Digitising Locally Sourced Data for Improved Environmental Management of the Rakaia River & Hāpua

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Executive Summary

- Mr Bill Southward has collected data on the Rakaia River and Hāpua over the past 30-40 years. The aim of this project was to digitise Mr Southward's analogue data.
- Digitisation of Mr Southward's data will aid in preserving it for future groups who can utilise this data for better environmental management of the Rakaia Hāpua.
- The research question for this project was, '*How can locally sourced data be preserved and used to assess temporal change in the condition of the Rakaia Hāpua?'*
- Mr Southward's analogue documents were scanned, and categorised into six topics, with subfolders for data type, and labelling of documents with year and location. The title and author were included if appropriate.
- The digitisation process followed the 3-2-1 back-up rule. Three copies of the data were stored on two different storage mediums, with one copy offsite.
- Changes identified in Mr Southward's data included a reduction in stream size and clarity, thinning and shallowing of the Hāpua, increased frequency of ponding events, formation of washover fans and landward sediment features, increased silt, and increased bank movement.
- A case study on Mr Southward's data on ponding and river flow in combination with academic literature demonstrates the importance and validity of local knowledge and tacit knowledge.
- The digitised data increases the accessibility and sustainability of the data. This will enable it to benefit stakeholders such as ECAN, mana whenua and braided river communities.
- The volume and diverse nature of Mr Southward's data combined with the small time frame meant the methodological approach for digitising was limited.
- Future groups should take a more digital approach by recording interviews with Mr Southward, interviewing data preservation specialists, converting data for manipulation, and using GIS.

1.0 Introduction

The Rakaia River Hāpua is a significant coastal feature located on the East Coast of the South Island, New Zealand. North Rakaia Huts resident Bill Southward has collected data on the Hāpua over the past 30-40 years. The aim of this project was to digitise this data. Mr Southward's data will be beneficial to scientists, Māori, locals, and policy makers. Increasing accessibility to this knowledge will contribute towards sustainable environmental management decisions within the catchment.

Preserving scientific ideas, observations and research is important for future generations (Faundeen et al, 2007). Organisation of this data is vital to ensuring long-term accessibility. Since much of the data was collected by Mr Southward himself or sourced by him, it is a form of citizen science. Many papers discuss the usefulness of online databases and repositories for accessibility of citizen science. A robust and accessible online database is crucial for a successful project, and to ensure the data will be able to be used by a range of people (Craig & Hawkins, 2020; Harley & Kinsela, 2022; Shwe, 2020). Citizen science is becoming more prevalent in scientific research as its potential benefits are realised. It promotes equitable and universal access to scientific information (Sherbinin et al, 2021). It also promotes inclusion of opinions from minority groups such as indigenous populations, so that they can become informed and take action regarding changes happening to their land (Estuary Watch, 2021). Citizen science is also essential for increasing public involvement and interest in science (Burgess et al, 2017).

The research question for this project was: "*How can locally sourced data be preserved and used to assess temporal changes in the condition of the Rakaia Hāpua?".* The question consists of two parts. The first part asks, "*How can locally sourced data be preserved?*". Mr Southward's data is largely analogous, including many data types such as photographs, personal notations, and reports. Without digitisation, this data is at risk of being lost or damaged. Research in this project has focused on three sub-topics of data digitisation. These include:

1) Data organisation – Ensuring documents are filed logically and consistently.
2) Data storage – Determining the best storage media, number of copies and where they will be kept.
3) Data sustainability – Ensuring that data is stored so it can be accessed as time and technology progresses.

The second part of the research question focuses on how this locally sourced data can be used to assess temporal change in the condition of the Rakaia Hāpua. From analysing Mr Southward's data, a diverse range of changes in the river and Hāpua environments were identified. A significant portion of these changes are connected to reduced flow in the Rakaia River. Flow rate can be altered by many things, such as floods, water locked in ice at the headwaters, irrigation, and droughts. Water within New Zealand is a valuable resource, which can be used in multiple ways (Jenkins, 2018). Land use change and demand for irrigation are a significant factor contributing to reduced flows in the Rakaia (KC et al, 2018).

