Time series (1980-2012) crop areas in the districts and canal commands of Pakistan

Mac Kirby, Mobin-ud-Din Ahmad

April 2016

A report prepared for the DFAT Australian Aid – CSIRO Sustainable Development Investment Portfolio
Contents

Acknowledgments ........................................................................................................................................ iii
Executive summary ...................................................................................................................................... iv
1 Introduction ........................................................................................................................................... 5
2 District crop areas, production and yield .............................................................................................. 7
3 Canal command crop areas: maps and method ....................................................................................... 12
   3.1 Maps and overlay areas ................................................................................................................ 12
   3.2 Calculating canal command crop areas ......................................................................................... 14
   3.3 Calculating canal command fresh and saline crop areas ............................................................ 15
   3.4 Implementation ............................................................................................................................. 16
4 Results: provincial and canal command crop group areas .................................................................... 17
   4.1 Crop group areas in the provinces of Pakistan ............................................................................. 17
   4.2 Crop group areas in selected canal commands ........................................................................... 19
References ................................................................................................................................................. 21
Figures

Figure 3.1. Districts, canal commands and agro-climatic zones in Pakistan. ................................. 12

Figure 3.2. Sketch of the overlay of districts with Marala Ravi canal command. The areas of overlay with Sialkot, Narowal and Sheikhupura districts are given by $A_{MR}^{S}$, $A_{MR}^{N}$ and $A_{MR}^{Sh}$ 14

Figure 4.1. Areas of crop groups (in 1000s of hectares) in the provinces of Pakistan, 1981-82 to 2011-12. Note the different scales for the Y axes of the graphs. ................................. 18

Figure 4.2. Areas of crop groups (in 1000s of hectares) in selected canal commands and agro-climatic zones of Pakistan, 1981-82 to 2011-12. Note the different scales for the Y axes of the graphs. ........................................................................................................................................... 20

Tables

Table 1 Sources of data for crop area, production and yield in Pakistan ........................................ 9

Table 2 Crop groups ...................................................................................................................... 11

Table 3 Sources of district maps. .................................................................................................. 13
Acknowledgments

This study was funded by the Department of Foreign Affairs and Trade (DFAT) Australian Aid and CSIRO, through the DFAT Australia Aid Sustainable Development Investment Portfolio and through CSIRO Land and Water Flagship. Most of the crop statistics information presented in this report was acquired from publically available datasets including Pakistan Bureau of Statistics and provincial Crop Reporting Departments. We also thank Dr Muhammad Jehanzeb M. Cheema and Dr Tasneem Khaliq from University of Agriculture, Faisalabad, for their help in collecting the data.

For spatial GIS analysis district boundaries were downloaded from Humanitarian Response Pakistan (http://www.pakresponse.info/MapDataCenter/GISData.aspx, data downloaded on 20th May 2015). The canal command boundaries shape file was provided by Indus River System Authority (IRSA).
Executive summary

We aimed to use crop area, production and yield data for several purposes: to estimate crop water demand and use, and hence river water diversions and groundwater pumpage in a hydrological model of the Indus River basin; to make crop production estimates from the river basin model for use in a model of the Pakistan economy, and hence assess potential impacts of water management policies on the economy; to assess the volumes of water used in irrigation and hence assess the sustainability of use; and to assess trends in crop area, production and productivity in order to assess the likely future food security for Pakistan, and whether limited water availability will jeopardise the prospects for food security.

To fulfil these aims, we collated crop area, production and yield information for the districts in Pakistan. For 13 major crops, the data are available from 1981-82 to 2011-12. For minor crops, the data are available for 2007-08 to 2011-12. We extrapolated the minor crop area backwards in time to 1981-82, by assuming constant ratios of minor crop areas to major crop areas.

We further summed the district areas of individual crops into crop groups. The crop groups comprise crops with similar requirements for amounts and timing (seasonality) of irrigation water supply. They also correspond to groups of crops considered in an economic model of the Pakistan economy.

