and organization role	Data entry and analysis
Organization name	Punjab Irrigation and Power Department
Organization abbreviation name	ID
Organization address	Head Office Secretary, Punjab Irrigation and Power Department Irrigation Secretariat Old Anarkali Lahore Phone: (92 42) 7354993 – 7354165 Fax: (92 42) 7323897
Organization role	PID staff has made and updated the maps every five years.
Function of the organization	The Irrigation and Power Department has been assigned the following major functions: • Maintaining and operating irrigation systems • Operation and management of SCARPs, improvement / maintenance of drainage systems, land reclamation, etc. • Flood control and flood protection measures • Regulation of river flows and hydrological observation • Administration of Electricity Act, 1910, Electricity Rules, 1937, and other related matters
3.7 Point of contact and point of contact role	
Point of contact name	Director
Point of contact address	12 km Multan Road Lahore, 53700 Phone: (042) 541-0050-53 Fax: (042) 541-0054 E-mail: iimi-pak@cgiar.org
Point of contact role	Director, IIMI-Pakistan
3.8 Distribution	
Restrictions on use	Prior permission from the Director, IIMI-Pakistan, and acknowledgements in the published document.
Copyright owners	IIMI-Pakistan
Media	Hard and soft copies; whole data set on CD-ROM.
Formats	Arc/Info Coverage
Order	Request to the Director, IIMI-Pakistan
Support services	Not available at the moment
3.9 Metadata reference	
Entry date	September 19, 1997
Last check date	December 03, 1997
Last update date	December 03, 1997

4 PHYSIOGRAPHY (SSP)

Chishtian Sub-division **(Processed data)**



Metadata	Description
4.1 Data set identification	
Data set title	Physiography coverage of the Chishtian Sub-division
Physical name	\DB-chishtian\Physical environment\Soil \Physiography\ └── \SSP └── \covs └── \Physsop
Format	PC Arc/Info coverage
4.2 Data set overview	
Abstract	This is a physiography and texture type data set, which describes the boundaries of the geomorphology for the Chishtian Sub-division Irrigation System. The texture type has been taken into account to assess the physiography, therefore, it has been included in the processed coverage.
Purpose of production	The use of physiography information for modeling purposes was undertaken in the "Integrated Approach for Irrigation Management".
Usage	Used by Frank Schoenmaker, Marcel Kuper, and Pierre Strosser. Period: August 1996 to February 1998 This spatial database is prepared by Frank Schoenmaker.
Geographical extent	Aerial-photo data and ground survey for the whole Chishtian Sub-division has been collected and analyzed.
Temporal extent	
From date	1996
To date	1996
Output document	Frank Schoenmakers' MSc Thesis on Geographic Information Systems: "GIS in an integrated approach to study irrigation system performance". Reference of processed information: Coverage of Salinity and Land Capability.
Document reference	Arc/Info coverage on the Chishtian Sub-division (Frank Schoenmakers, July, 96)
Sample	
4.3 Data set quality indicators	
Process history	• **DATA ENTRY:** Map polygons and attributes of digitized / entered polygons by IIMI-Pakistan staff. Regular corrections provided by SSP staff enabled matching the classes to the objectives better.

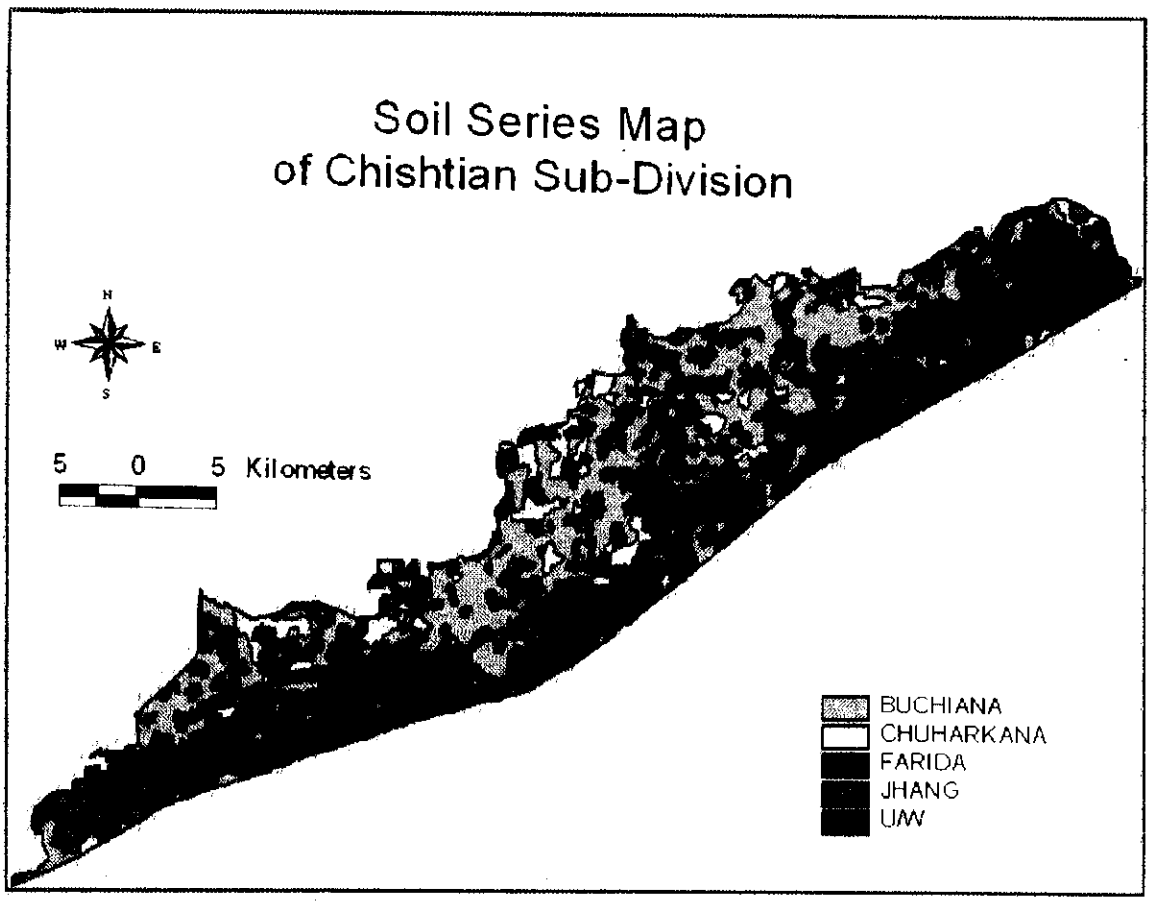
	• **DATA PROCESSING:** Reclassification of the soil types from ground survey, according to the soil texture and geomorphology observations, had provided the physiography data described here.
Overall positional accuracy	Geo-referencing, according to the Chishtian Watercourse Coverage (reference coverage for Chishtian).
Overall thematic accuracy	Boundaries between the main landforms (terraces) are quite accurate (50 to 75 meters). The boundaries of smaller and longitudinal units, those with more stereo differences and those with significantly different textural classes, are more accurate.
Overall temporal accuracy	The boundaries of units are not changing over time, except in cases of fresh large-scale floods that could spread recent terraces.
Overall completeness	Available for the whole Chishtian Sub-division.
4.4 Object type	Geographical object
Object type name	Soil physiography and textural units
Object type definition	Texture, origins and geomorphology are the object types. Physiography units are geomorphology classes where the main characteristic used is texture.
Object type code	Phys
4.5 Attribute type	DBF fields
Attribute type name	1. NEWLEG 2. PHYSIO 3. TEXTURE
Attribute type definition	1. Soil legend classes 2. Physiography classes 3. Texture classes
Attribute type code	1)*NEWLEG:* Aw8/W3: Awagat, Water table 50-100cm Aw8/W4: Awagat, Water table 100-150cm Ch: Cholistan Ch-DLx: Cholistan-Dune Land complex Di: Dungi DL: Dune Land Gd: Gandhara GY: Grave Yard HM: Habitat Mound Hr: Haroonabad Hr(ss): Haroonabad (saline-sodic) Hr/W3: Haroonabad, Water table 50-100cm Hr/W4: Haroonabad, Water table 100-150cm Jg: Jhang Jg-DLx: Jhang-Dune Land Complex Jk: Jhakkar Jk-Adx: Jhakkar-Adilpur Complex Jk-Dix: Jhakkar-Dungi Complex Jk-Stx: Jhakkar-Satghara Complex Mi: Miani Mi-Pcx: Miani-Pacca Complex Mk: Makai ML: Marsh Land Mr/W4: Mariala, Water table 100-150cm Nb: Nabipur

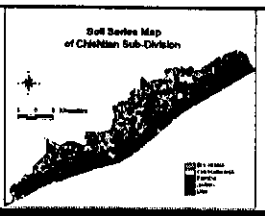
	OW: Open Water Pc: Pacca Rs: Rasulpur Rs(ss): Rasulpur (saline-sodic) Rs(ss)/W3: Rasulpur (saline-sodic) Rs/W3: Rasulpur Rs/W4: Rasulpur Rs-DLx: Rasulpur-Dune Land Complex Sd: Sodhra Sd(mt): Sodhra medium textured Sd(mt)/W4: Sodhra medium textured, Water table 100-150cm Sh: Shadhra Su: Sultanpur Su(ss): Sultanpur (saline-sodic) 2)*PHYSIO:* 1: Sub-recent [1]/Rasulpur terrace 2: Sub-recent [2]/Sultanpur terrace 3: Recent/Shadhra terrace 4: Cholistan 3)*Texture:* 1: Moderately coarse 2: Medium 3: Medium fine 4: Fine
Thematic accuracy	The accuracy of attributes observed directly, like that of soil types and physiography, are linked to the overall accuracy of the data set. The accuracy of the attribute texture is variable, in consideration of the aggregation that has been undertaken.
4.6 Organization and organization role	Data collection
Organization name	Soil Survey of Pakistan
Organization abbreviation name	SSP
Organization address	12 km Multan Road Lahore, 54780 Phone: 042-78 43 691 Fax: 042-78 32 209
Organization role	Data was originated by SSP
Function of the organization	Survey of all related soil sciences in Pakistan
Organization and organization role	Data entry and analysis
Organization name	International Irrigation Management Institute
Organization abbreviation name	IIMI-Pakistan
Organization address	12 km Multan Road Lahore, 53700 Phone: (042) 541-0050-53 Fax: (042) 541-0054 E-mail: iimi-pak@cgiar.org
Organization role	IIMI-Pakistan entered and analyzed the data.
Function of the organization	IIMI-Pakistan's mission is to improve food security and the lives of poor people by fostering sustainable increases in the productivity of water used in agriculture through better management of irrigation and water basin systems.

4.7 Point of contact and point of contact role	
Point of contact name	Director
Point of contact address	12 km Multan Road Lahore, 53700 Phone: (042) 541-0050-53 Fax: (042) 541-0054 E-mail: iimi-pak@cgiar.org
Point of contact role	Director, IIMI-Pakistan
4.8 Distribution	
Restrictions on use	Prior permission from the Director, IIMI-Pakistan, and acknowledgements in the published document.
Copyright owners	IIMI-Pakistan
Media	Hard and soft copies; whole data set on CD-ROM.
Formats	Arc/Info Coverage
Order	Request to the Director, IIMI-Pakistan
Support services	Not available at the moment
4.9 Metadata reference	
Entry date	December 01, 1997
Last check date	December 03, 1997
Last update date	December 01, 1997

5 *PROFILE TEXTURE (WAPDA)*

Chishtian Sub-division



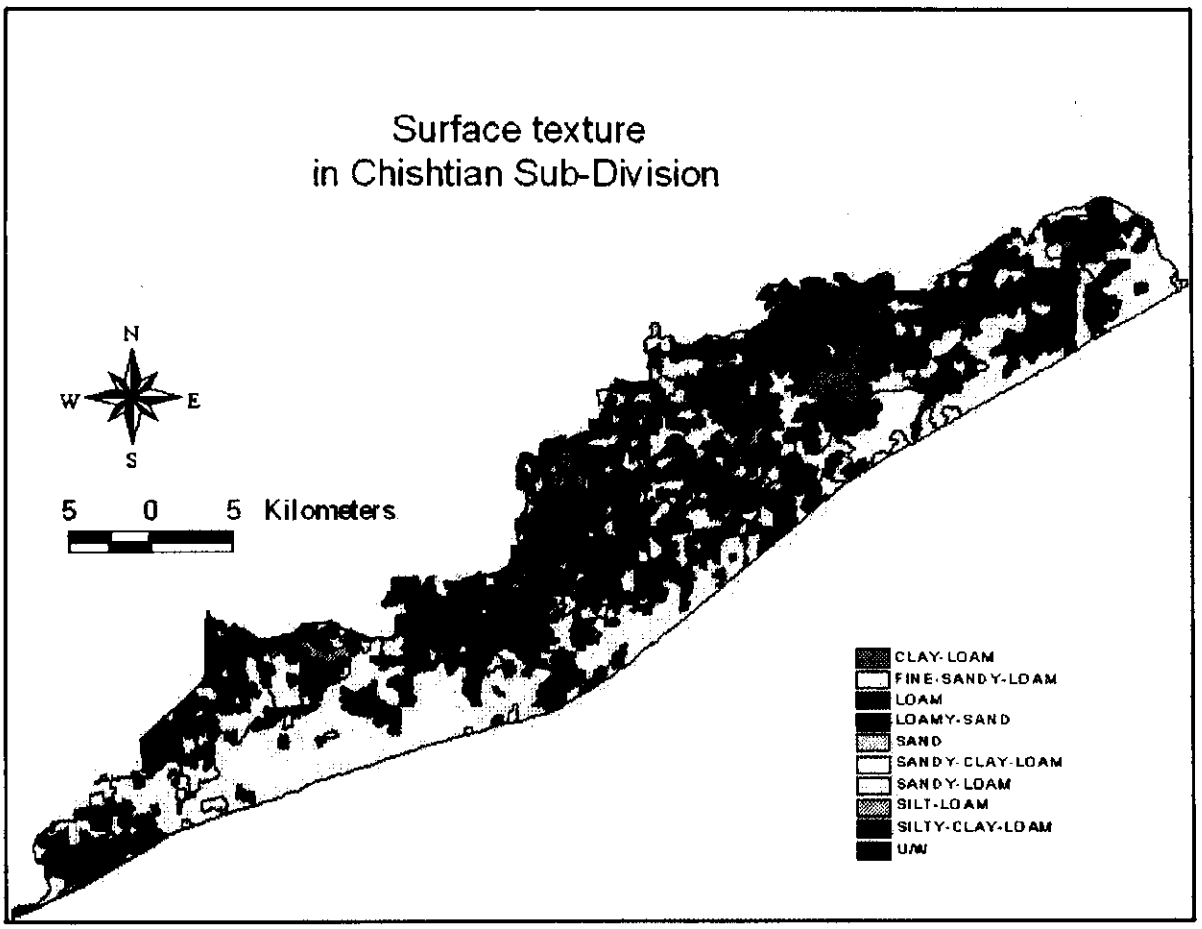
Metadata	Description
5.1 Data set identification	
Data set title	Soil Series
Physical name	\DB-Chishtian\Physical Environment\Soil\Texture\Profile\Sub-division └ \SERIES
Format	Arc/Info
5.2 Data set overview	
Abstract	This coverage contains the dominant soil texture in the top six feet of the Chishtian Sub-division.
Purpose of production	The use of soil information as a layer in several analyses undertaken in the Chishtian Sub-division irrigation management project.
Usage	This information is used to determine the different types of soil textures in various parts of the irrigation system. This information is also used as ground truth in image processing to segregate the sand in several saline areas. Mobin-ud-Din Ahmad, Irrigation Engineer, International Irrigation Management Institute, IIMI-Pakistan prepared the Spatial Database.
Geographical extent	This database is prepared for the Chishtian Sub-division.
Temporal extent	
From date	1955
To date	1960
Output document	"Use of Satellite Image for Soil Salinity Monitoring", Dunia Tabet, M.Sc. thesis. "Geo-spatial Assessment of Soil Salinity and its Multi-criterion Physical Constraints: A case study in the Fordwah/Eastern Sadiqia Irrigation System, Punjab, Pakistan", Iftikhar Ahmad, M.Sc. thesis, August 1996, Asian Institute of Technology, Bangkok.
Document reference	
Sample	
5.3 Data set quality indicators	
Process history	• **DATA COLLECTION** The data set was based on the survey conducted by the Water and Soil Investigation Division (WASID) during 1955-60. Originally, this map was prepared at the scale of 1:63,360 (1 inch = 1mile). WASID was responsible for surveying. This information is now available with SCARP Monitoring Organization (SMO). • **DATA ENTRY** This information was collected from SMO in map form. IIMI-Pakistan previously digitized this information in ILWIS software. This map was then converted into Arc/Info format through AutoCAD. This coverage was transformed in accordance with the existent geo-referenced watercourse coverage with respect to Satellite Image.