Assessing change in the condition of the Rakaia Hāpua requires both temporal and spatial orientated information. The Rakaia Hāpua is a highly sensitive landform, which is changeable depending on river inflows and outflows (Hart, 2009). Land use surrounding the Rakaia Hāpua has changed significantly since early Māori settlement (Holdaway, 2018). Land clearance and intensification of agricultural practices after European settlement have encroached on the lateral plains of the river (Evans, 2004; Environment Canterbury, 2015). A substantial amount of flow is reduced due to water abstraction for surrounding farmland (Environment Canterbury, 2015). Saurian (2015) describes that changes in the Hāpua occur quickly over a geological timescale, so assessing these and the processes causing them is essential for better environmental management.

1.1 Study Site

The Rakaia Hāpua is located 50km South of Christchurch, where the Rakaia River reaches the Pacific Ocean (refer to Figure 1). The Rakaia River is a large high energy braided river starting in the Southern Alps of New Zealand. It is one of the largest braided rivers in New Zealand, with a catchment area of 2,900km^2 and an average flow rate of 203m^3 s^{-1} (BRaided Rivers New Zealand, 2022).

Hāpua form at the coastal-fluvial interface of a mixed sand and gravel beach and a braided river. Hāpua have no tidal cycle influence and are defined as non-estuarine lagoons (Hart, 2009). They occur from a combination of fluvial energy, wave energy and sediment load from the river. The river mouth, or outlet channel, constantly changes and moves from shore normal to shore parallel under different wave and river flow regimes (Measures et al., 2020).