The areas of crop groups are then re-mapped from districts into areas irrigated by individual main canals (such areas are known as canal commands). The re-mapping is based on maps of districts and canal commands, and involves assessing the portion of a district which overlays a canal command; crop groups are then mapped into the canal command in that proportion, subject to the total for all crops not exceeding the area of available for cropping within the canal command.
1 Introduction

In common with many another countries, Pakistan surveys crop area, production and yield within administrative districts. We aim to use crop data for several purposes:

- to understand agriculture production, water demand and use trends in the Indus basin with particular focus on food security aspects;
- to specify historical crop areas within a hydrological (river) model of the Indus basin, in order to estimate historical crop water use;
- to use the hydrological model crop production estimates as an input to an economic model (specifically, CGE-W, Robinson and Gueneau, 2014) to assess the economic impacts of water management scenarios;
- to assess the water demand and likely water use in different areas of Pakistan and, by comparing use with availability (and, for groundwater, the likely salinity), assess the likely sustainability of use; and,
- to assess trends in crop area, production and productivity and hence to assess the likely future food security in Pakistan and possible constraints (in particular, limits to the volume of water that may be sustainably used and how this might change in the future) to achieving food security.

Crop data in Pakistan may be obtained from several public sources (described in detail in the next section). Datasets for the major crops such as wheat and rice give crop areas for all districts for the full period of 1980-2012. Datasets for minor crops such as fruit and vegetables generally give crop areas for all districts only for a few recent years. No dataset that we are aware of gives crop areas for canal commands. To satisfy the requirements indicated above, we wanted a dataset that gives crop areas for all districts and years, and also the areas for canal commands.

To this end, we collated crop area, production and yield data from several Pakistani sources. The data cover about 50 different crops; we aggregated the data for minor crops into groups (such as pulses, which includes ten individual pulse crops). For some major crops, such as wheat and cotton, data are available by district for over 30 years. For other crops, particularly minor crops, the data are available by district only for a few recent years. We extrapolated the recent minor crop data backwards in time to provide a more complete set of estimates.

Our first aim in this report is to describe the district datasets and the extrapolation of minor crop area data backwards in time.

For use in the river model, it is useful to know the crop areas within hydrological units. The spatial units for economic surveys (including agricultural land use and production) and hydrology in most countries differ, and reconciling the two can present a significant challenge (de Lange et al., 2010, Qureshi and Whitten, 2010). Herr (2007) used map overlay techniques to re-map agricultural production from administrative units to hydrological units in the coastal area of Queensland, Australia. Ahmad et al. (2009) used spatial analysis techniques to reconcile administrative and hydrological units in the Karkheh river basin in Iran.
In Pakistan, water is diverted from the rivers into irrigation canals, and an area served by a single main canal (which branches into many smaller distributary canals) is called a canal command. Assessing the volume of water required to irrigate the crops in a canal command requires that the areas of the crops be known. This in turn requires that the survey data of areas of crops in districts be re-mapped into the areas within canal commands. Much irrigation in Pakistan uses groundwater; it may be assumed that where a canal command is underlain by saline groundwater the canal (surface) water forms the main source, whereas a canal command that is underlain by fresh water is likely to have a substantial fraction of the water demand met by groundwater.

Our second aim in this report is to describe the re-mapping of district crop areas to crop areas in canal commands. We describe the assumptions made in the re-mapping, and give the equations used. We also use other sources of data that give the fractions of fresh and saline groundwater within canal commands.

Our third aim is to make this organised information available to the community interested in understanding agricultural production systems in Pakistan.
2 District crop areas, production and yield

We obtained the crop area, production and yield data listed in Table 1 from the Pakistan Bureau of Statistics, the Agriculture Marketing Information Service of the Punjab Agriculture Department, and the Punjab Crop reporting Service.