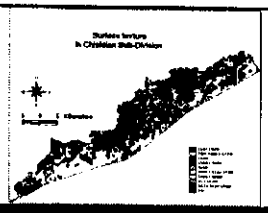
Overall positional accuracy	Location of the water lakes on the coverage does not correspond with the satellite image.
Overall thematic accuracy	As this information was collected based on the survey of sample locations, the extent of objects may, in reality, differ.
Overall temporal accuracy	
Overall completeness	Chishtian Sub-division
5.4 Object type	
Object type name	Area under a specific soil series
Object type definition	Based on the type of soil texture in the soil profile, different soil series are prepared.
Object type code	Soilseries1
5.5 Attribute type	
Attribute type name	Soil series
Attribute type definition	The area has been classified into five different classes/series based on the soil texture.
Attribute type code (Name and definition)	Jhang Coarse Soil Farida Moderately Coarse Buchiana Medium Chuharkana Moderately Medium Nokhar Fine U/W Area Under Water
5.6 Organization and organization role	Data Collection
Organization name	Water and Soil Investigation Division
Organization abbreviation name	WASID
Organization address	Water and Power Development Authority, WAPDA
Organization role	The data collected by WASID through intensive field surveys.
Function of the organization	To conduct the survey of irrigated areas and to collect information about waterlogging and salinity.
Organization and organization role	Data entry and analysis
Organization name	International Irrigation Management Institute
Organization abbreviation name	IIMI
Organization address	International Irrigation Management Institute (IIMI-Pakistan) 12 km Multan Road Chowk Thokhar Niaz Baig Lahore-53700 Pakistan Phone: (042) 541-0050-53 Fax: (042) 541-0054 Email: IIMI-Pakistan<iimi-pak@cgiar.org>
Organization role	Preparation of digital database and spatial analysis.
Function of the organization	IIMI-Pakistan's mission is to improve food security and the lives of poor people by fostering sustainable increase in the productivity of water used in agriculture through better management of irrigation and water basin systems.
5.7 Point of contact and point of contact role	
Point of contact name	Chief Engineer
Point of contact address	SCARP Monitoring Organization (SMO) Canal Bank Mughal Pura Lahore (Pakistan) Phone: 6823013, 6823035

Point of contact role	SMO is responsible for the collection and management of all the information related to waterlogging and salinity in the Indus Basin.
5.8 Distribution	
Restrictions on use	Prior permission from the Director, IIMI-Pakistan, and Chief Engineer, SMO, is required.
Copyright owners	IIMI-Pakistan, SMO
Media	Hard and soft copies may be available on CDROM.
Formats	Arc/Info
Order	Request to the Director, IIMI-Pakistan
Support services	Not available at the moment
5.9 Metadata reference	
Entry date	August 13, 1997
Last check date	September 10, 1997
Last update date	August 17, 1998

6 *SURFACE TEXTURE (WAPDA)*

Chishtian Sub-division



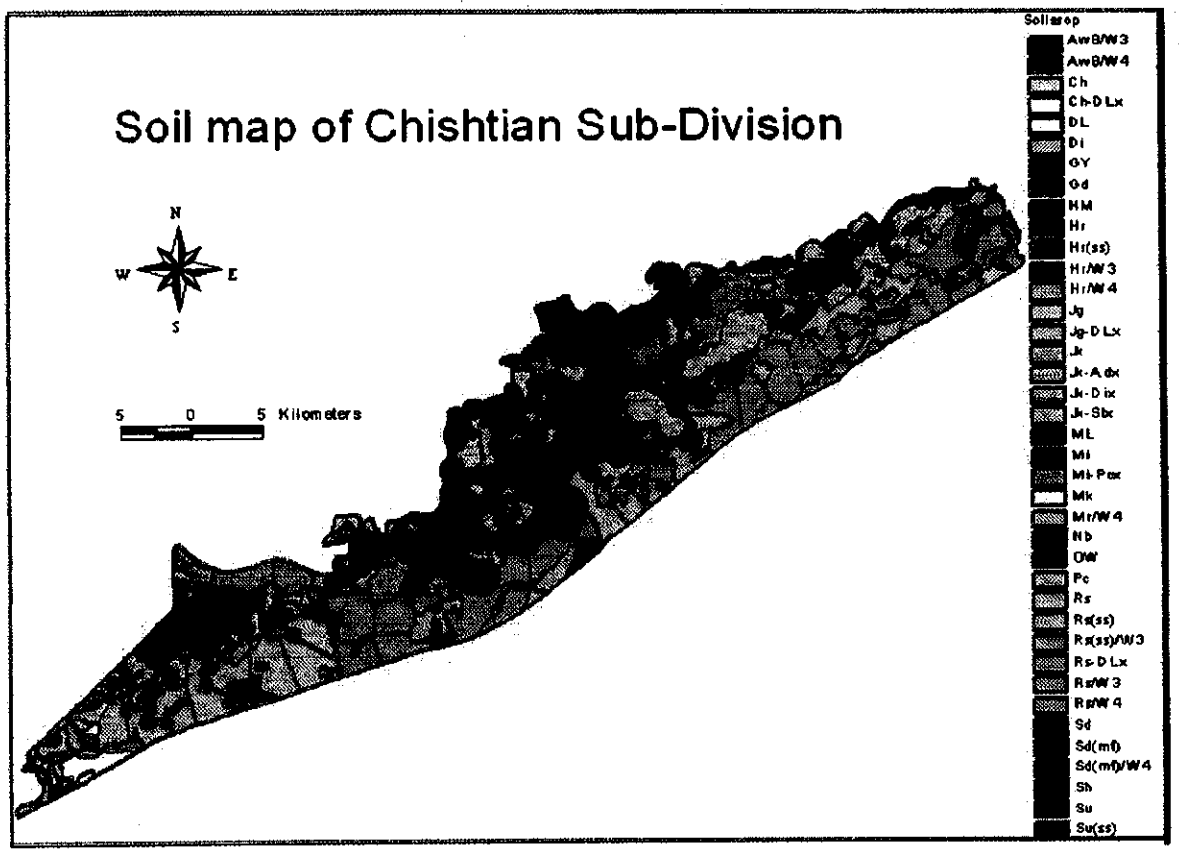
Metadata	Description
6.1 Data set identification	
Data set title	Surface Soil Texture
Physical name	\DB-Chishtian\Physical Evironment\Soil\Texture\surface\Sub-Division └ Surtext
Format	Arc/Info
6.2 Data set overview	
Abstract	This coverage contains the soil texture information pertaining to the top six inches in the Chishtian Sub-division.
Purpose of production	The use of soil information as a layer in several analyses undertaken in the Chishtian Sub-division irrigation management project.
Usage	This information has been used to identify different types of soil in the topsoil. Also, it has been used as ground truth information to identify the sandy areas in the satellite image. Mobin-ud-Din Ahmad, Irrigation Engineer, International Irrigation Management Institute, IIMI-Pakistan prepared the Spatial Database.
Geographical extent	This database was prepared for the Chishtian Sub-division.
Temporal extent	
From date	1955
To date	1960
Output document	"Use of Satellite Image for the Soil Salinity Monitoring", Dunia Tabet, M.Sc. thesis. "Geo-spatial Assessment of Soil Salinity and its Multi-criterion Physical Constraints: A case study in the Fordwah/Eastern Sadiqia Irrigation System, Punjab, Pakistan", Iftikhar Ahmad, M.Sc. thesis, August 1996, Asian Institute of Technology, Bangkok.
Document reference	
Sample	
6.3 Data set quality indicators	
Process history	• **Data collection** The data set was based on the survey conducted by the Water and Soil Investigation Division (WASID) during 1955-60. Originally, this map was prepared at the scale of 1:63,360 (1 inch = 1 mile). WASID was responsible for surveying. This information is now available with the SCARP Monitoring Organization (SMO). • **Data Entry** This information was collected from SMO in map form. Previously, IIMI-Pakistan had digitized this information in ILWIS software. This map was then converted into Arc/Info format through AutoCAD. This coverage was transformed in accordance with the existent geo-referenced watercourse coverage with respect to satellite image.

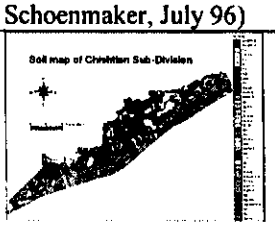
Overall positional accuracy	Location of the water lakes on the coverage does not correspond with the satellite image.
Overall thematic accuracy	As this information was collected based on the survey of sample locations, the extent of objects may, in reality, differ.
Overall temporal accuracy	
Overall completeness	Chishtian Sub-division
6.4 Object type	
Object type name	Soil texture area
Object type definition	Area under a specific soil texture. This map was prepared based on the type of soil texture in the topsoil.
Object type code	Textarea
6.5 Attribute type	
Attribute type name	Name
Attribute type definition	The area has been classified into different classes based on the soil texture.
Attribute type code (Name and definition)	Sand Loamy-Sand Sandy-Loam Fine-Sandy-Loam Loam Silt-Loam Silt Sandy-Clay-Loam Clay-Loam Silty-Clay-Loam Sandy-Clay Silty-Clay Clay
6.6 Organization and organization role	Data collection
Organization name	Water and Soil Investigation Division
Organization abbreviation name	WASID
Organization address	Water and Power Development Authority (WAPDA)
Organization role	The data was collected by WASID through intensive field surveys.
Function of the organization	To conduct the survey of irrigated areas in order to collect information pertaining to waterlogging and salinity.
Organization and organization role	Data entry and analysis
Organization name	International Irrigation Management Institute
Organization abbreviation name	IIMI
Organization address	International Irrigation Management Institute (IIMI-Pakistan) 12 km Multan Road Chowk Thokhar Niaz Baig Lahore-53700 Pakistan Phone: (042) 541-0050-53 Fax: (042) 541-0054 Email: IIMI-Pakistan<iimi-pak@cgiar.org>
Organization role	Preparation of digital database and spatial analysis.
Function of the organization	IIMI-Pakistan's mission is to improve food security and the lives of poor people by fostering sustainable increase in the productivity of water used in agriculture through better management of irrigation and water basin systems.

