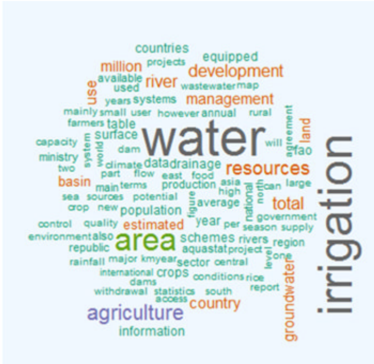

Irrigation Systems Inventory

Inception Report: Part 3/5 – Database Design

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Contents

Executive summary

This report represents the third of five inception phase reports documenting the development of an Irrigation Scheme Inventory of smallholder irrigation schemes in Zimbabwe. It presents the start of the development of the database design. It starts of with a description of the **essential elements of database design** so that the novice reader can understand the design process which is ordered in eight steps.

By the end of this step, four of the eight steps had been completed. A graphical representation of the **database structure** is presented in Appendix 1 and provided in more detail as a bitmap file that accompanies this report. Information has been **turned into columns** in an Excel spreadsheet that accompanies this report.

This is as much progress that can be made at this stage of the design. In the next report (Report 4 of the ISI Inception Phase: Development of Field Survey Methodology and Field Testing of Instruments at Irrigation Schemes) the spreadsheet will be further refined to include the final set of fields.

Introduction

Agriculture contributes 15-20% to Zimbabwe's Gross Domestic Product, estimated at US$ 11.427 billion in 2012 (GOZ, 2012), and accounts for 40% of the nation's exports (GOZ, 2013a). The sector accounts for 25% of formal employment and provides livelihoods for over 70% of the rural population. The sector is central to the economy in guaranteeing food security and backward and forward linkage to markets. The agro-processing industry draws some 63% of its input requirements from agriculture (GOZ, 2013a).

The government of Zimbabwe has prioritised irrigation development since 1930 when it embarked on a national dam construction programme for large scale commercial farmers (GOZ, 2004). In a country where agriculture is dependent on a single rainy season (November through March) irrigation is an important strategy for increasing productivity through:

- Provision of supplementary water during mid-season dry spells, or seasonal droughts.
- Winter production of crops such as pulses (sugar beans), cereals (wheat) and horticulture.

In addition, access to irrigation allows farmers to explore the production of new, higher valued crops.

According to the World Bank (2013a), the country now has more than 8 000 dams which in 2000, commanded more than 120 000 ha of irrigation land[1]. The Fast Track Land Reform Programme that commenced in 2000, and the related decade-long period of economic decline, contributed to a reduction in this irrigated area. The same report estimates that in 2012 the area under irrigation was only 51 000 ha[2] (*ibid.*).

Government policy is to rehabilitate these idle irrigation schemes before developing new ones (e.g. GOZ, 2013b). It is estimated that about 200 000 ha can be developed from existing under-utilized storage capacity and dams under construction (World Bank, 2013b). Furthermore, the irrigation potential of the country is estimated at around 365 000 ha, considerably less than irrigable land, estimated at 600 000 ha (*ibid.*).

The Government of Zimbabwe continues to promote irrigated agriculture through various policy documents including the Medium Term Plan (GOZ, 2011), CAADP compact (GOZ, 2013c), Zimbabwe Agricultural Investment Programme (GOZ, 2013a), Zim-Asset (GOZ, 2013d) and most recently, the 2014 National Budget Statement (GOZ, 2013b).

Since independence in 1980 government has focused on irrigation development in communal farming areas, many of which are located in drought-prone regions. Over 180 smallholder schemes have since been developed on communal and old resettlement schemes commanding an area of 8103 ha (GOZ, 2004). A further 2000 ha have been developed on small scale commercial farms. Thus a total of up to 10000 ha of irrigation are

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[1] This value is based on satellite imagery. However estimates vary widely in the literature. For example, the ZAIP document (GOZ, 2013a) reports that 200 000 ha were irrigated in 2000

[2] See Footnote 1. The ZAIP report (GOZ, 2013a) estimates that 135 580 ha was under irrigation in 2009. World Bank (2013b) estimate that between 70 000 and 135 000 ha are currently being irrigated. The equivalent estimate in Zim-Asset (GOZ, 2013d) is 150 000 ha.

available in the formal smallholder subsector (*ibid.*). One of the features of these schemes is that, for the most part, they are stuck in a recurring cycle of build, operate, decline and rehabilitation with the latter process usually being funded by government or international donors on a grant basis. To this end, government has allocated US$9.4 million for communal irrigation schemes in the 2014 budget, whilst the Swiss government recently provided a grant for the rehabilitation of Rupike and Pfuve Panganayi irrigation schemes in Masvingo Province. This cycle points to a lack of capacity of scheme beneficiaries to maintain their equipment. World Bank (2013a) note that a lack of technical capacity also extends to national institutions such as ZINWA.