The data include:

- 53 crops and crop varieties for all districts in Pakistan for 2010-11 and 2011-12
- 47 crops and crop varieties for all districts in Pakistan for 2007-08 and 2008-09,
- 13 major crops for all districts in Pakistan for 1981-82 to 2008-09.

With the exception of the provincial crop area and production statistics from the Pakistan Bureau of Statistics and the Ministry of National Food Security and Research (items 4 and 5 in Table 1), no information is given about survey methods. The Pakistan Bureau of Statistics and the Ministry of National Food Security and Research data sources in items 4 and 5 in Table 1 have an introduction to the published statistics in which it is stated “It is important to mention that the crops data is collected through acreage surveys as well as sample village surveys by the enumerators who fill up a number of prescribed Performas and submit to Provincial Crop Reporting Services. The accuracy of estimates is further cross checked and verified by joint inspection teams of Revenue and Extension Departments of Provincial Governments.” No information is given on the actual survey (how many farms were surveyed, etc.), nor is there any information on survey sampling errors. In the absence of such information, we take the data at face value, but recognise that the errors may mean that other data collection methods (such as remotely sensed crop area estimates) could yield a different.

An example of different area estimation techniques yielding different results to the crop surveys arises in the district of Lahore. Lahore district has a total land area of 1772 km$^2$. Zaman and Baloch, (2011), Riaz (2013) and Bhalli and Ghaffar (2015) all used remotely sensed data to classify urban, agricultural and other land in Lahore district. According to Zaman and Baloch (2011), agricultural land occupied 522 km$^2$ in 2010, with urban and other non-agricultural land occupying the remaining 1250 km$^2$. Riaz (2013) gave the figure only for urban land in 2009 as 992 km$^2$, which is consistent with the Zaman and Baloch figure of 1250 km$^2$ for urban and other non-agricultural land. The area of agricultural land from the survey data sources in Table 1 gives wheat as occupying 660 km$^2$ in 2009-10, rice as occupying 380 km$^2$ and fodder as occupying 630 km$^2$. The area occupied by all other crops was about 80 km$^2$ in 2009-10, according to the survey results. The distribution of fodder between summer and winter is not given in the data, but however we split the 630 km$^2$ between summer and winter, adding the summer portion to the rice area and the winter portion to the wheat area results in one or both areas being significantly larger than the figure of around 500 – 600 km$^2$ for agricultural land from Zaman and Baloch (2011) and Riaz (2013). However, Bhalli and Ghaffar (2015) concluded that agricultural land occupied 1002 km$^2$ in 2014, which may be consistent with the crop area survey results if summer and winter crops are mostly sown on the same area.
The data from all data sources are arranged by years such as 2012-13, not calendar year. It is not described in any of the data sources when the year starts, but since the statistics are published alongside other economic data we assume that the year is the Pakistan fiscal year, starting on the 1st of July. Kharif (summer) crops are grown across the start of the fiscal year – that is, they are generally sown before the 1st of July and harvested afterwards. It is not described in any of the data sources whether the Kharif crop statistics are for the year in which the crop was sown, or the next year in which it was harvested. We have assumed that the statistics are collected for the year in which the crop was harvested. Thus, we assume that the data for the 2012-13 year (as an example) comprise the data for Kharif crops harvested around October 2012 and Rabi crops harvested around April 2013.

Before using the data, we took several steps to clean, reformat and re-structure the data, and also grouped minor crops into crop groups.

The first step was to remove errors and inconsistencies in the data. Errors included typographical and other errors, such as two decimal points in a number (eg 1..23). Inconsistencies included frequent use of different indicators for no or missing data: NA, n.a., -, and ---- were replaced with -999. NOT GROWN and * (described as nominal, and generally occurring next to other zero or small values) were replaced with zeros. In addition, the data table structures differed from table to table. Some tables had columns of production next to columns of area, others had columns of production beneath columns of area. Others tables were derived from printed (pdf) tables which had page breaks in the middle of tables.