6.7 Point of contact and point of contact role	
Point of contact name	Chief Engineer
Point of contact address	SCARP Monitoring Organization (SMO) Canal Bank Mughal Pura Lahore (Pakistan) Phone: 6823013, 6823035 Fax: Email:
Point of contact role	SMO is responsible for the collection and management of all the information related to waterlogging and salinity in the Indus Basin.
6.8 Distribution	
Restrictions on use	Prior permission from the Director, IIMI-Pakistan, and the Chief Engineer, SMO, is required.
Copyright owners	IIMI-Pakistan, SMO
Media	Hard and soft copies may be available on CDROM.
Formats	Arc/Info
Order	Request to the Director, IIMI-Pakistan
Support services	Not available at the moment
6.9 Metadata reference	
Entry date	August 13, 1997
Last check date	September 10, 1997
Last update date	August 17, 1998

7 SOIL ASSOCIATIONS (SSP)

Chishtian Sub-division **(Raw data)**



Metadata	Description
7.1 Data set identification	
Data set title	Soil map of the Chishtian Sub-division
Physical name	\DB-chishtian\Physical environment\Soil \Soil association\ └── \Ssop └── \covs └── \soilssop
Format	PC Arc/Info coverage
7.2 Data set overview	
Abstract	This is a soil association type data set describing the soil association boundaries as sub-classes of the physiographic units (geomorphology) for the Chishtian Sub-division irrigation system.
Purpose of production	The use of soil information as a layer in several analyses undertaken in the Chishtian Sub-division irrigation management project, especially primary salinity (soil nature related).
Usage	Used by Frank Schoenmaker, Salman Asif and Yann Chemin. Period: August 1996 to February 1998 This spatial database is prepared by Frank Schoenmaker.
Geographical extent	Aerial-photo data and ground survey for the whole Chishtian Sub-division has been collected and analyzed.
Temporal extent	
From date	1996
To date	1996
Output document	Geographic Information Systems: "Watercourse analysis in the Chishtian Sub-division", Frank Schoenmaker, MSc thesis. "Semi-detailed soil survey of Chishtian Sub-Division", Blue Report No. R-45. "Visual salinity analysis for Chishtian Sub-division", Salman Asif, Blue Report to come. "Salinity and salinity risk assessment – A GIS-based approach", Yann Chemin, Blue Report to come. Reference of processed information: Coverage of Salinity and Land Capability
Document reference	Arc/Info coverage on the Chishtian Sub-division (Frank Schoenmaker, July 96)
Sample	

7.3 Data set quality indicators	
Process history	• **DATA COLLECTION:** Aerial photo-interpretation of 1954 image set, followed by ground survey campaign for correction of the limits and collection of soil samples at a rate of at least one sample watercourse per expected soil type from Aerial Photo-Interpretation of Chishtian sub-division (see Frank Schoenmaker's M.Sc. thesis for more details). • **DATA ENTRY:** Map polygons and attributes of digitized / entered polygons by IIMI-Pakistan staff. Regular corrections provided by SSP staff enabled matching the classes to the objectives better.
Overall positional accuracy	Geo-referencing according to the Chishtian Watercourse Coverage (reference coverage for Chishtian)
Overall thematic accuracy	Boundaries between the main landforms (terraces) are quite accurate (50 to 75 meters). Boundaries between normal soil and saline-sodic soil units are similar. However, saline-sodic soil units are partly reclaimed, or are under reclamation efforts, which has been mentioned and not delineated. On the other hand, boundaries between normal soil units are the result of grouping similar observations with careful photo-interpretation. Thus, every possibility of boundary overlapping (100-200 meters) is evident. Moreover, the boundaries of smaller and longitudinal units, units with more stereo differences and units with significantly different textural classes, are more accurate.
Overall temporal accuracy	Boundaries between the waterlogged phases represent the situation at the time of the survey and are variable in accordance with the amount of water passing through the irrigation system and weather conditions during the seasons of the year. Apart from that, the temporal accuracy of soil associations and physiographic units can be considered valid from 1996 up to 2020.
Overall completeness	Available for the whole Chishtian Sub-division
7.4 Object type	Geographical object
Object type name	Soil associations and physiographic units
Object type definition	Soil classes are aggregated in association types according to common physical properties (texture, origins, geomorphology, etc.). Physiographic units are geomorphology classes where the main characteristic used is texture.
Object type code	Soil
7.5 Attribute type	DBF fields
Attribute type name	4. SOIL 5. LEG 6. NEWLEG 7. SOILNR 8. SOILCLS 9. PHYSIO 10. TEXTURE 11. SALINITY 12. CODE

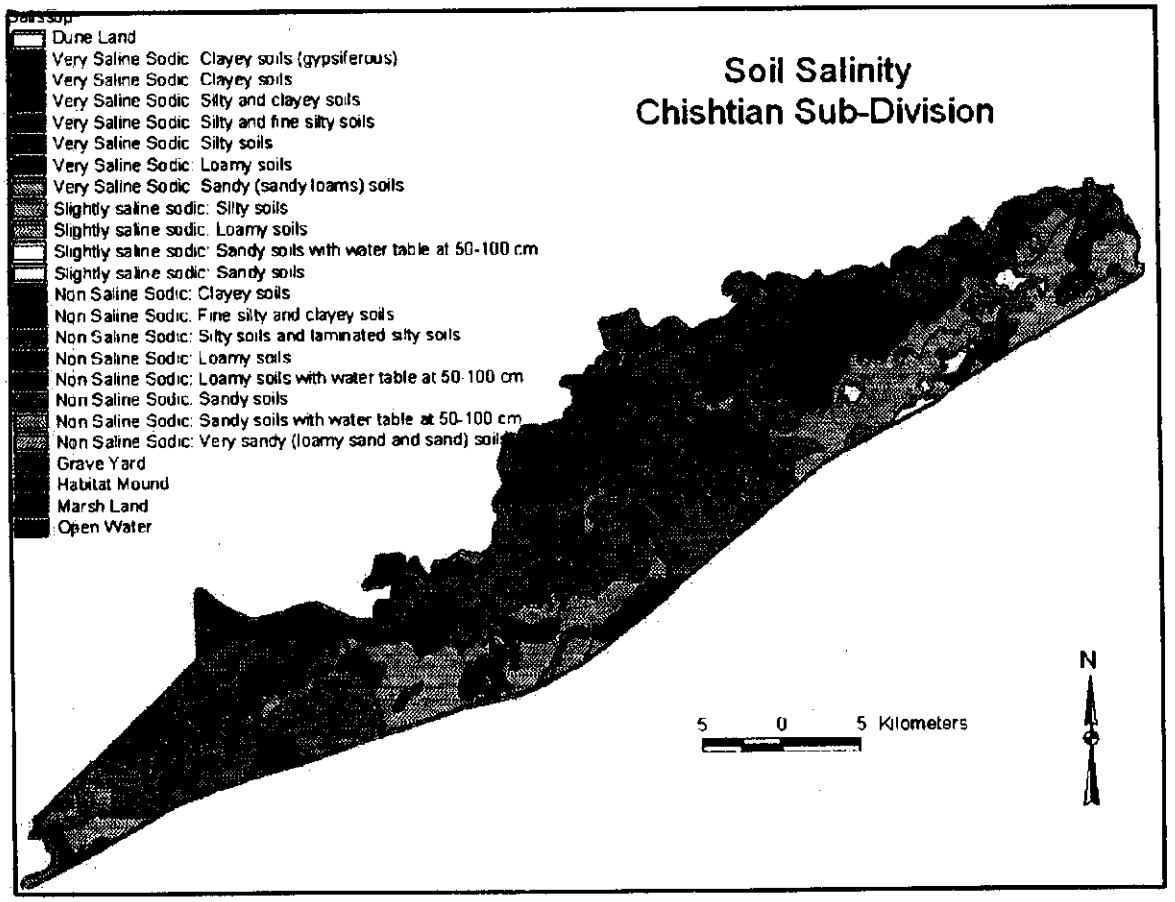
Attribute type definition	4. Original soil association classes 5. Original legend classes 6. Final soil legend classes 7. Soil numbering for map composition 8. Soil classification from 6, 7 & 8 (for typology study) 9. Physiography classes 10. Texture classes 11. Salinity classes 12. Color code for map composition
Attribute type code	3)*NEWLEG:* Aw8/W3: Awagat, Water table 50-100cm Aw8/W4: Awagat, Water table 100-150cm Ch: Cholistan Ch-DLx: Cholistan-Dune Land complex Di: Dungi DL: Dune Land Gd: Gandhara GY: Grave Yard HM: Habitat Mound Hr: Haroonabad Hr(ss): Haroonabad (Saline Sodic) Hr/W3: Haroonabad, Water table 50-100cm Hr/W4: Haroonabad, Water table 100-150cm Jg: Jhang Jg-DLx: Jhang-Dune Land Complex Jk: Jhakkar Jk-Adx: Jhakkar-Adilpur Complex Jk-Dix: Jhakkar-Dungi Complex Jk-Stx: Jhakkar-Satghara Complex Mi: Miani Mi-Pcx: Miani-Pacca Complex Mk: Makai ML: Marsh Land Mr/W4: Mariala, Water table 100-150cm Nb: Nabipur OW: Open Water Pc: Pacca Rs: Rasulpur Rs(ss): Rasulpur (saline-sodic) Rs(ss)/W3: Rasulpur (saline-sodic) Rs/W3: Rasulpur Rs/W4: Rasulpur Rs-DLx: Rasulpur-Dune Land Complex Sd: Sodhra Sd(mt): Sodhra medium textured Sd(mt)/W4: Sodhra medium textured, Water table 100-150cm Sh: Shadhra Su: Sultanpur Su(ss): Sultanpur (saline-sodic) 5)*SOILCLS:* Classes have been ascertained by joining the three values of the classes of Physiography (6), Texture (7), and Salinity (8) next to each other.

	6)*PHYSIO:* 1--: Sub-recent [1]/Rasulpur terrace 2--: Sub-recent [2]/Sultanpur terrace 3--: Recent/Shadhra terrace 4--: Cholistan 7)*Texture:* -1-: Moderately coarse -2-: Medium -3-: Medium fine -4-: Fine 8)*Salinity:* --1: No salinity --2: Surface salinity --3: Profile salinity
Thematic accuracy	The accuracy of directly observed attributes like soil types and physiography are linked to the overall accuracy of the data set. In consideration of the aggregation that has been undertaken, the two attributes, texture and salinity, have variable accuracy.
7.6 Organization and organization role	Data collection
Organization name	Soil Survey of Pakistan
Organization abbreviation name	SSP
Organization address	Multan Road Lahore, 54780 Phone: 042-78 43 691 Fax: 042-78 32 209
Organization role	Data was originated by SSP
Function of the organization	Survey of all related soil sciences in Pakistan
Organization and organization role	Data entry and analysis
Organization name	International Irrigation Management Institute
Organization abbreviation name	IIMI-Pakistan
Organization address	12 km Multan Road Lahore, 53700 Phone: (042) 541-0050-53 Fax: (042) 541-0054 E-mail: iimi-pak@cgiar.org
Organization role	IIMI-Pakistan entered and analyzed the data.
Function of the organization	IIMI-Pakistan's mission is to improve food security and the lives of poor people by fostering sustainable increases in the productivity of water used in agriculture through better management of irrigation and water basin systems.
7.7 Point of contact and point of contact role	
Point of contact name	Director
Point of contact address	12 km Multan Road Lahore, 53700 Phone: (042) 541-0050-53 Fax: (042) 541-0054 E-mail: iimi-pak@cgiar.org
Point of contact role	Director, IIMI-Pakistan

7.8 Distribution	
Restrictions on use	Prior permission from the Director, IIMI-Pakistan, and acknowledgements in the published document.
Copyright owners	IIMI-Pakistan
Media	Hard copies and soft copies; the entire data set on CD-ROM.
Formats	Arc/Info Coverage
Order	Request to the Director, IIMI-Pakistan
Support services	Not available at the moment
7.9 Metadata reference	
Entry date	July 31, 1997
Last check date	September 19, 1997
Last update date	September 19, 1997

8 SOIL SALINITY (SSP)

Chishtian Sub-division (Processed data)



Metadata	Description
8.1 Data set identification	
Data set title	Salinity map of the Chishtian Sub-division
Physical name	\DB-chishtian\Physical environment\Salinity\Profile \Sub-Division └── \Ssp └── \covs └── \Salissop
Format	PC Arc/Info coverage
8.2 Data set overview	
Abstract	This is a soil salinity type data set describing the soil salinity boundaries as sub-classes of the soil association units for the Chishtian Sub-division irrigation system.
Purpose of production	The use of soil salinity information as a layer in several analyses undertaken in the Chishtian Sub-division irrigation management project, especially primary salinity (soil nature related). Comparison with visual salinity and remote sensing salinity.
Usage	Used by Frank Schoenmaker, Salman Asif and Yann Chemin. Period: August 1996 to February 1998 This spatial database is prepared by Yann Chemin.
Geographical extent	Aerial-photo data and ground survey for the whole Chishtian Sub-division has been collected and analyzed.
Temporal extent	
From date	1996
To date	1996
Output document	"Semi-detailed survey of Chishtian Sub-division", Blue Report **No. 45.** "Visual salinity analysis for Chishtian Sub-division", Salman Asif, Blue Report **to come.** "Salinity and salinity risk assessment – A GIS-based approach", Yann Chemin, Blue Report **to come.** Reference of raw information: Soil association sub-division
Document reference	Arc/Info coverage on the Chishtian Sub-division (Frank Schoenmaker, July 96)
Sample	
8.3 Data set quality indicators	
Process history	• **DATA ENTRY:** Map polygons and attributes of digitized / entered polygons by IIMI-Pakistan staff. Regular corrections provided by SSP staff enabled matching the classes to the objectives better. • **DATA PROCESSING:** The soil water analyses from SSP were implemented on a soil association type basis for comparison with the generic characteristics. An important part of SSP staff experience is included in this salinity class attribution by soil association type. The RSC (RSC, SAR, ECe) classification from the

	USDA standards used by WAPDA as a reference for water quality widely used in Pakistan. This classification is leading to decision-making.
Overall positional accuracy	Geo-referencing according to the Chishtian Watercourse Coverage (reference coverage for Chishtian).
Overall thematic accuracy	Boundaries between the main landforms (terraces) are quite accurate (50 to 75 meters). Boundaries between normal soil and saline-sodic soil units are similar. However, saline-sodic soil units are partly reclaimed, or under reclamation efforts, which has been mentioned and not delineated. On the other hand, the boundaries between normal soil units are the result of grouping similar observations with careful photo-interpretation. Thus, every possibility of boundary overlapping (100-200 meters) is evident. Moreover, the boundaries of smaller and longitudinal units, units with more stereo differences and units with significantly different textural classes are more accurate.
Overall temporal accuracy	As far as salinity is concerned, the soil in general, and more particularly, alkali topsoil association types, are subject to modification around a year decade, according to the level of use and the quality of ground water (see the corresponding coverage). Mariala and Jhang are in reclamation and this modification implies inaccuracy on two decades of years. Boundaries between the waterlogged phases represent the situation at the time of survey and are variable in accordance with the amount of water passing through the irrigation system and weather conditions during the seasons of the year. Apart from this, the temporal accuracy of soil associations and physiographic units can be considered valid from 1996 to 2020.
Overall completeness	Available for the whole Chishtian Sub-division.
8.4 Object type	Geographical object
Object type name	Soil salinity units
Object type definition	Soil classes are aggregated in salinity classes according to common physical properties (texture, origins, geomorphology, etc…) and laboratory analyses of soil water minerals.
Object type code	Sali
8.5 Attribute type	DBF fields
Attribute type name	13. NEWLEG 14. SALINR 15. CODE
Attribute type definition	13. Final soil legend classes 14. Salinity classes 15. Color code for map composition
Attribute type code	1)*NEWLEG:* Aw8/W3: Awagat, Water table 50-100cm Aw8/W4: Awagat, Water table 100-150cm Ch: Cholistan Ch-DLx: Cholistan-Dune Land complex Di: Dungi DL: Dune Land Gd: Gandhara