According to World Bank (2013a), the restoration of irrigation infrastructure is necessary *but not sufficient* to restore irrigated agricultural production. Other constraints include uncertainties about land tenure, absence or dilapidated infrastructure, unreliable power supplies and weak input and output markets. They argue that past budgetary allocations by the Ministry of Finance have not been effectively used because of these constraints. There is thus a need to focus on 'software' (i.e. capacity) and market issues as well as the more obvious hardware limitations.

It is against this background that Welthungerhilfe (WHH) and GIZ through the Food Security and Agriculture Programme plan to develop methods and tools that will assist investors (private sector, government and donors) in making decisions on selection of irrigation schemes providing the best investment opportunities. WHH and GIZ have considerable experience in smallholder irrigation system development and the smallholder farming sector in Zimbabwe and throughout the developing world. These organisations have contracted Floranature, an agricultural consulting firm specialising in the smallholder farming sector, to develop the framework for an Irrigation Systems Inventory (ISI).

This report is the third in a series of five, documenting the initial steps in the design of the database.

The essential elements of database design

Database design is the process of producing a detailed database model. A database model is a type of data model that determines the logical structure of a database and fundamentally determines in which manner data can be stored, organized, and manipulated. The most popular example of a database model is the **relational** model, which uses a table-based format. A common misconception is that the relational model is so called because of the stating of relationships between data elements therein. This is not true. The relational model is so named because it is based upon the mathematical structures known as relations.

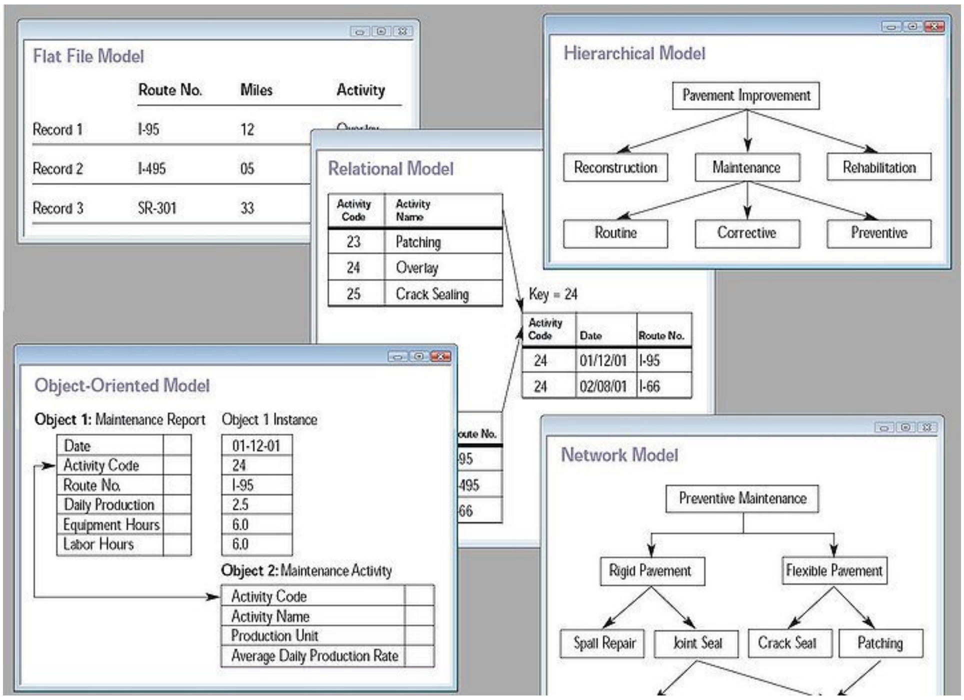

Figure 1: Collage of five types of database models

The term database design can be used to describe many different parts of the design of an overall database system. Principally, and most correctly, it can be thought of as the logical design of the base data structures used to store the data. In the relational model these are the tables and views. In an object database the entities and relationships map directly to object classes and named relationships. However, the term database design could also be used to apply to the overall process of designing, not just the base data structures, but also the forms and queries used as part of the overall database application within the database management system.

Determining the data to be stored

In a majority of cases, the person who is designing the database is a person with expertise in the area of database design rather than expertise in the domain from which the data to be stored is drawn; for example, financial information, biological information etc. Therefore, the data to be stored in the database must be determined in cooperation with individuals who have expertise in the particular domain and who are aware of what data must be stored within the system.