The next step was to extrapolate the minor crop (47 or 53 crops) areas data backwards in time from recent years to 1981-82. The backward extrapolation was based on assuming that the ratios of district areas of a minor crop to the total provincial area of that crop in the earlier years was the same as in the recent years. Thus:

\[ A_{ij} = A_{Tj} \cdot \bar{A}_{IR} / \bar{A}_{TR} \]  

where \( A_{ij} \) is the area of crop i in a district in year j (j is a year from 1981-2 to 2005-6), \( A_{Tj} \) is the total provincial cropped area in year j, \( \bar{A}_{IR} \) is the average area of crop i in a district in recent years (averaged over 2007-08, 2008-09, 2010-11 and 2011-12) and \( \bar{A}_{TR} \) is the averaged total provincial cropped area in recent years. The main justification for the backward extrapolation in time is that failure so to do will underestimate total crop areas in earlier years, and thus lead to an underestimate of water use. There is no particular evidence to support our assumption of constancy of ratios of areas amongst districts, nor evidence to support an alternative assumption.

The third step was to aggregate minor crops into groups. To fulfil our aims of assessing crop water use and the economic impacts of various crops, we aggregated data into crop groups broadly similar to those use by the CGE-W economic model of the Pakistan. (However, the CGE-W crop groups are derived from a smaller set of crops than we have considered.) The river modelling and irrigation water use modelling requires only that water demand be assessed, and this is achieved by grouping crops with similar irrigation requirements (grown in the same season).

The crop groups are shown in Table 2, with the crop groups used by the CGE-W model also shown for comparison.
### Table 1 Sources of data for crop area, production and yield in Pakistan

<table>
<thead>
<tr>
<th>File containing dataset</th>
<th>Source</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 53 tables of individual crops: Table1-Wheat.xls Table3-Rice.xls Table5-Maize.xls etc....</td>
<td>Crop Reporting Service, collected by Dr Cheema, University of Agriculture, Faisalabad</td>
<td>Province area, production and yield data for 53 crops for 2010-11 to 2011-12 for wheat, wheat varieties, rice, rice varieties, maize, bajra, jowar, barley, sugarcane, cotton, sunhemp, tobacco, guarseed, gram, mung, mash, masoor, matter, other Kharif pulses, other Rabi pulses, rapeseed, groundnut, sesamum, linseed, castorseed, soybean, sunflower, safflower, onion, garlic, ginger, chillies, coriander, turmeric, potato, tomato, all vegetables, fodder, citrus, mango, banana, apple, guava, apricot, peach, pear, plum, grape, pomegranate, dates, almonds, all fruits.</td>
</tr>
</tbody>
</table>
| 5 | fodder area and production by province 1976-7 to 2011-12.xlsx | Pakistan Bureau of Statistics  
Also at Ministry if National Food Security and Research  
http://www.mnfsr.gov.pk/gop/index.php?q=aHR0cDovLzE5Mi4xNjguNzAuMTM2L21uZnNyL3B1YkRldGFpbHMuYXNweA%3D%3D (1994-5 to 2011-12) | Province area, production and yield data for 1947-8 to 2008-09 for fodder (total fodder, not given by Rabi / Kharif or by annual / perennial, etc.) |
### Table 2 Crop groups