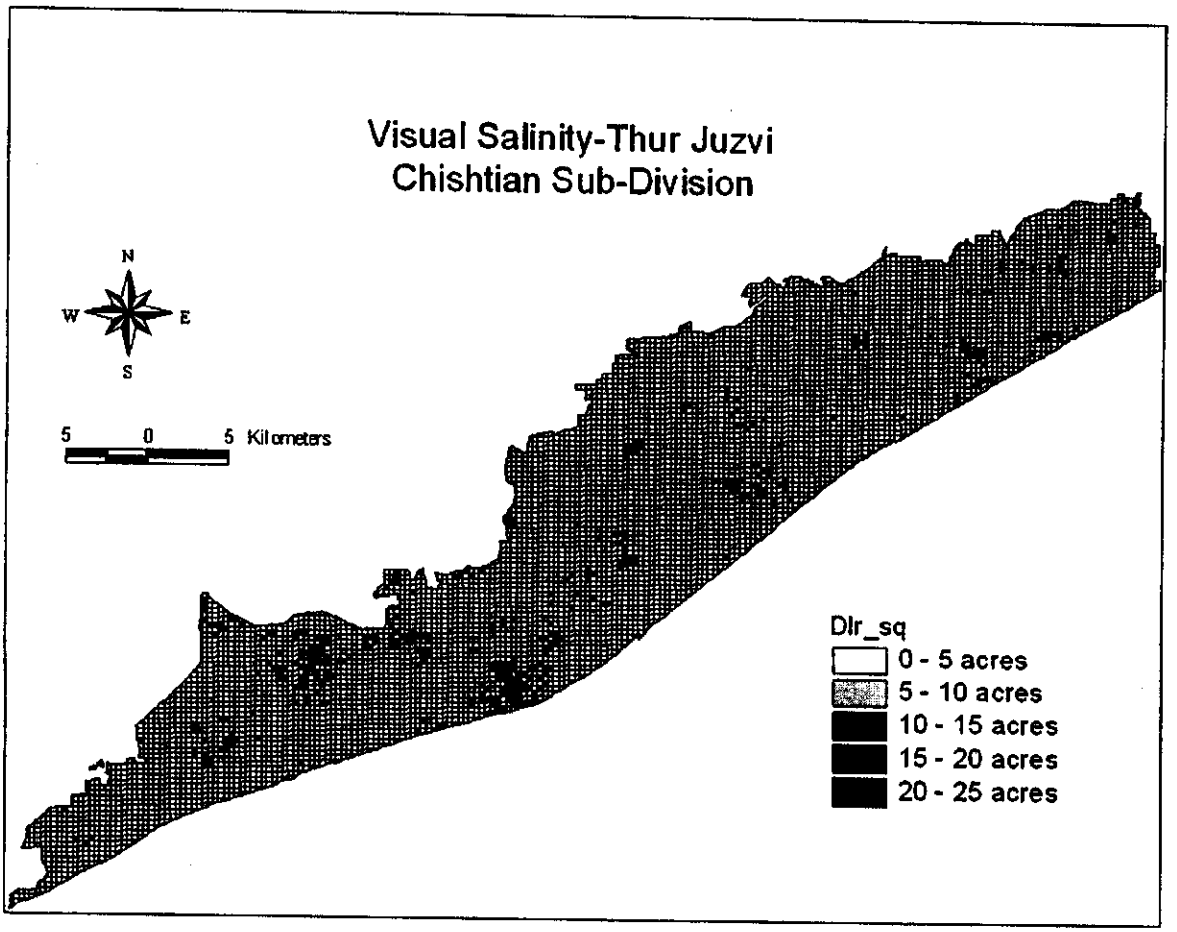
	GY: Grave Yard HM: Habitat Mound Hr: Haroonabad Hr(ss): Haroonabad (Saline Sodic) Hr/W3: Haroonabad, Water table 50-100cm Hr/W4: Haroonabad, Water table 100-150cm Jg: Jhang Jg-DLx: Jhang-Dune Land Complex Jk: Jhakkar Jk-Adx: Jhakkar-Adilpur Complex Jk-Dix: Jhakkar-Dungi Complex Jk-Stx: Jhakkar-Satghara Complex Mi: Miani Mi-Pcx: Miani-Pacca Complex Mk: Makai ML: Marsh Land Mr/W4: Mariala, Water table 100-150cm Nb: Nabipur OW: Open Water Pc: Pacca Rs: Rasulpur Rs(ss): Rasulpur (saline-sodic) Rs(ss)/W3: Rasulpur (saline-sodic) Rs/W3: Rasulpur Rs/W4: Rasulpur Rs-DLx: Rasulpur-Dune Land Complex Sd: Sodhra Sd(mt): Sodhra medium textured Sd(mt)/W4: Sodhra medium textured, Water table 100-150cm Sh: Shadhra Su: Sultanpur Su(ss): Sultanpur (saline-sodic) 2)*SALINR:* Severely saline-sodic soils 1.1 Clayey soils (Gypsiferous) 1.2 Clayey soils 1.3 Silty and clayey soils 1.4 Silty and fine silty soils 1.5 Silty soils 1.6 Loamy soils 1.7 Sandy (sandy loams) soils Slightly saline-sodic soils 2.1 Silty soils 2.2 Loamy soils 2.3 Sandy soils with water table at 50-100 cm 2.4 Sandy soils Non saline-sodic soils 3.1 Clayey soils 3.2 Fine silty and clayey soils 3.3 Silty soils and laminated silty soils 3.4 Loamy soils 3.5 Loamy soils with water table at 50-150 cm 3.6 Sandy soils 3.7 Sandy soils with water table at 50-150 cm

	3.8 Very sandy (loamy sands and sands) soil Miscellaneous areas HM Habitant Mound ML Marsh Land GY Grave Yard OW Open Water
Thematic accuracy	The accuracy of directly observed attributes like the soil types and physiography are linked to the overall accuracy of the data set. Mariala and Jhang are in reclamation; an inaccuracy has been generated from that (see October 95 SPOT image to visualize this with the coverage).
8.6 Organization and organization role	Data collection
Organization name	Soil Survey of Pakistan
Organization abbreviation name	SSP
Organization address	Multan Road Lahore, 54780 Phone: 042-78 43 691 Fax: 042-78 32 209
Organization role	Data was originated by SSP
Function of the organization	Survey of all related soil sciences in Pakistan
Organization and organization role	Data entry and analysis
Organization name	International Irrigation Management Institute
Organization abbreviation name	IIMI-Pakistan
Organization address	12 km Multan Road Lahore, 53700 Phone: (042) 541-0050-53 E-mail: iimi-pak@cgiar.org
Organization role	IIMI-Pakistan staff entered and analyzed the data.
Function of the organization	IIMI-Pakistan's mission is to improve food security and the lives of poor people by fostering sustainable increases in the productivity of water used in agriculture through better management of irrigation and water basin systems.
8.7 Point of contact and point of contact role	
Point of contact name	Director
Point of contact address	12 km Multan Road Lahore, 53700 Phone: (042) 541-0050-53 E-mail: iimi-pak@cgiar.org
Point of contact role	Director, IIMI-Pakistan
8.8 Distribution	
Restrictions on use	Prior permission from the Director, IIMI-Pakistan, and acknowledgements in the published document.
Copyright owners	IIMI-Pakistan
Media	Hard and soft copies; whole data set on CD-ROM
Formats	Arc/Info Coverage
Order	Request to Director, IIMI-Pakistan
Support services	Not available at the moment

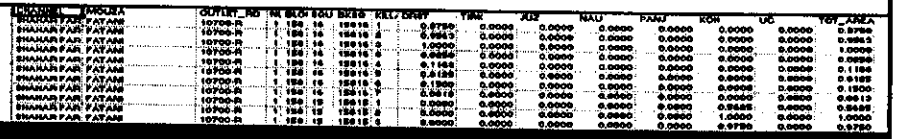
8.9 Metadata reference	
Entry date	September 19, 1997
Last check date	October 03, 1997
Last update date	September 19, 1997

9 *VISUAL SALINITY (DLR)*

Chishtian Sub-division



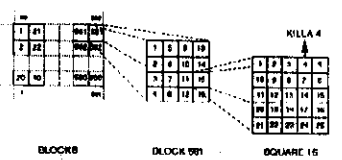
Metadata	Description
9.1 Data set identification	
Data set title	DLR's Visual Salinity Data
Physical name	\DB-Chishtian \ Physical environment \ Salinity \ Surface \ Sub-Division \ \DLR \ Grand.dbf \ Covs (Pc Arc \ Info coverages) \ DLR_SQ (Square level information) \ DLR_WC (Watercourse level information)
	Dbase file and Pc Arc / Info coverage
9.2 Data set overview	
Abstract	This is the visual salinity data collected by the Directorate of Land Reclamation (DLR) for the Chishtian Sub-division. The Directorate of Land Reclamation (DLR) of the Punjab Irrigation & Power Department was formed in 1945 to allocate extra canal water supplies for the reclamation of saline fields. The main activities undertaken by DLR include: (i) to assess the extent of salinity and waterlogging in canal command areas; (ii) to plan, organize and monitor the allocation of extra canal water supplies (or *reclamation shoots*) to salinity-affected areas, in coordination with the operating staff of the Punjab Irrigation & Power Department; and, (iii) to conduct research on soil- and water-related issues to identify (and test) options that would tackle waterlogging and salinity in an effective way (Bandaragoda and Rehman, 1994). The data was collected during the winter, i.e. from November-December and February-March, as salinity is visible on the surface during these months. Salinity information was collected at the level of the field, or *killa,* and classified according to specific classes, such as: i) **Thur Kohna**. Land that has never been brought under cultivation due to salinity. ii) **Thur Panjsala**. Land, which has been left uncultivated for more than five years, but had been cultivated before then. iii) **Thur Nau**. Land abandoned from cultivation due to salinity within a period of five years. iv) **Thur Juzvi.** Saline-affected land and land under cultivation that shows patches of salts existent on more than 20 percent of the area. v) **Thur Tirk**. Land where salts hamper the opening of cotton balls is present in the root zone.
Purpose of production	This data set was developed to spatially analyse the distribution of salinity in the Chishtian Sub-division and to attempt determining the relation (if any) with other parameters like soil texture, water table depth, ground water quality, etc..
Usage	This data set will be used for country series Blue Report on Spatial Analysis of Visual Salinity in the Chishtian Sub-division. This spatial database is prepared by Salman Asif.
Geographical extent	This data set covers the whole Chishtian Sub-division.

Temporal extent	
From date	Nov – Dec. 1995
To date	Mar – Apr. 1996
Output document	"Visual salinity in Chishtian Sub-division", Salman Asif, Blue Report **to come.**
Document reference	
Sample	

9.3 Data set quality indicators

Process history	• **Data Collection / Entry** The data from the field was collected by canal *patwaris* and recorded in Khasra registers at the *killa* level. These, more than 200 registers from ALRO, Bahawalnagar, were brought to the IIMI-Lahore office, where data entry was carried out on the *killa* basis. • **Data Processing** After entering the data set for the whole Chishtian Sub-division, errors were corrected, e.g. any *killa* (equivalent to 8 acres) with more area entered, etc.. The *killa*-level information was then summed up for each square in order to get the salinity data at the square level. The same has been undertaken for the watercourse level.
Overall positional accuracy	Salinity for some areas was estimated, therefore, the data set is not 100% accurate.
Overall thematic accuracy	
Overall temporal accuracy	As the data was collected over a period of 4-5 months, some effect on seasonal variations may affect (e.g. rain fall) the visibility of salinity.
Overall completeness	Although the data for the whole Chishtian Sub-division has been collected, some gaps still exist, i.e., for area where no data is available due to non-availability of *patwaris* responsible for that area, or the non-availability or loss of registers, etc..

9.4 Object type

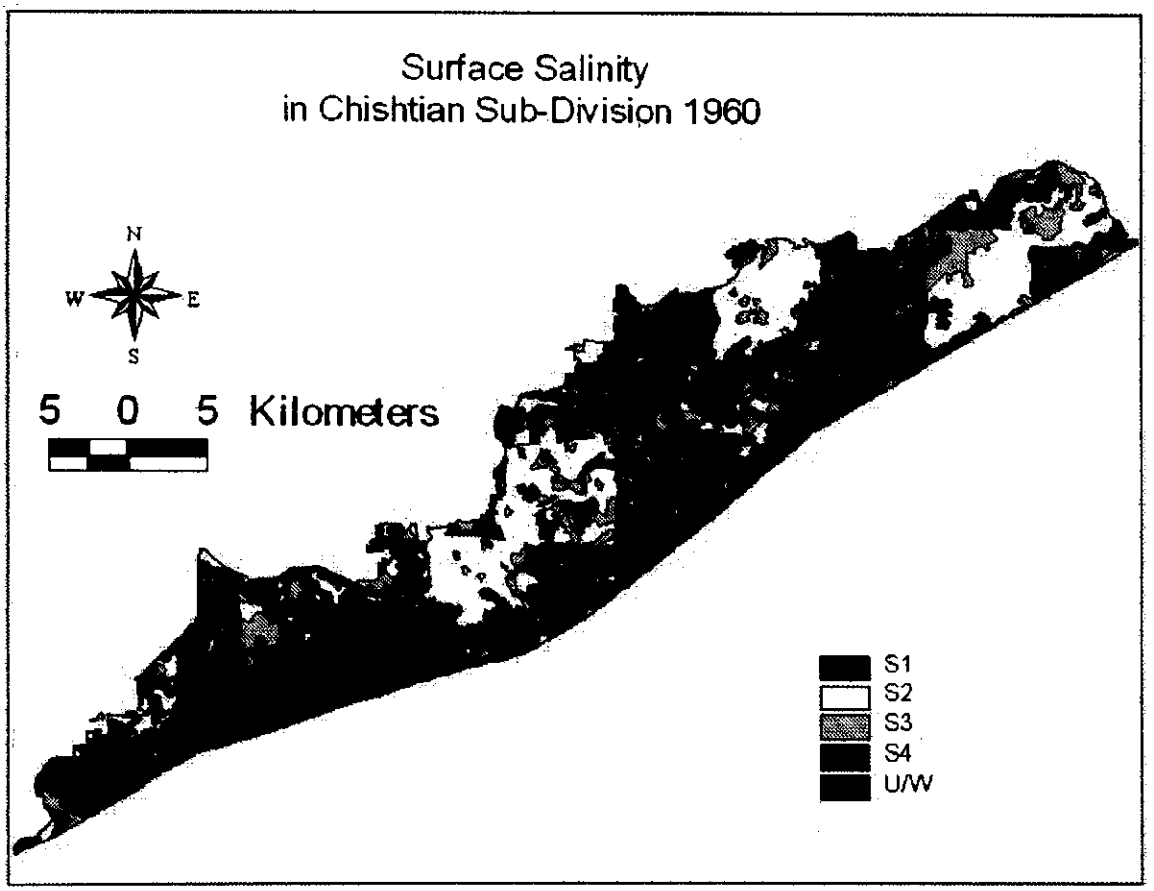
Object type name	*Killa*
Object type definition	For administrative purposes, the agricultural land in the Punjab province is divided into a grid-like structure comprising Blocks (1342m X 1270m), Squares (335.5m X 301.95m) and *Killas* (66m X 60.95m). There are 16 squares in each block and 25 *killas* in each square. Therefore, *killa* is the smallest administrative unit, equal to one acre, or eight kanals. 
Object type code	*Killa*