This process is one which is generally considered part of requirements analysis and requires skill on the part of the database designer to elicit the needed information from those with the domain knowledge. Often this is because those with the necessary domain knowledge frequently cannot express clearly what their system requirements for the database are as they are unaccustomed to thinking in terms of the discrete data elements which must be stored.

Design process

The process of database design consists of a number of steps that will be carried out by the database designer. These steps are as follows:

1. **Determine the purpose of the database.** This helps prepare for the remaining steps.

2. **Find and organise the information required.** Gather all of the types of information to record in the database, such as product name and order number.

3. **Divide the information into tables.** Divide information items into major entities or subjects such as Products or Orders. Each subject then becomes a table.

4. **Turn information items into columns.** Decide what information needs to be stored in each table. Each item becomes a field, and is displayed as a column in the table. For example, an Employees table might include fields such as Last Name and Hire Date.

5. **Specify primary keys.** Choose each table's primary key. The primary key is a column, or a set of columns, that is used to uniquely identify each row. An example might be Product ID or Order ID.

6. **Set up the table relationships.** Look at each table and decide how the data in one table is related to the data in other tables. Add fields to tables or create new tables to clarify the relationships, as necessary.

7. **Refine the design.** Analyse the design for errors. Create tables and add a few records of sample data. Check if results come from the tables as expected. Make adjustments to the design, as needed.

8. **Apply the normalisation rules.** Apply the data normalisation rules to see if tables are structured correctly. Make adjustments to the tables.

Database normalisation is the process of organising the fields and tables of a relational database to minimise redundancy. Normalisation usually involves dividing large tables into smaller (and less redundant) tables and defining relationships between them. The objective is to isolate data so that additions, deletions, and modifications of a field can be made in just one table and then propagated through the rest of the database using the defined relationships.

Status of ISI database design

The current inception phase of the ISI requires that the design process stops short of activities pertaining to the building of the database. The following description reflects the order provided in the foregoing section on the design process:

1. **Determine the purpose of the database.** The objective of the database is to develop an inventory of smallholder irrigation schemes in Zimbabwe for the purpose of informing investment decisions.

2. **Find and organise the information required.** The requisite information was categorised and described in the previous two ISI project reports. Fields were categorised under headings of

   [A] Water Resources
   [B] Land Resources
   [C] Infrastructural Resources
   [D] Socio Economic and Management; and
   [E] Agricultural Productivity and Marketing

   Category [D] was further divided into four subcategories:
   [D1] Stream and System Management
   [D2] Irrigators at the scheme
   [D3] Farmer Organisation
   [D4] Functions of the farmer organisation; and
   [D5] Legal and Financial Viability

3. **Divide the information into tables.** A draft allocation of the information fields into tables was completed and can be viewed in a Data Structure Diagram in Appendix 1. We have chosen to use a graphic layout as it is easier to conceptualise the entire database than traditional techniques (e.g. Entity-Relationship model diagrams or Crow's Foot Notation). The Data Structure Diagram sets out graphically the five core tables of the database and the fields and attributes of each field. Appendix 1 is difficult to read and is presented in this report for the sake of completeness. The reader is invited to view the bitmap file which accompanies this report (ISI_Dbase_Structure.bmp).

4. **Turn information items into columns.** Once the diagram was developed, the information was turned into columns using an Excel spreadsheet. The reader is invited to view the spreadsheet (ISI_Dbase_Columns.xlsx) which lists:

- Unique identification number [Column A]
- Field description [Column B]
- Field type [Column C]. Field types have been allocated in accordance with Microsoft Access® 2013 data field types and are selectable from a drop down box in each cell. See Appendix 2 for explanations on field types.
- Options [Column D]. This column provides the possible options for applicable field types (e.g. short text, Yes/No)
- Any additional comments are provided in Column E.

It should be noted that at the time that this stage of the inception phase was completed, column names and Field IDs had not been finalised. The spreadsheet therefore represents a phase in the process that would be finalised in the next Stage if the ISI – the development of field survey methodology.

It is not possible to complete the final four stages of the database design process during this inception phase of the ISI project. This work will be done during implementation.