<table>
<thead>
<tr>
<th>Crop group</th>
<th>Individual crops in group</th>
<th>Corresponding CGE-W crop group</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Winter cereals</td>
<td>Wheat, barley</td>
<td>Rainfed wheat, Irrigated wheat</td>
</tr>
<tr>
<td>2 Other rice</td>
<td>Rice other than Basmati rice</td>
<td>Rice</td>
</tr>
<tr>
<td>3 Basmati rice</td>
<td>Basmati rice</td>
<td>Basmati rice</td>
</tr>
<tr>
<td>4 Cotton</td>
<td>Cotton</td>
<td>Cotton</td>
</tr>
<tr>
<td>5 Sugarcane</td>
<td>Sugarcane</td>
<td>Sugarcane</td>
</tr>
<tr>
<td>6 Summer grains</td>
<td>Maize, bajra, jowar</td>
<td></td>
</tr>
<tr>
<td>7 Oilseeds</td>
<td>Rapeseed, sesamum, linseed, castorseed, sunflower, safflower</td>
<td>Other</td>
</tr>
<tr>
<td>8 Pulses</td>
<td>Gram, mung, mash, masoor, matter, groundnut, soybean, guarseed, other Kharif pulses, other Rabi pulses</td>
<td>Other</td>
</tr>
<tr>
<td>9 Other</td>
<td>Potato, sunhemp, tobacco, sugarbeet, onion, garlic, ginger, coriander, turmeric, tomato</td>
<td></td>
</tr>
<tr>
<td>10 Fodder (summer)</td>
<td>Summer fodder</td>
<td></td>
</tr>
<tr>
<td>11 Fodder (winter)</td>
<td>Winter fodder</td>
<td></td>
</tr>
<tr>
<td>12 Orchard (evergreen)</td>
<td>Citrus, mango, banana, guava, pomegranate, dates</td>
<td>Horticulture</td>
</tr>
<tr>
<td>13 Orchard (deciduous)</td>
<td>Apple, apricot, peach, pears, plums, grapes, almonds</td>
<td></td>
</tr>
</tbody>
</table>
3 Canal command crop areas: maps and method

We used a simple method of overlaying a district map with a canal command map to transform the original district agricultural survey area data into canal command data. We also used a third map, of agro-climatic zones (zones of similar cropping and climate). As discussed later, information of areas of fresh and saline groundwater is associated with agro-climatic zones. Thus, the overlay of the agro-climatic zones enables the derivation of areas underlain by fresh and saline groundwater within each canal command. The overlay of the three maps is shown in Figure 3.1.

Figure 3.1. Districts and agro-climatic zones in Pakistan. The districts are shown by the thin grey boundaries and each is named. The agro-climatic zones are given by the key. Within each agro-climatic zone are one or more canal commands, bounded by the thicker grey lines. Sources: district areas as discussed in Section 3.1; canal commands and agro-climatic zones from the Indus River System Authority (IRSA).

3.1 Maps and overlay areas

Figure 3.1 suggests a well-defined set of district, canal command and agro-climatic zone boundaries. In reality, there is much uncertainty about the exact boundaries of all three spatial units. District maps can be found from various sources (Table 3). The district boundaries differ in detail amongst maps, which may be expected since some maps are based on older hand-drawn maps, whereas others are more contemporary digital maps. There are also differences caused by
the subdivision of districts to create newer, smaller districts. However, there are also some more serious discrepancies amongst maps, such as the alignment of the boundary between Mirpurkhas and Umerkot in the southern part of Sindh province. On some maps, Umerkot is to the south of Mirpurkhas and the boundary is roughly WSW to ENE, whereas in other maps, Umerkot is to the east of Mirpurkhas and the boundary is roughly S to N.

### Table 3. Sources of district maps.

<table>
<thead>
<tr>
<th>Data Source</th>
<th>Web links</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Pakistan Census Organisation (PCO) district boundary¹</td>
<td>Pak_adm3_PCO_20110324.shp downloaded from <a href="http://www.pakresponse.info/MapDataCenter/GISData.aspx">http://www.pakresponse.info/MapDataCenter/GISData.aspx</a></td>
</tr>
</tbody>
</table>

After comparison of various GIS district level maps with information available at Wikipedia (https://en.wikipedia.org/wiki/List_of_districts_of_Pakistan) and other published hard copy maps, it was decided to use Pakistan Census organisation (PCO) map for this study. However, the following inconsistencies were observed in the PCO map:

- Rajanpur and Dera Ghazi Khan district boundaries do not match those of other sources. Due to lack of information no attempt was made to address this inconsistency.