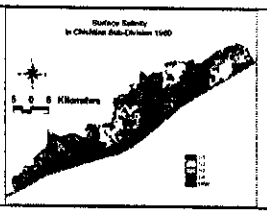
9.5 Attribute type	GRAND.DBF fields
Attribute type name	1. CHANNEL 2. MOUZA 3. OUTLET_RD 4. BLOCK 5. SQUARE 6. KILLA 7. DRST 8. TIRK 9. JUZ 10. NAU 11. PANJ 12. KOH 13. UC
Attribute type definition	1) Name of the distributary 2) Name of the *mouza* where the information was collected from 3) The watercourse name or number 4) The block number 5) The square number 6) The *killa* number 7) The salt-free area, mentioned in acres 8) The area under *thur tirk*, mentioned in acres 9) The area under *thur juzvi*, in acres 10) The area under *thur nau*, in acres 11) The area under *thur panjsala*, in acres 12) The area under *thur kohna*, in acres 13) The un-commanded area, i.e. the areas not receiving any canal water
Attribute type code	1. CHANNEL 2. MOUZA 3. OUTLET_RD 4. BLOCK 5. SQUARE 6. KILLA 7. DRST 8. TIRK 9. JUZ 10. NAU 11. PANJ 12. KOH 13. UC
Thematic accuracy	
9.6 Organization and organization role	**Data Collection**
Organization name	Directorate of Land Reclamation
Organization abbreviation name	DLR
Organization address	Mughal Pura Canal Road Lahore Phone: (92-42) 68 23 025
Organization role	The data was collected by canal DLR *patwaris*
Function of the organization	The Directorate of Land Reclamation (DLR) of the Punjab Irrigation & Power Department was formed in 1945 to allocate extra canal water supplies for the reclamation of saline fields. The main activities undertaken by DLR include: (i) To assess the extent of salinity and waterlogging in canal command areas;

	(ii) to plan, organize and monitor the allocation of extra canal water supplies (or *reclamation shoots*) to salinity-affected areas, in co-ordination with the operating staff of the Punjab Irrigation & Power Department; and, (iii) to conduct research on soil- and water-related issues to identify (and test) options that would tackle waterlogging and salinity in an effective way (Bandaragoda and Rehman, 1994).
Organization and organization role	Data entry and analysis
Organization name	International Irrigation Management Institute
Organization abbreviation name	IIMI
Organization address	12 km Multan Road, Chowk Thokar Niaz Baig Lahore-53700 Phone: (42) 541-0050-53 Fax : (042) 541-0054 Email : Iimi-pak@cgiar.org
Organization role	IIMI-Pakistan entered and analyzed the data.
Function of the organization	IIMI-Pakistan's mission is to improve food security and the lives of poor people by fostering sustainable increases in the productivity of water used in agriculture through better management of irrigation and water basin systems.
9.7 Point of contact and point of contact role	
Point of contact name	Director
Point of contact address	12 km Multan Road Chowk Thokar Niaz Baig Lahore-53700 Phone: (42) 541-0050-53 Fax: (042) 541-0054 Email : Iimi-pak@cgiar.org
Point of contact role	Director, IIMI-Pakistan
9.8 Distribution	
Restrictions on use	Prior permission from the Director, IIMI-Pakistan, and acknowledgments in the published document.
Copyright owners	IIMI-Pakistan
Media	Hard and soft copies; an entire data set for the Chishtian Sub-division is available on CDROM.
Formats	Dbase and PC Arc/Info Coverage
Order	Request to the Director, IIMI-Pakistan
Support services	Not available at the moment
9.9 Metadata reference	
Entry date	August 1997
Last check date	November 4, 1997
Last update date	October 28, 1997

10 SOIL SALINITY (WAPDA-1960)

Chishtian Sub-division



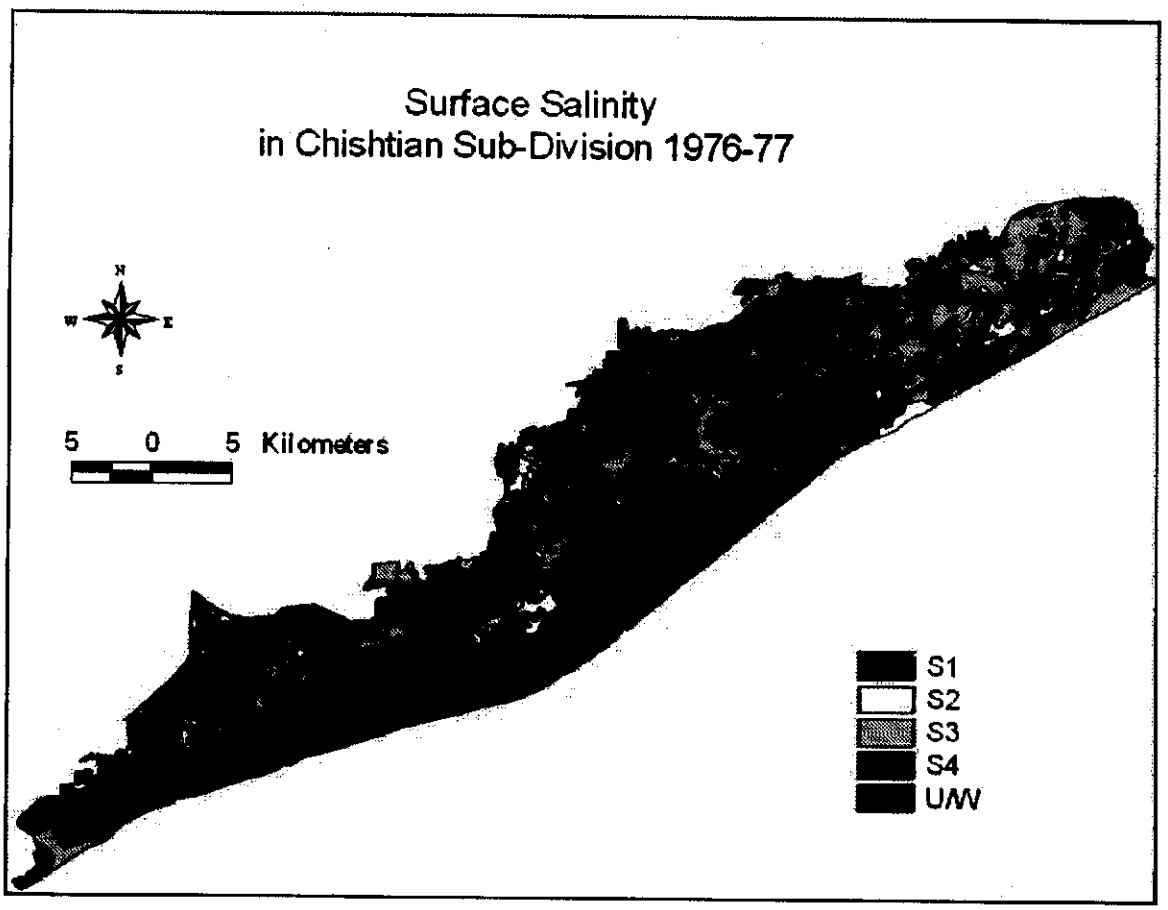
Metadata	Description
10.1 Data set identification	
Data set title	Soil Salinity
Physical name	\DB-Chishtian\Physical Environment\Salinity\Surface\Sub-Division\WAPDA └── SAL60
Format	Arc/Info
10.2 Data set overview	
Abstract	Salinity has always been an important issue for irrigation and policy makers in Pakistan. To combat salinity hazards, the Government of Pakistan has launched several large-scale salinity control and reclamation programs. The Water and Power Development Authority (WAPDA) has conducted several salinity surveys in different areas of Pakistan to monitor and evaluate these projects. This data set was prepared for the salinity survey of 1955-60 in the Chishtian Sub-division. According to this survey, area has been classified into four different classes based on the extent of salinity.
Purpose of production	The digital database was prepared for historical salinity surveys in the Chishtian Sub-division. This coverage has been used as ground truth information for the salinity classification through satellite image. This information was further used for several analyses undertaken in the Chishtian Sub-division irrigation management project, such as the relationship between the occurrence of salinity with high water table.
Usage	IIMI-Pakistan uses this to ascertain the temporal trend in the extent of salinity. This information was further used in GIS for the spatial analysis of irrigation system performance. Mobin-ud-Din Ahmad, Irrigation Engineer, International Irrigation Management Institute, IIMI-Pakistan prepared the Spatial Database.
Geographical extent	This database was prepared for the Chishtian Sub-division.
Temporal extent	
From date	1955
To date	1960
Output document	"Use of Satellite Image for the Soil Salinity Monitoring", Dunia Tabet, M.Sc. thesis. "Geo-spatial Assessment of Soil Salinity and its Multi-criterion Physical Constraints: A case study in the Fordwah/Eastern Sadiqia Irrigation System, Punjab, Pakistan", Iftikhar Ahmad, M.Sc. thesis, August 1996, Asian Institute of Technology, Bangkok. Reference of processed Metadata:
Document reference	
Sample	

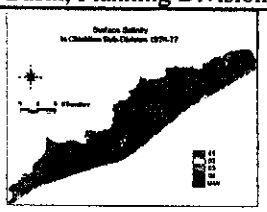
10.3 Data set quality indicators	
Process history	• **Data collection** The data set was based on the survey conducted by the Water and Soil Investigation Division (WASID) during 1955-60. Originally, this map was prepared at the scale of 1:63,360 (1 inch = 1mile). WASID was responsible for the surveying. This information is now available with the SCARP Monitoring Organization (SMO). • **Data Entry** This information was collected from SMO in map form. Previously, IIMI-Pakistan had digitized this information in ILWIS software. This map was then converted into Arc/Info format through AUTO-CAD. This coverage was transformed in accordance with the existent geo-referenced watercourse coverage with respect to satellite image.
Overall positional accuracy	Location of the water lakes on the coverage does not correspond with the satellite image.
Overall thematic accuracy	As this information was collected based on the survey of sample locations, the extent of objects may, in reality, differ.
Overall temporal accuracy	
Overall completeness	Chishtian Sub-division
10.4 Object type	
Object type name	Saline Area
Object type definition	Area under a specific salinity class
Object type code	Salinarea
10.5 Attribute type	
Attribute type name	Class
Attribute type definition	The area has been classified into four different classes based on the percent salts in the top 6 inches of soils.
Attribute type code (Name and definition)	S1 Salt Free (less than 0.2 % Salt) S2 Slightly Saline (0.2 % - 0.5 % Salt) S3 Moderately Saline (0.5 % - 1 % Salt) S4 Strongly Saline (more than 1 % Salt) U/W Area Under Water
10.6 Organization and organization role	Data Collection
Organization name	Water and Soil Investigation Division
Organization abbreviation name	WASID
Organization address	Water and Power Development Authority (WAPDA)
Organization role	Data collected by WASID through intensive field surveys.
Function of the organization	To conduct a survey of irrigated areas in order to collect information about waterlogging and salinity.
Organization and organization role	Data entry and analysis
Organization name	International Irrigation Management Institute
Organization abbreviation name	IIMI
Organization address	12 km Multan Road Chowk Thokhar Niaz Baig Lahore-53700 Pakistan Phone: (042) 541-0050-53 Fax: (042) 541-0054 Email: iimi-pak@cgiar.org>

Organization role	Preparation of digital database and spatial analysis.
Function of the organization	IIMI-Pakistan's mission is to improve food security and the lives of poor people by fostering sustainable increase in the productivity of water used in agriculture through better management of irrigation and water basin systems.
10.7 Point of contact and point of contact role	
Point of contact name	Chief Engineer
Point of contact address	SCARP Monitoring Organization (SMO) Canal Bank Mughal Pura Lahore (Pakistan) Phone: 6823013, 6823035 Fax: Email:
Point of contact role	SMO is responsible for the collection and management of all information related to waterlogging and salinity in the Indus Basin.
10.8 Distribution	
Restrictions on use	Prior permission from the Director, IIMI-Pakistan, and the Chief Engineer, SMO, is required.
Copyright owners	IIMI-Pakistan, SMO
Media	Hard and soft copies may be available on CD.
Formats	Arc/Info
Order	Request to the Director, IIMI-Pakistan
Support services	Not available at the moment
10.9 Metadata reference	
Entry date	August 13, 1997
Last check date	August 17, 1998
Last update date	August 17, 1998