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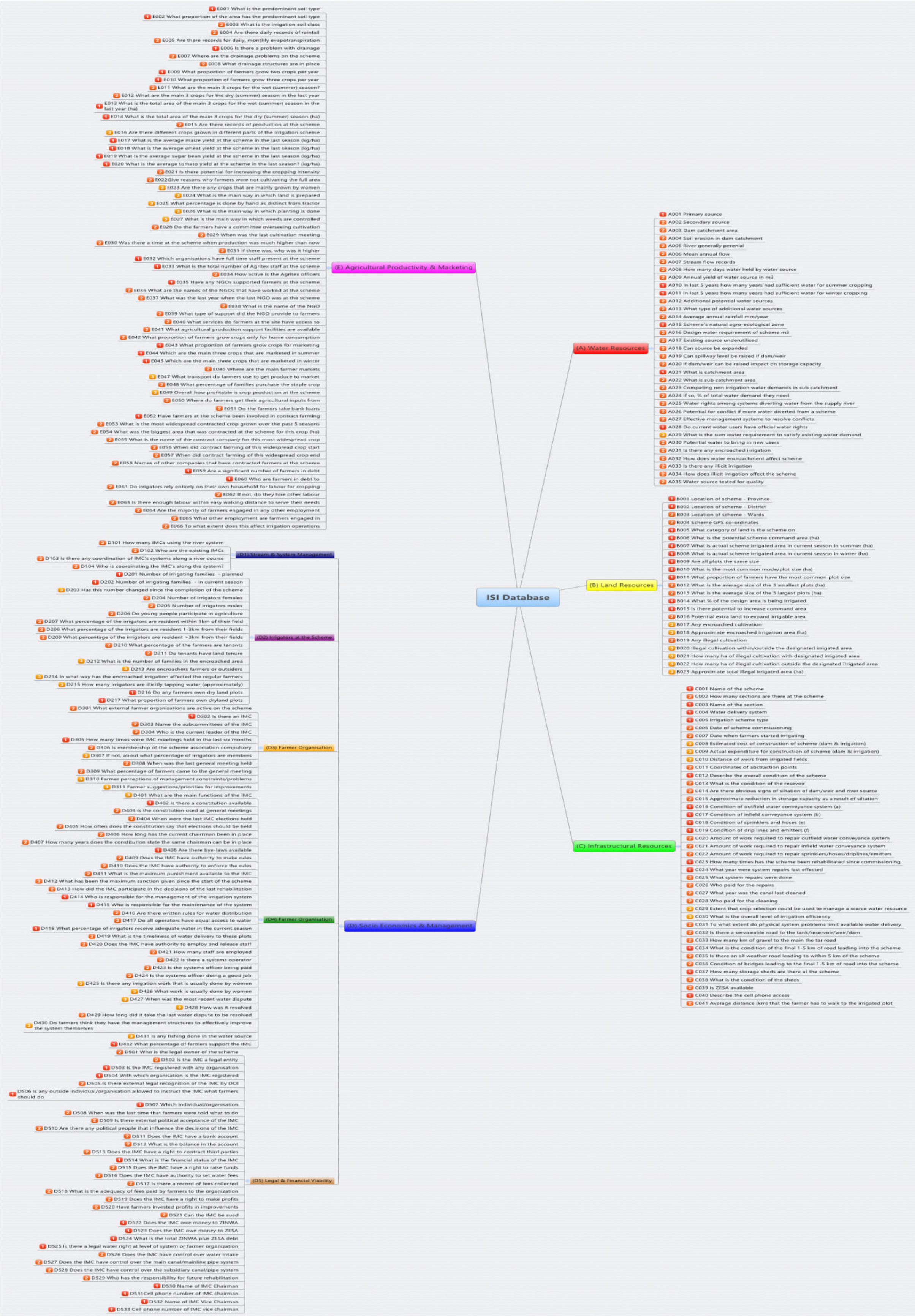
Appendix 1 ISI Data Structure Diagram

(see ISI_Dbase_Structure.bmp sized 35 MB)



Appendix 2 Data field types used in the ISI

Short Text	Text up to 255 characters long (including spaces and punctuation). Use a Text field, not a Number field, for codes even if they look like numbers, such as phone numbers, zip codes, and other postal codes
Long Text	Text up to 65,536 characters. A Long Text field can contain Rich Text (formatted text), and you can set it to Append Only so that it can accumulate text notes without allowing the user to delete what's already there
Number	Only numbers. You may use + or –before the number, as well as a decimal point. If you plan to do calculations with a field, use a Number or Currency field
Currency	Numbers with a currency sign in front of them ($, ¥, and so on)
AutoNumber	Numbers unique to each record and assigned by Access as you add records, starting at 1. Use an AutoNumber field as the primary key field for most tables
Date/Time	Dates, times, or both
Hyperlink	Text string formatted as a hyperlink. (If you click the link, it takes you to the webpage or email address.) This field type is especially useful if related information is available on the web
Yes/No	Yes or no (a particular condition is, or isn't, in effect) — or other two-word sets, such as True/False, On/Off, and Male/Female. Use a Yes/No field if you want to display the field as a check box on forms
OLE Object	Stores one or more entire files — pictures, sound, Word documents, even video — in one Attachment field
Lookup Wizard	Displays a list of values that is retrieved from another table or from a static set of values specified when creating the field