- Two small polygons, labelled Rahim Yar Khan (which is a district in Punjab), on the Indus river within Sindh province were split at the Indus river and merged with neighbouring districts in Sindh province.

The canal command and agro-climatic zone maps were obtained from Indus River System Authority (IRSA).

We used ArcGIS to calculate the areas of overlay of canal commands and districts, as shown in Figure 3.2 for the Marala Ravi canal command.

¹ These data are made available free of charge for strictly humanitarian uses only. Permission must be sought from the Pakistan Census Organisation for any other use.
Figure 3.2. Sketch of the overlay of districts with Marala Ravi canal command. The areas of overlay with Sialkot, Narowal and Sheikhupura districts are given by $A_{Si-MR}$, $A_{AN-MR}$ and $A_{Sh-MR}$.

3.2 Calculating canal command crop areas

For each district, the area of Rabi crops, $A^D_R$, and Kharif crops, $A^D_K$, is found by summing the individual crop areas:

$$
A^D_R = \sum_{i=1}^{NR} A^D_{iR}
$$

$$
A^D_K = \sum_{i=1}^{NK} A^D_{iK}
$$

(1)

where $A^D_{iR}$ and $A^D_{iK}$ are the areas and $NR$ and $NK$ the numbers of individual crops (wheat, rice, cotton, etc.) within each season. The superscript $D$ refers to a district area; in what follows, $C$ will refer to a canal command area, $D-C$ to an overlay of a district and canal command area, and $D\mid C$ to a district area outside a canal command.

We assume that the area within a canal command actually under crop is a fraction, $F_C$ (where $0 \leq F_C \leq 1$, typically around 0.5 as described further below) of the area of the canal command. Using the fraction with Equation (1), we find the fraction of Rabi and Kharif crops in a district that are within the canal command:

$$
F^D_{RC} = \frac{A^D_{iR}}{A^D_{iR}}
$$

$$
F^D_{KC} = \frac{A^D_{iK}}{A^D_{iK}}
$$

(2)

where $A^{D-C}$ is the area of overlay of a district and a canal command (such as $A^{Sh-MR}$, the area of overlay of the Sheikhupura district and the Marala Ravi canal in Figure 3.2). The fraction calculated in equation (2) are then used to calculate the areas in a district of each crop within a canal command and the corresponding areas outside the canal command.
\[ A_{IR}^{D-C} = F_{R}^{D-C} A_{IR}^{D} \]
\[ A_{IK}^{D-C} = F_{K}^{D-C} A_{IK}^{D} \]  
\[ (3a) \]
\[ A_{IR}^{DC} = (1 - F_{R}^{D-C}) A_{IR}^{D} \]
\[ A_{IK}^{DC} = (1 - F_{K}^{D-C}) A_{IK}^{D} \]  
\[ (3b) \]

where \( A_{IR}^{D-C} \) and \( A_{IK}^{D-C} \) are the areas individual Rabi and Kharif crops within the overlay area of the district and canal command, and \( A_{IR}^{D-C} \) and \( A_{IK}^{D-C} \) are the corresponding areas of district crops outside the canal command.

Equations (3a) and (3b) are based on the assumption that all crops within a district and in a season (Rabi, Kharif) are distributed inside and outside the district – canal command overlay area in the same proportions. Other assumptions are possible, such that some crops are preferentially given access to canal water. In some (wetter) areas and in the case of some crops, the district crops outside the canal command area are grown rainfed, without irrigation. In other areas and other crops, it may imply that groundwater is used for irrigation outside the canal command area. In yet other areas, there may be use of surface water sources (such as direct diversion from small rivers) that are outside the canal command system. Given these possibilities, and in the absence of direct evidence to the contrary, we use the assumption for its simplicity.