11 SOIL SALINITY (WAPDA-1977)

Chishtian Sub-division



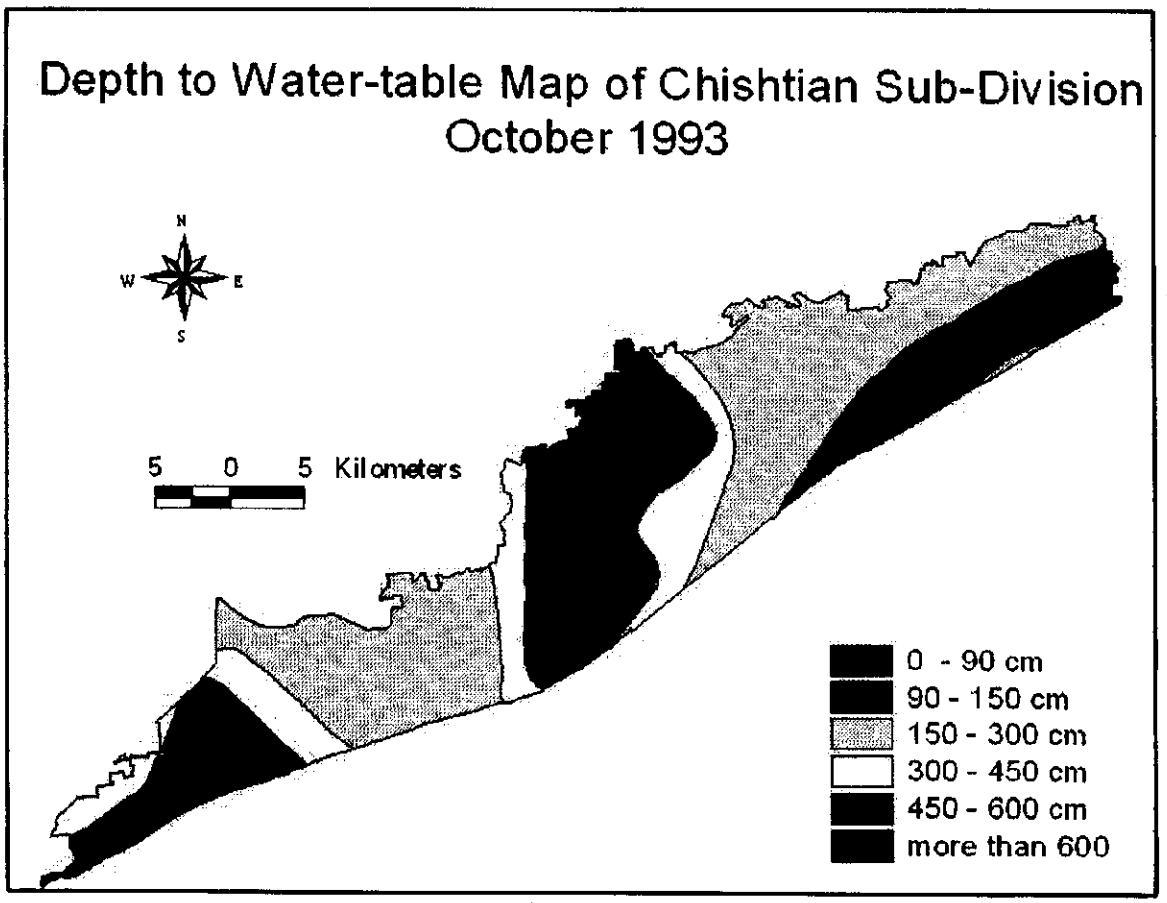
Metadata	Description
11.1 Data set identification	
Data set title	Soil Salinity
Physical name	\DB-Chishtian\Physical Environment\Salinity\Profile\Sub-division\WAPDA └── SAL76
Format	Arc/Info
11.2 Data set overview	
Abstract	Salinity has always been an important issue for irrigation and policy makers in Pakistan. To combat salinity hazards, the Government of Pakistan has launched several large-scale salinity control and reclamation programs. The Water and Power Development Authority (WAPDA) has conducted several salinity surveys in different areas of Pakistan to monitor and evaluate these projects. This data set was prepared for the salinity survey of 1976-77 in the Chishtian Sub-division. According to this survey, area has been classified into four different classes based on the extent of salinity.
Purpose of production	The digital database was prepared for historical salinity surveys in the Chishtian Sub-division. This coverage has been used as ground truth information for the salinity classification through satellite image. This information was further used for several analyses undertaken in the Chishtian Sub-division irrigation management project, such as the relationship between the occurrence of salinity with high water table depths.
Usage	IIMI-Pakistan used the information to determine the temporal trend in the extent of salinity. This information was further used in GIS for the spatial analysis of irrigation system performance. Mobin-ud-Din Ahmad, Irrigation Engineer, International Irrigation Management Institute, IIMI-Pakistan prepared the Spatial Database.
Geographical extent	This database was prepared for the Chishtian Sub-division.
Temporal extent	
From date	1976
To date	1977
Output document	"Use of Satellite Image for the Soil Salinity Monitoring", Dunia Tabet, M.Sc. thesis. "Geo-spatial Assessment of Soil Salinity and its Multi-criterion Physical Constraints: A case study in the Fordwah/Eastern Sadiqia Irrigation System, Punjab, Pakistan", Iftikhar Ahmad, M.Sc. thesis, August 1996, Asian Institute of Technology, Bangkok. Reference of processed Metadata:
Document reference	Soil Salinity Atlas 1976-77 of 41 million acres of irrigated areas of the Indus Basin, Planning Division, WAPDA, 1981.
Sample	

11.3 Data set quality indicators	
Process history	• **Data Collection** The data set was based on the survey conducted by Master Planning and Review Division, Water and Power Development Authority, during 1976-77. Originally, this map was prepared at the scale of 1:250,000. • **Data Entry** This information was collected from the Soil Salinity Atlas 1976-77 in map form. Previously, IIMI-Pakistan had digitized this information in ILWIS software. This map was then converted into Arc/Info format through AUTO-CAD. This coverage was transformed in accordance with the existent geo-referenced watercourse coverage with respect to satellite image.
Overall positional accuracy	Location of the water lakes on the coverage does not correspond with satellite image.
Overall thematic accuracy	As this information was collected based on the survey of sample locations, the extent of objects may, in reality, differ.
Overall temporal accuracy	
Overall completeness	Chishtian Sub-division
11.4 Object type	
Object type name	Saline area
Object type definition	Area under a specific salinity class
Object type code	Salinarea2
11.5 Attribute type	
Attribute type name	Class
Attribute type definition	The area has been classified into four different classes based on the visibility of salts, crop growth and laboratory analysis (electrical conductivity) of soil samples.
Attribute type code (Name and definition)	S1 EC is less than 4 mmohs/cm, no salt is visible on the soil and crop growth is unaffected. S2 EC is between 4 - 8 mmohs/cm, salts are slightly visible on the soil and crop growth is even or patchy. S3 EC is between 8 - 15 mmohs/cm, salts are fairly visible on the soil and crop growth is very patchy. S4 EC is more than 15 mmohs/cm, salts are widespread on the soil and crop growth is nil, or very poor cover of wild salt-tolerant plants may, or may not be, observed. U/W Area Under Water
11.6 Organization and organization role	Data Collection
Organization name	Water and Power Development Authority
Organization abbreviation name	WAPDA
Organization address	Water and Power Development Authority, WAPDA House The Mall Road, Lahore (Pakistan)

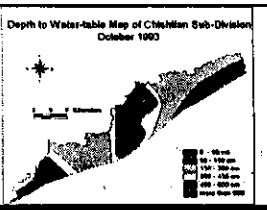
Organization role	The data collected by the Planning Division, WAPDA, during 1976-77 through intensive field surveys of 41 acres of irrigated areas in the Indus Basin.
Function of the organization	To conduct the survey of irrigated areas in order to collect information about waterlogging and salinity, and to plan the Irrigation and Drainage Scheme in Pakistan.
Organization and organization role	Data entry and analysis
Organization name	International Irrigation Management Institute
Organization abbreviation name	IIMI
Organization address	International Irrigation Management Institute (IIMI-Pakistan) 12 km Multan Road Chowk Thokhar Niaz Baig Lahore-53700 Pakistan Phone: (042) 541-0050-53 Fax: (042) 541-0054 Email: IIMI-Pakistan<iimi-pak@cgiar.org>
Organization role	Preparation of digital database and spatial analysis.
Function of the organization	IIMI-Pakistan's mission is to improve food security and the lives of poor people by fostering sustainable increase in the productivity of water used in agriculture through better management of irrigation and water basin systems.
11.7 Point of contact and point of contact role	
Point of contact name	Chief Engineer
Point of contact address	SCARP Monitoring Organization (SMO) Canal Bank Mughal Pura Lahore (Pakistan) Phone: 6823013, 6823035 Fax: Email:
Point of contact role	SMO is responsible for the collection and management of all information related to waterlogging and salinity in the Indus Basin.
11.8 Distribution	
Restrictions on use	Prior permission from the Director, IIMI-Pakistan, and the Chief Engineer, Planning Division, WAPDA, is required.
Copyright owners	IIMI-Pakistan, WAPDA
Media	Hard and soft copies may be available on CDROM.
Formats	Arc/Info
Order	Request to the Director, IIMI-Pakistan
Support services	Not available at the moment
11.9 Metadata reference	
Entry date	August 13, 1997
Last check date	September 18, 1997
Last update date	August 17, 1998

12 DEPTH TO WATER-TABLE (SMO)

Chishtian Sub-division



Metadata	Description
12.1 Data set identification	
Data set title	Depth to Watertable
Physical name	\DB-Chishtian\Physical Evironment\Ground Water\Depth\Sub-Division └ DTW1960 DTWJ80 (June 80) DTWO80 (Oct. 80) DTWJ85 (June 85) DTWO85 (Oct. 85) DTWJ90 (June 90) DTWO90 (Oct. 90) DTWJ91 (June 91) DTWO91 (Oct. 91) DTWJ92 (June 92) DTWO92 (Oct. 92) DTWJ93 (June 93) DTWO93 (Oct. 93) DTWJ96 (June 96) DTWO96 (Oct. 96)
Format	Arc/Info
12.2 Data set overview	
Abstract	The DTW1960 coverage shows the extent of waterlogging in the Chishtian Sub-division in 1960, i.e. before the Salinity Control and Reclamation Program (SCARP) was initiated, and is the base map to analyze the historical trends in watertable conditions. All other coverage shows the extent of waterlogging in the Chishtian Sub-division, which displays the pre- (June) and post-monsoon (October) changes to depth to watertable. This coverage has been used to identify the relationship between waterlogging and salinity in the Chishtian Sub-division. This information is also used for the estimation of water balance in the Chishtian Sub-division.
Purpose of production	The Depth to Water table (DTW) maps prepared was to estimate the extent of waterlogging in the Chishtian Sub-division. This information was further used for several analyses undertaken in the Chishtian Sub-division irrigation management project, such the relationship between the occurrence of salinity with high watertable, as well as spatial and temporal seasonal changes in depth to watertable.
Usage	IIMI-Pakistan uses the information to ascertain the seasonal and temporal trends in depth to water table changes. This information was further used in GIS for the spatial analysis of irrigation system performance. Mobin-ud-Din Ahmad, Irrigation Engineer, International Irrigation Management Institute, IIMI-Pakistan prepared the Spatial Database.
Geographical extent	This database was prepared for the Chishtian Sub-division.
Temporal extent	
From date	1960
To date	1996
Output document	"Spatial and Temporal Analysis of Depth to Watertable in Chishtian Sub-

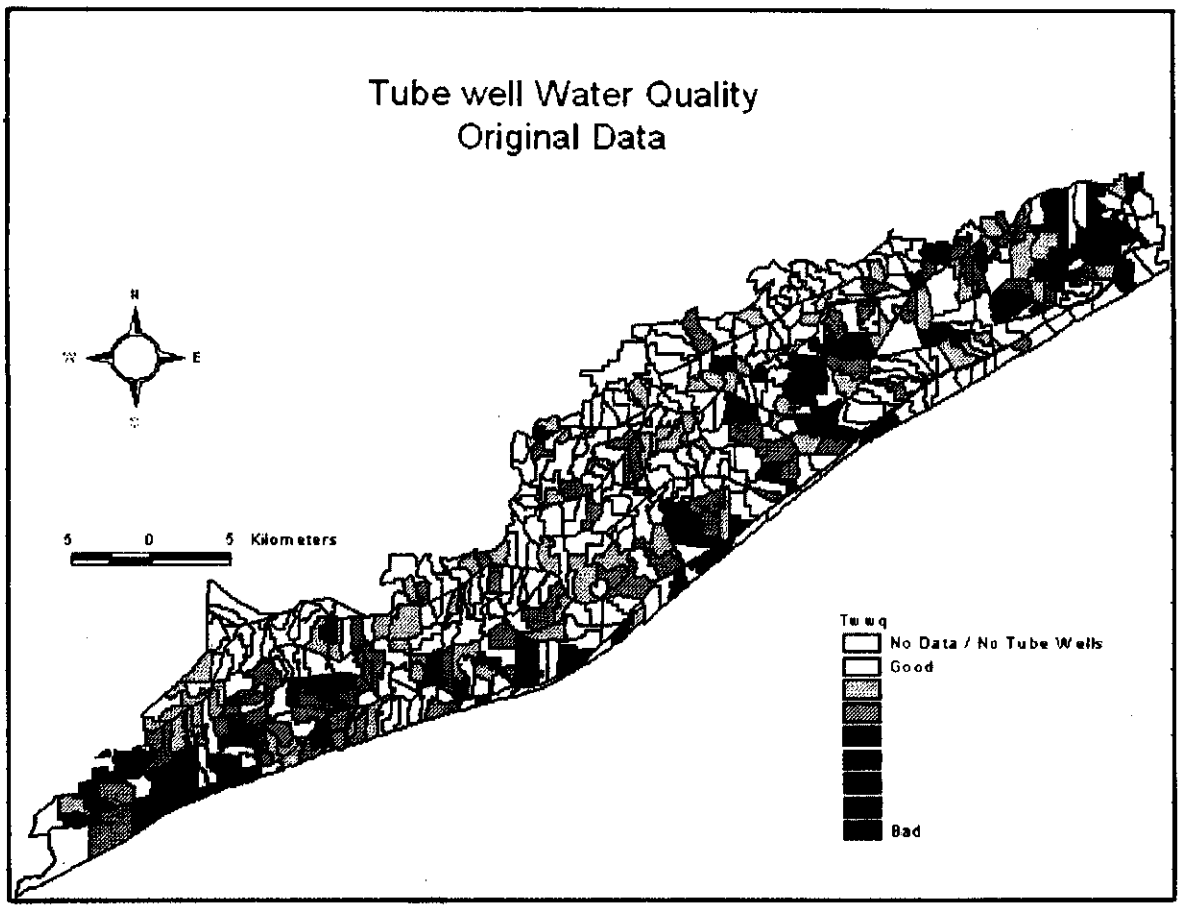
	division", Mobin-ud-Din Ahmad, unpublished report. "Water balance and gross performance of Chishtian Sub-division", Zaigham Habib. "Visual Salinity (DLR) Analysis", Salman Asif, Blue Report to come. "Salinity and Salinity Risk Assessment", Yann Chemin (SSP), Blue Report to come.
Document reference	
Sample	
12.3 Data set quality indicators	
Process history	For DTW1960 • **Data collection** The data set was based on the survey conducted by the Water and Soil Investigation Division (WASID) during 1955-60. Originally, this map was prepared at the scale of 1:63,360. WASID was responsible for surveying. This information is now available with the SCARP Monitoring Organization (SMO). • **Data Entry** This information was collected from SMO in map form. Previously, IIMI-Pakistan digitized the information in ILWIS software. This map was then converted into Arc/Info format through AutoCAD. This coverage was transformed in accordance with the existent geo-referenced watercourse coverage with respect to satellite image. For all other DTW coverage from 1980 to 1996 • **Data collection** SCARP Monitoring Organization (SMO) collects depth to water table maps through a network of piezometers in the Indus Basin twice a year, i.e. pre- and post-monsoon. The depth-to-water table maps from this information are produced by SMO through linear interpolation. Originally, this map was prepared at the scale of 1:506,880(1 inch = 8 miles). • **Data Entry** This information was collected from SMO in map form. IIMI-Pakistan has digitized the information in Arc/Info. This coverage was then transformed in accordance with the existent geo-referenced watercourse coverage with respect to satellite image.
Overall positional accuracy	As the source of this coverage is the depth to water table maps prepared from the linear interpolation (manually) of piezometer data, the boundaries of each class are not very accurate.
Overall thematic accuracy	These maps (1980-96) were prepared based on data collected through 40 piezometers across the Chishtian Sub-division. Based on the density of piezometers, it is suggested that this information be used only for macro level analysis.
Overall temporal accuracy	