The overall area of a particular crop within a canal command is calculated as the sum of the crops in the overlay areas that comprise the canal command.

### 3.3 Calculating canal command fresh and saline crop areas

The irrigation areas in Pakistan are underlain by both saline and fresh groundwater, with fresher groundwater generally more available in the Punjab, while the Sindh is mostly underlain by saline groundwater. Groundwater is used for irrigation, but mainly only where fresh groundwater is available (though some slightly saline groundwater may be mixed with fresh groundwater in some areas). Assessments of water use, particularly where it is intended to estimate the volumes of water drawn from surface and groundwater, must take account of the salinity of the groundwater. Therefore, we used some ancillary information about fresh and saline groundwater areas that is available for the agro-climatic zones.

The Marala Ravi canal command shown as an example in Figure 3.2 falls completely within the Punjab Mixed Wheat (PMW) agro-climatic zone, and is all underlain by fresh groundwater. For such a case, the areas of canal command crops underlain by fresh groundwater are identical to the areas calculated in Equation (3a).

In some agro-climatic zones, the groundwater is partly fresh and partly saline. For such a case, the areas of canal command crops underlain by fresh and saline groundwater are given by multiplying the areas calculated in Equation (3a) by the respective fresh and saline fractions. Ahmad et al. (1990), defined the proportions of up to four sub-areas per canal command, the agro-climatic zones within which the sub-areas fall, and which sub-areas are saline and which are fresh (specifically on pages 175 and 176, in the tables for SUBDEF, ZSA and GWF). The information in Ahmad et al. (1990) was used to derive the fresh and saline fractions with which to calculate the canal command fresh and saline crop areas.
Some canal commands fall within two agro-climatic zones, and the overlay areas have different fresh and saline areas. For such a case, the overlay areas of districts and canal commands (as identified in Section 2.1 above) must be further subdivided by the agro-climatic zone overlay. The crops are assumed to fall into the two agro-climatic zone overlay areas in the same proportions. This assumption gives the areas of crops in each unique district – canal command – agro-climatic zone overlay area. The fresh and saline areas are given by multiplying these areas by the respective fresh and saline fractions (from Ahmad et al., 1990), and summing the results to the canal command area.

3.4 Implementation

The assignment of district crop areas to canal command crop areas is done in two phases; each phase is done in a single spreadsheet.

In the first spreadsheet, the district crop area data for 1981-82 to 2011-12 for all major and minor crops are collated from datasets 1, 2 and 3 in Table 1. The areas of individual crops are summed into the crop groups in Table 3 (one worksheet per crop group) and converted to units of 1000 ha as necessary (in the original datasets major crops are given in 1000 ha, minor crops in ha).

In the second spreadsheet, the tables of crop groups from above are re-mapped from districts to canal commands. Some cross-checks are built into the computations, such as checking that the total area of a crop group summed across the canal commands equals the total area summed across the districts (excluding those portions of the district areas that fall outside canal commands).

The spreadsheets are available at http://doi.org/10.4225/08/575657BA87EFB.
4 Results: provincial and canal command crop group areas

In this section, we give as examples the crop group areas for the four provinces of Pakistan, and crop group areas from five contrasting canal commands.

4.1 Crop group areas in the provinces of Pakistan

The observed and estimated crop group areas in the four provinces are shown in Figure 4.1. The graphs in the figure result from summing the individual district crop data to the provincial level. The graphs do not depend on the re-mapping of district area data to canal command areas.

The Punjab has the greatest area of crops, with approximately three times the area of cropping as Sindh, eight times that of Khyber Pakhtunkhwa and fourteen times that of Balochistan. The crop groups, in terms of area, are dominated by the grains (wheat, rice and other grains such as maize and barley), cotton, pulses, fodder and sugarcane. Basmati rice occupies about twice the area of other rice. The area of cropping has grown by about a quarter over the period from 1981-82 to 2011-12.

Sindh has a smaller area of crops, and the area has declined by about a quarter over the period from 1981-82 to 2011-12. The mix of crop groups in Sindh is broadly similar to that in the Punjab, but with proportionally somewhat less area devoted to wheat and pulses, and somewhat more to oilseeds. The rice is mostly non-basmati, in contrast to the Punjab.

In Khyber Pakthunkhwa, cropping is dominated by wheat and other grains, with proportionally much less rice and very little cotton. Although the areas of fruit orchards are small, both in terms of absolute area and the proportion of the area, the orchards in Khyber Pakthunkhwa are mostly deciduous orchards (pears, plums, etc.), in contrast to the evergreen orchards (citrus, mangoes, etc.) of the Punjab and Sindh. The area of cropping expanded during the first half of the period from 1981-82 to 2011-12, and then declined again in the second half.

Balochistan differs from the other provinces in the larger proportion of the area devoted to orchards, especially deciduous orchards. Most of these orchards are in the north-western districts of Balochistan, outside areas irrigated from the Indus. The area of cropping approximately doubled from 1981-82 to 2011-12.
Figure 4.1. Areas of crop groups (in 1000s of hectares) in the provinces of Pakistan, 1981-82 to 2011-12. Note the different scales for the Y axes of the graphs.
4.2 Crop group areas in selected canal commands

The observed and estimated crop group areas in five contrasting canal commands, drawn from different agro-climatic zones, are shown in Figure 4.2. These figures result from the re-mapping of district area data to canal command areas.

The Sidhnai canal command is in the Punjab Cotton-Wheat East (PCWE) agro-climatic zone. The crop group areas are dominated by wheat, cotton and fodder. The canal command also has a large area of evergreen orchards, mostly citrus and mango.

The Upper Chenab canal command is in the Punjab Rice-Wheat (PRW) agro-climatic zone. The crop group areas are dominated by wheat, basmati rice, other rice and fodder.

The Lower Jhelum canal command is in the Punjab Sugarcane-Wheat (PSW) agro-climatic zone. The crop group areas are dominated by wheat, fodder, sugarcane and evergreen orchards (mostly citrus).

The Nara canal command is in the Sindh Cotton-Wheat South (SCWS) agro-climatic zone. The crop group areas are dominated by wheat, cotton, fodder and oilseeds (mostly sunflower). The areas of crops was greater in the 1990s than before or after, perhaps reflecting greater water availability for a period following the Provincial Water Accord of 1991. The decline in crop areas in 2011-12 may result from the damage of the 2010 floods.

The Fuleli canal command is in the Sindh Rice-Wheat South (SRWS) agro-climatic zone. The crop group areas are dominated by oilseeds (mostly sunflower), wheat, rice and sugarcane. The decline in crop areas in 2011-12 may result from the damage of the 2010 floods.
Figure 4.2. Areas of crop groups (in 1000s of hectares) in selected canal commands and agro-climatic zones of Pakistan, 1981-82 to 2011-12. Note the different scales for the Y axes of the graphs.
References


AT CSIRO WE SHAPE THE FUTURE

We do this by using science to solve real issues. Our research makes a difference to industry, people and the planet.

As Australia’s national science agency we’ve been pushing the edge of what’s possible for over 85 years. Today we have more than 5,000 talented people working out of 50-plus centres in Australia and internationally. Our people work closely with industry and communities to leave a lasting legacy. Collectively, our innovation and excellence places us in the top ten applied research agencies in the world.

WE ASK, WE SEEK AND WE SOLVE

FOR FURTHER INFORMATION

CSIRO Land and Water
Mac Kirby
t +61 2 6426 5921
e mac.kirby@csiro.au

CSIRO Land and Water
Mobin-ud-Din Ahmad
t +61 2 6426 5936
e mobin.ahmad@csiro.au