Overall completeness	This information is available for the whole Chishtian Sub-division.
12.4 Object type	
Object type name	Area under a specific class of water-table depth.
Object type definition	The distance from ground surface to ground water table.
Object type code	DTW
12.5 Attribute type	
Attribute type name	DTW _ _ (Depth to Water table in a specific season/month and/or year)
Attribute type definition	A specific name was given to each class based on the extent of water-logging.
Attribute type code (Name and definition)	For coverage DTW1960 1 0-3 feet 2 3-6 feet 3 6-10 feet 4 more than 10 feet For coverage DTWJ80 & DTWO80 1 0-5 feet 2 5-10 feet 3 10-15 feet 4 15-20 feet 5 more than 20 feet For coverage DTWJ85 & DTWO85 1. 0-150 cm deep from ground surface 2. 150-300 cm 3. 300-450 cm 4. 450-600 cm 5. more than 600 cm **For coverage (1990-96)** 1 0-90 cm deep from ground surface 2 90-150 cm 3 150-300 cm 4 300-450 cm 5 450-600 cm 6 more than 600 cm U/W Area under water
12.6 Organization and organization role	Data collection
Organization name	SCARP Monitoring Organisation
Organization abbreviation name	SMO
Organization address	SCARP Monitoring Organization (SMO) Canal Bank Mughal Pura Lahore (Pakistan) Phone: 6823013, 6823035 Fax: Email:
Organization role	The data was collected by SMO through intensive field surveys.
Function of the organization	To conduct the survey of irrigated areas in order to collect information pertaining

	to waterlogging and salinity.
Organization and organization role	Data entry and analysis
Organization name	International Irrigation Management Institute
Organization abbreviation name	IIMI
Organization address	International Irrigation Management Institute (IIMI-Pakistan) 12 km Multan Road Chowk Thokhar Niaz Baig Lahore-53700 Pakistan Phone: (042) 541-0050-53 Fax: (042) 541-0054 Email: IIMI-Pakistan<iimi-pak@cgiar.org>
Organization role	Preparation of digital database and spatial analysis.
Function of the organization	IIMI-Pakistan's mission is to improve food security and the lives of poor people by fostering sustainable increase in the productivity of water used in agriculture through better management of irrigation and water basin systems.
12.7 Point of contact and point of contact role	
Point of contact name	Chief Engineer
Point of contact address	SCARP Monitoring Organization (SMO) Canal Bank Mughal Pura Lahore (Pakistan) Phone: 6823013, 6823035 Fax: Email:
Point of contact role	SMO is responsible for the collection and management of all the information related to waterlogging and salinity in the Indus Basin.
12.8 Distribution	
Restrictions on use	Prior permission from the Director, IIMI-Pakistan, and the Chief Engineer, SMO, is required.
Copyright owners	IIMI-Pakistan, SMO
Media	Hard and soft copies may be available on CDROM.
Formats	Arc/Info
Order	Request to the Director, IIMI-Pakistan
Support services	Not available at the moment
12.9 Metadata reference	
Entry date	August 13, 1997
Last check date	September 25, 1997
Last update date	August 17, 1998

13 TUBE WELL WATER QUALITY

Chishtian Sub-division **(Processed Data)**



Metadata	Description
13.1 Data set identification	
Data set title	Tube Well Water Quality of Chishtian
Physical name	\DB-chishtian\Physical environment\Tube well water \Quality\All Watercourses └── \covs └── \gwq
Format	PC Arc/Info coverage
13.2 Data set overview	
Abstract	This is a tube well water quality data set, describing the classified ground water quality as aggregation classes of the SAR, RSC and Ece values for the Chishtian Sub-division irrigation system. One value of SAR, RSC and Ece for one watercourse, is one class per watercourse. Data collected by IIMI-Pakistan field staff has been analyzed in Soil Survey of Pakistan laboratories, and then IIMI-Pakistan staff entered the data.
Purpose of production	The use of tube well water quality information as a layer in several analyses undertaken in the Chishtian Sub-division irrigation management project, especially the correlation with salinity and low crop production. The quality of the water used by farmers to complement lack of canal water influences the level of crop stress by mineral content increase and salinity development.
Usage	Used by Pierre Strosser, Frank Schoenmaker, Salman Asif, Mobin ud Din Ahmad and Yann Chemin. Period: August 1996 to February 1998 This spatial database is prepared by Frank Schoenmaker.
Geographical extent	In most of the Chishtian Sub-division, tubewell water samples have been collected at a rate of two to four by watercourses.
Temporal extent	
From date	*Kharif* 1996
To date	*Kharif* 1996
Output document	"Geographic Information Systems: "Watercourse analysis in the Chishtian Sub-division", Frank Schoenmaker, MSc thesis. Reference of raw information: Tubewell Water Quality (raw data)
Document reference	Arc/Info coverage on the Chishtian Sub-division (Frank Schoenmaker, July 96)
Sample	
13.3 Data set quality indicators	
Process history	• **DATA ENTRY:** Entry and checking data has been conducted by IIMI-

	Pakistan staff members. • **DATA PROCESSING:** The data collected for each watercourse have been averaged to give one value for each factor. The data were then been joined with the watercourse coverage of the Chishtian Sub-division.
Overall positional accuracy	Geo-referencing according to the Chishtian Watercourse Coverage (reference coverage for Chishtian). The exact location of the sampled tubewells is unknown, therefore, the information has to be averaged and assigned to watercourse labels.
Overall thematic accuracy	Results show a very high variability in groundwater quality over short distances, which makes it doubtful whether one data point per watercourse is enough, and whether the calculated average of this point is representative for the whole watercourse. The water samples have been taken from tubewells with totally different depths, in other words, probably taking water from different aquifers, with different qualities.
Overall temporal accuracy	Variation along time in the concentration of tube well water may arise due to heavy water coming from irrigation or rainfall, but also rising groundwater.
Overall completeness	Available for 406 out 510 watercourses for the Chishtian Sub-division.
13.4 Object type	Geographical object
Object type name	Tube well water quality classes
Object type definition	Classes of tube well water quality according to SAR, RSC and Ece, from the threshold of USDA used in WAPDA, and widely in Pakistan.
Object type code	Gwq
13.5 Attribute type	DBF fields
Attribute type name	16. LINK 17. PH 18. CO3 19. HCO3 20. CL 21. SO4 22. CA_MG 23. NA 24. SAR 25. RSC 26. ECe 27. CLASSAR 28. CLASRSC 29. CLASECE 30. CLASFINAL
Attribute type definition	1 Reference name of the watercourses in the watercourse coverage (universal link) 2 pH values 3 (meq/l): CO3 quantities in water 4 (meq/l): HCO3 quantities in water 5 (meq/l): Cl quantities in water 6 (meq/l): SO4 quantities in water 7 (meq/l): Ca + Mg quantities in water 8 (meq/l): Na quantities in water

	9 (%): calculated SARe values 10 (meq/l): calculated RSC values 11 (dS/m): calculated Ece values 12 classified SARe values (<6, 6-10, >10) 13 classified RSC values (<0, 0-1.25, >1.25) 14 classified Ece values (<11.5, 11.5-14.5, >14.5) 15 classified SARe, RSC and Ece values together; the final classification merges the three preceding ones:

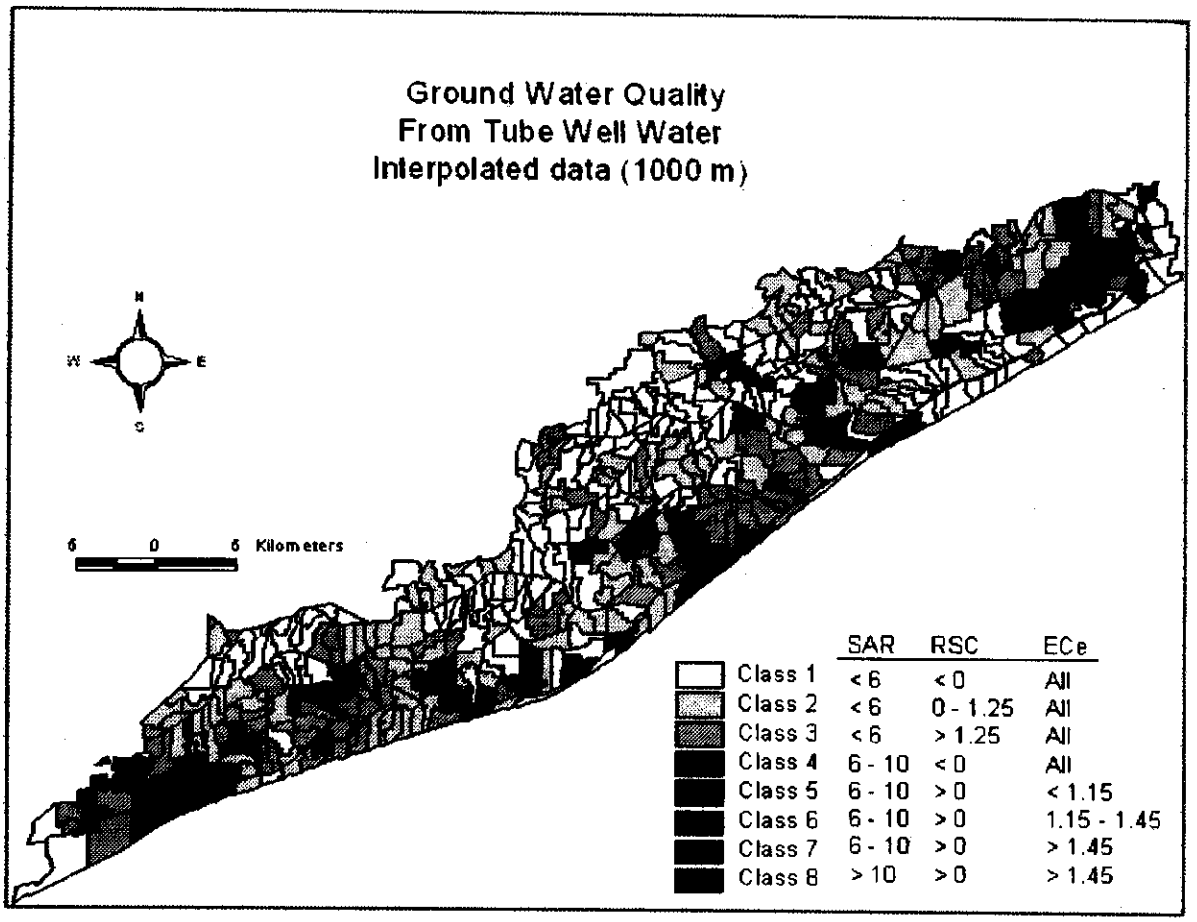
CLASS	SAR (-)	RSC (meq/l)	EC (mS/m)
1	< 6	< 0	All values
2	< 6	0 - 1.25	All values
3	< 6	> 1.25	All values
4	6 - 10	< 0	All values
5	6 - 10	> 0	< 1150
6	6 - 10	> 0	1150 – 1450
7	6 - 10	> 0	> 1450
8	> 10	> 0	> 1450

Attribute type code	1 LINK 2 PH 3 CO3 4 HCO3 5 CL 6 SO4 7 CA_MG 8 NA 9 SAR 10 RSC 11 ECe
Thematic accuracy	The tubewell water quality is often very variable from one tubewell to another, even along the same watercourse. An easy conclusion to reach is the significance of the low accuracy of the data. The classification is just a means to present the data; however, it strengthens the sodium content regardless of the total salts content in the water.
13.6 Organization and organization role	Data collection
Organization name	International Irrigation Management Institute
Organization abbreviation name	IIMI-Pakistan
Organization address	12 km Multan Road Lahore, 53700 Phone: (042) 541-0050-53 Fax: (042) 541-0054 E-mail: iimi-pak@cgiar.org
Organization role	IIMI-Pakistan field staff collected the data.
Function of the organization	IIMI-Pakistan's mission is to improve food security and the lives of poor people by fostering sustainable increases in the productivity of water used in agriculture through better management of irrigation and water basin systems.
Organization and organization role	Data entry and analysis
Organization name	International Irrigation Management Institute
Organization abbreviation name	IIMI-Pakistan
Organization address	12 km Multan Road Lahore, 53700 Phone: (042) 541-0050-53

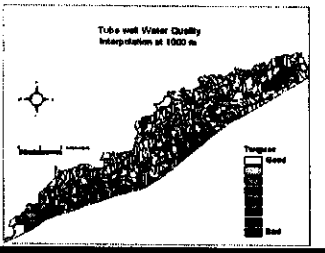
	Fax: (042) 541-0054 E-mail: iimi-pak@cgiar.org
Organization role	The data was entered and analyzed by IIMI-Pakistan staff.
Function of the organization	IIMI-Pakistan's mission is to improve food security and the lives of poor people by fostering sustainable increases in the productivity of water used in agriculture through better management of irrigation and water basin systems.
13.7 Point of contact and point of contact role	
Point of contact name	Director
Point of contact address	12 km Multan Road Lahore, 53700 Phone: (042) 541-0050-53 Fax: (042) 541-0054 E-mail: iimi-pak@cgiar.org
Point of contact role	Director, IIMI-Pakistan
13.8 Distribution	
Restrictions on use	Prior permission from the Director, IIMI-Pakistan, and acknowledgements in the published document.
Copyright owners	IIMI-Pakistan
Media	Hard and soft copies; whole data set on CD-ROM.
Formats	Arc/Info Coverage
Order	Request to the Director, IIMI-Pakistan
Support services	Not available at the moment
13.9 Metadata reference	
Entry date	20 September, 1997
Last check date	3 October, 1997
Last update date	26 September, 1997

14 TUBE WELL WATER QUALITY INTERPOLATED

Chishtian Sub-division (Processed Data)



Metadata	Description
14.1 Data set identification	
Data set title	Tube well Water Quality Interpolation coverage of the Chishtian Sub-division
Physical name	\DB-chishtian\Physical environment\Tube Well Water\ Quality\ └── \covs └── \Twqprox
Format	PC Arc/Info coverage
14.2 Data set overview	
Abstract	This is a data set of proximity analysis by interpolation of tube well water quality for the Chishtian Sub-division irrigation system. The original data has missing values due to non-collection of data, or the absence of tubewells in the area surveyed. Therefore, a program has been used to resample the information based on search radii to average different water quality indicators. The result is a set of radii search reclassifications for each watercourse in the Chishtian Sub-division.
Purpose of production	This information has been used for modeling purposes conducted in the "Integrated Approach for Irrigation Management", because tube well water quality is an important indicator of salinity risks by use of ground water as irrigation water.
Usage	Used by Frank Schoenmaker, Marcel Kuper and Pierre Strosser. Period: August 96 to February 1998 This spatial database is prepared by Frank Shoenmaker.
Geographical extent	Ground survey for 400 watercourses of the Chishtian Sub-division has been collected and interpolated in order to encompass all the watercourses.
Temporal extent	
From date	1996
To date	1996
Output document	Geographic Information System s: "GIS in an integrated approach to study irrigation system performance", Frank Schoenmaker, M.Sc. thesis. Reference of raw information: Metadata of tubewell water quality for the Chishtian Sub-division at watercourse level.
Document reference	Arc/Info coverage on the Chishtian Sub-division (Frank Schoenmaker, July 96) \Tube Well Water \ Quality \ docs \ Prox.prg (FoxPro program file, it is a text file)

Sample	

14.3 Data set quality indicators

Process history	**DATA ENTRY:** The water samples have been analyzed by the Soil Survey of Pakistan, which performed a complete chemical analysis on these samples. This analysis included pH, EC_e, SAR, RSC, CO_3, HCO_3, Cl, SO_4, Ca+Mg and Na. Attributes have been appended according to the watercourse name by IIMI-Pakistan staff. Exact locations of the tubewells are unknown, thus, the approximate center of the watercourse has been used to locate the data by its label. • **DATA PROCESSING:** Classification has been performed according to the following table: CLASS / SAR (-) / RSC (meq/l) / EC (mS/m) 1 / < 6 / < 0 / All values 2 / < 6 / 0 - 1.25 / All values 3 / < 6 / > 1.25 / All values 4 / 6 - 10 / < 0 / All values 5 / 6 - 10 / > 0 / < 1150 6 / 6 - 10 / > 0 / 1150 - 1450 7 / 6 - 10 / > 0 / > 1450 8 / > 10 / > 0 / > 1450 The interpolation of the data has been done by indicator first (SAR, RSC and Ece), then the above classification scheme has been applied.
Overall positional accuracy	Geo-referencing according to the Chishtian Watercourse Coverage (reference coverage for Chishtian)
Overall thematic accuracy	The accuracy of this coverage is limited by two factors: - The exact location of the sampled tubewells is unknown, therefore the information has to be averaged and assigned to watercourse labels. However, the first results show a very high variability in groundwater quality over short distances, which makes it doubtful whether one data point per watercourse is enough, and whether the calculated average of this point is representative for the whole watercourse. - The water samples have been taken from tubewells with totally different depths, in other words, probably taking water from different aquifers, with different qualities..
Overall temporal accuracy	For 1996 only
Overall completeness	Available for 400 watercourses of the Chishtian Sub-division in survey data, and for the whole area in interpolated form.

14.4 Object type	Geographical object
Object type name	Tube well water quality interpolated
Object type definition	Tube well water analyses of SAR, RSC and Ece, for a set of watercourses in the Chishtian Sub-division and interpolation data by proximity analysis.
Object type code	Twqprox
14.5 Attribute type	DBF fields
Attribute type name	1. LINK 2. X_COORD 3. Y_COORD 4. DX 5. DY 6. DIST 7. NUMBER 8. PH 9. ECE 10. ECECLS 11. CO3 12. HCO3 13. CL 14. SO4 15. CA_MG 16. NA 17. SAR 18. SARCLS 19. RSC 20. RSCCLS 21. SARPROX1 22. RSCPROX1 23. ECPROX1 24. COUNT1 25. PRSARCL 26. PRRSCCL 27. PRECCL 28. PRCL1 29. CLASS
Attribute type definition	16. Universal Link (identification system for the watercourses) 17. Geographical Co-ordinates following the x axis 18. Geographical Co-ordinates following the y axis 19. Difference between x co-ordinates of two consecutive watercourses 20. Difference between y co-ordinates of two consecutive watercourses 21. Computed distance between the two consecutive watercourse centers ($d = \sqrt{x^2 + y^2}$) 22. Number of watercourses 23. PH value 24. Ece value 25. Ece class 26. CO3 (meq/l) 27. HCO3 (meq/l) 28. Cl (meq/l) 29. SO4 (meq/l)

	30. CA_MG (meq/l) 31. NA (meq/l) 32. SAR value 33. SAR class 34. RSC value 35. RSC class 36. SAR interpolation by proximity analysis at 1000m. 37. RSC interpolation by proximity analysis at 1000m. 38. Ece interpolation by proximity analysis at 1000m. 39. Counting of watercourses falling under the 1000m-radius search. 40. Program SAR class result 41. Program RSC class result 42. Program Ece class result 43. Program quality class result 44. Class of the original data
Attribute type code	
Thematic accuracy	The accuracy was linked to the classification mode, as was the proximity interpolation method, and as described in Frank Schoenmaker's M.Sc. thesis. The representation methodology used to classify three indicators (SAR, RSC and Ece) is only a means to disseminate, and not an effective result in itself.
14.6 Organization and organization role	Data collection
Organization name	Soil Survey of Pakistan
Organization abbreviation name	SSP
Organization address	Multan Road Lahore, 54780 Phone: 042-78 43 691 Fax: 042-78 32 209
Organization role	IIMI-Pakistan field staff has collected the data, and then the water samples have been analyzed in the SSP laboratories.
Function of the organization	Survey of all related soil sciences in Pakistan
Organization and organization role	Data entry and analysis
Organization name	International Irrigation Management Institute
Organization abbreviation name	IIMI-Pakistan
Organization address	12 Km Multan Road Lahore, 53700 Phone: (042) 541-0050-53 Fax: (042) 541-0054 E-mail: iimi-pak@cgiar.org
Organization role	The data was entered and analyzed by IIMI-Pakistan staff.
Function of the organization	IIMI-Pakistan's mission is to improve food security and the lives of poor people by fostering sustainable increases in the productivity of water used in agriculture through better management of irrigation and water basin systems.
14.7 Point of contact and point of contact role	
Point of contact name	Director
Point of contact address	12 km Multan Road

	Lahore, 53700 Phone: (042) 541-0050-53 Fax: (042) 541-0054 E-mail: iimi-pak@cgiar.org
Point of contact role	Director, IIMI-Pakistan
14.8 Distribution	
Restrictions on use	Prior permission from the Director, IIMI-Pakistan, and acknowledgements in the published document.
Copyright owners	IIMI-Pakistan
Media	Hard and soft copies; whole data set on CD-ROM.
Formats	Arc/Info Coverage
Order	Request to the Director, IIMI-Pakistan
Support services	Not available at the moment
14.9 Metadata reference	
Entry date	9 December, 1997
Last check date	9 December, 1997
Last update date	9 December, 1997

IIMI-PAKISTAN PUBLICATIONS
RESEARCH REPORTS

Report No.	Title	Author	Year
R-1	**Crop-Based Irrigation Operations Study in the North West Frontier Province of Pakistan** Volume I: Synthesis of Findings and Recommendations	Carlos Garces-R D.J. Bandaragoda Pierre Strosser	June 1994
	Volume II: Research Approach and Interpretation	Carlos Garces-R Ms. Zaigham Habib Pierre Strosser Tissa Bandaragoda Rana M. Afaq Saeed ur Rehman Abdul Hakim Khan	June 1994
	Volume III: Data Collection Procedures and Data Sets	Rana M. Afaq Pierre Strosser Saeed ur Rehman Abdul Hakim Khan Carlos Garces-R	June 1994
R-2	Salinity and Sodicity Research in Pakistan - Proceedings of a one-day Workshop	J.W. Kijne Marcel Kuper Muhammad Aslam	Mar 1995
R-3	Farmers' Perceptions on Salinity and Sodicity: A case study into farmers' knowledge of salinity and sodicity, and their strategies and practices to deal with salinity and sodicity in their farming systems	Neeltje Kielen	May 1996
R-4	Modelling the Effects of Irrigation Management on Soil Salinity and Crop Transpiration at the Field Level (M.Sc Thesis - published as Research Report)	S.M.P. Smets	June 1996
R-5	Water Distribution at the Secondary Level in the Chishtian Sub-division	M. Amin K. Tareen Khalid Mahmood Anwar Iqbal Mushtaq Khan Marcel Kuper	July 1996
R-6	Farmers Ability to Cope with Salinity and Sodicity: Farmers' perceptions, strategies and practices for dealing with salinity and sodicity in their farming systems	Neeltje Kielen	Aug 1996
R-7	Salinity and Sodicity Effects on Soils and Crops in the Chishtian Sub-Division: Documentation of a Restitution Process	Neeltje Kielen Muhammad Aslam Rafique Khan Marcel Kuper	Sept 1996
R-8	Tertiary Sub-System Management: (Workshop proceedings)	Khalid Riaz Robina Wahaj	Sept 1996
R-9	Mobilizing Social Organization Volunteers: An Initial Methodological Step Towards Establishing Effective Water Users Organization	Mehmoodul Hassan Zafar Iqbal Mirza D.J. Bandaragoda	Oct 1996
R-10	Canal Water Distribution at the Secondary Level in the Punjab, Pakistan (M.Sc Thesis published as Research Report)	Steven Visser	Oct 1996
R-11	Development of Sediment Transport Technology in Pakistan: An Annotated Bibliography	M. Hasnain Khan	Oct 1996
R-12	Modeling of Sediment Transport in Irrigation Canals of Pakistan: Examples of Application (M.Sc Thesis published as Research Report)	Gilles Belaud	Oct 1996
R-13	Methodologies for Design, Operation and Maintenance of Irrigation Canals subject to Sediment Problems: Application to Pakistan (M.Sc Thesis published as Research Report)	Alexandre Vabre	Oct 1996

Report No.	Title	Author	Year
R-14	Government Interventions in Social Organization for Water Resource Management: Experience of a Command Water Management Project in the Punjab, Pakistan	Waheed uz Zaman D.J.Bandaragoda	Oct 1996
R-15	Applying Rapid Appraisal of Agricultural Knowledge Systems (RAAKS) for Building Inter-Agency Collaboration	Derk Kuiper Mushtaq A. Khan Jos van Oostrum M. Rafique Khan Nathalie Roovers Mehmood ul Hassan	Nov 1996
R-16	Hydraulic Characteristics of Chishtian Sub-division, Fordwah Canal Division	Anwar Iqbal	Nov 1996
R-17	Hydraulic Characteristics of Irrigation Channels in the Malik Sub-Division, Sadiqia Division, Fordwah Eastern Sadiqia Irrigation and Drainage Project	Khalid Mahmood	Nov 1996
R-18	**Proceedings of National Conference on Managing Irrigation for Environmentally Sustainable Agriculture in Pakistan**	M. Badruddin Gaylord V. Skogerboe M.S. Shafique (Editors for all volumes)	Nov 1996
R-18.1	Volume-I: Inauguration and Deliberations		
R-18.2	Volume-II: Papers on the Theme: Managing Canal Operations		
R-18.3	Volume-III: Papers on the Theme: Water Management Below the Mogha		
R-18.4	Volume-IV: Papers on the Theme: Environmental Management of Irrigated Lands		
R-18.5	Volume-V: Papers on the Theme: Institutional Development		
R-19	Detailed Soil Survey of Eight Sample Watercourse Command Areas in Chishtian and Hasilpur Tehsils	Soil Survey of Pakistan IIMI-Pakistan	Nov 1996
R-20	Unsteady Flow Simulation of the Designed Pehur High-Level Canal and Proposed Remodeling of Machai and Miara Branch Canals, North West Frontier Province, Pakistan	Zaigham Habib Kobkiat Pongput Gaylord V. Skogerboe	Dec 1996
R-21	**Salinity Management Alternatives for the Rechna Doab, Punjab, Pakistan**	Gauhar Rehman Waqar A. Jehangir Abdul Rehman Muhammad Aslam Gaylord V. Skogerboe	May 1997
R-21.1	Volume One: Principal Findings and Implications for Sustainable Irrigated Agriculture		
R-21.2	Volume Two: History of Irrigated Agriculture: A Select Appraisal	Gauhar Rehman Hassan Zia Munawwar Asghar Hussain	Jan 1997
R-21.3	Volume Three: Development of Procedural and Analytical Liniks	Gauhar Rehman Muhammad Aslam Waqar A. Jehangir Abdul Rehman Asghar Hussain Nazim Ali Hassan Zia Munawwar	Jan 1997
R-21.4	Volume Four: Field Data Collection and Processing	Gauhar Rehman Muhammad Aslam Waqar A. Jehangir Mobin Ud Din Ahmed Hassan Zia Munawwar Asghar Hussain Nazim Ali Faizan Ali Samia Ali	Jan 1997
R-21.5	Volume Five: Predicting Future Tubewell Salinity Discharges	Muhammad Aslam	Jan 1997

Report No.	Title		Author	Year
R-21.6	Volume Six:	Resource Use and Productivity Potential in the Irrigated Agriculture	Waqar A. Jehangir Nazim Ali	Feb 1997
R-21.7	Volume Seven:	Initiative for Upscaling: Irrigation Subdivision as the Building Block	Gauhar Rehman Asghar Hussain Hassan Zia Munawwar	Apr 1997
R-21.8	Volume Eight:	Options for Sustainability: Sector-Level Allocations and Investments	Abdul Rehman Gauhar Rehman Hassan Zia Munawar	Apr 1997
R-22	Salinisation, Alkalinisation and Sodification on Irrigated Areas in Pakistan: Characterisation of the geochemical and physical processes and the impact of irrigation water on these processes by the use of a hydro-geochemical model (M.Sc Thesis published as Research Report)		Nicolas Condom	Mar 1997
R-23	Alternative Scenarios for Improved Operations at the Main Canal Level: A Study of Fordwah Branch, Chishtian Sub-Division Using A Mathematical Flow simulation Model(M.Sc Thesis published as Research Report)		Xavier Litrico	Mar 1997
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