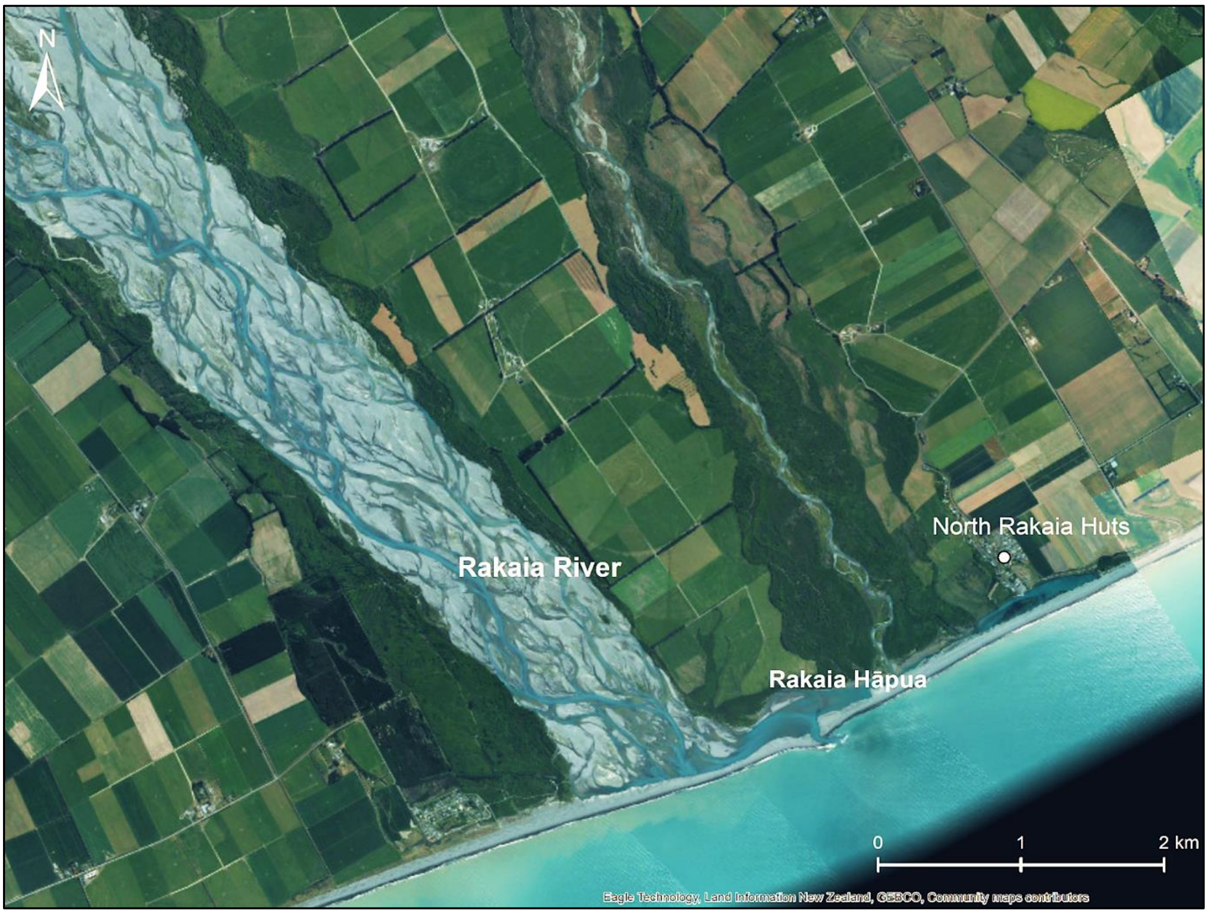

Figure 1: Aerial site map of the lower Rakaia River and Hāpua, North Rakaia Huts, surrounding farmland, and adjoining streams.
Source: (Google Earth, n.d.).

2.0 Methods

The first step in the methodological process was to visit the Rakaia Huts to see the Hāpua and talk to Mr Southward in person about the changes he has observed. This tacit knowledge combined with witnessing the environment in person was highly valuable in beginning to understand how human influence is impacting the unique and sensitive environment of the Hāpua. The trip also allowed the group to collect a portion of Mr Southward's analogue data to bring back to the university. The advice of a university librarian was sought after for establishing effective digital storage options for the data. The next step was to begin scanning documents chosen as 'valuable.' Data was excluded from digitisation if the document was already accessible online, a duplicate document, or unnecessary email correspondence. Once the data was scanned it was organised into categories and placed onto two USB sticks and stored in an online repository via Google Drive.

The files were organised based on advice from the literature such as the article from Briney (2015). Files were first organised into folders by topic. These topics include:
- River Flow
- Geomorphology
- Water Quality
- Ecology
- Freshwater Springs
- Groundwater

Within these topic folders, the data was then organised into folders based on data type. Data types include:
- Graphs
- Images
- Newspaper Articles
- Personal Notations
- Quantitative Measurements
- Reports
- Cross Sections

The data files within these folders were labelled as follows:
Year_Location

Reports or written documents were labelled as:
Year_Author_Title

Data that focuses on more than one topic or consists of more than one data type was placed in all folders of relevance. The 3-2-1 back-up rule from Briney (2015) was followed. This consists of having three copies of the data stored on two different storage mediums with one copy offsite. Three digital copies of Mr Southward’s data have been created. Two copies have been stored on USBs. One of these will be kept at The University of Canterbury, and one will be kept offsite with Mr Southward. A third copy will be stored in a Google Drive account which Mr Southward will have the ability to share with others.

The latter part of the research focused on the condition of the Rakaia Hāpua. Through site visits, conversation with Mr Southward and observing the data, it was established that seven key temporal changes are impacting the study site (refer to Table 1). Supporting documents, photographs, reports, and recordings were added to a separate document, whereby the extent of each observed change (refer to Table 1) was investigated.

3.0 Results

Figure 2 shows a flow diagram of the overall process that was taken to convert Mr Southward's data from analogue to digital. This diagram displays the different categories that the data was split into, including; ecology, groundwater, flow rate, water quality, and geomorphology. These categories were then broken up into subfolders containing the different types of data including; personal notation, graphs, reports, images, cross sections, newspaper articles, and numerical measurements. This is the result of the research and work in digitising Mr Southward's data all combined into one diagram.

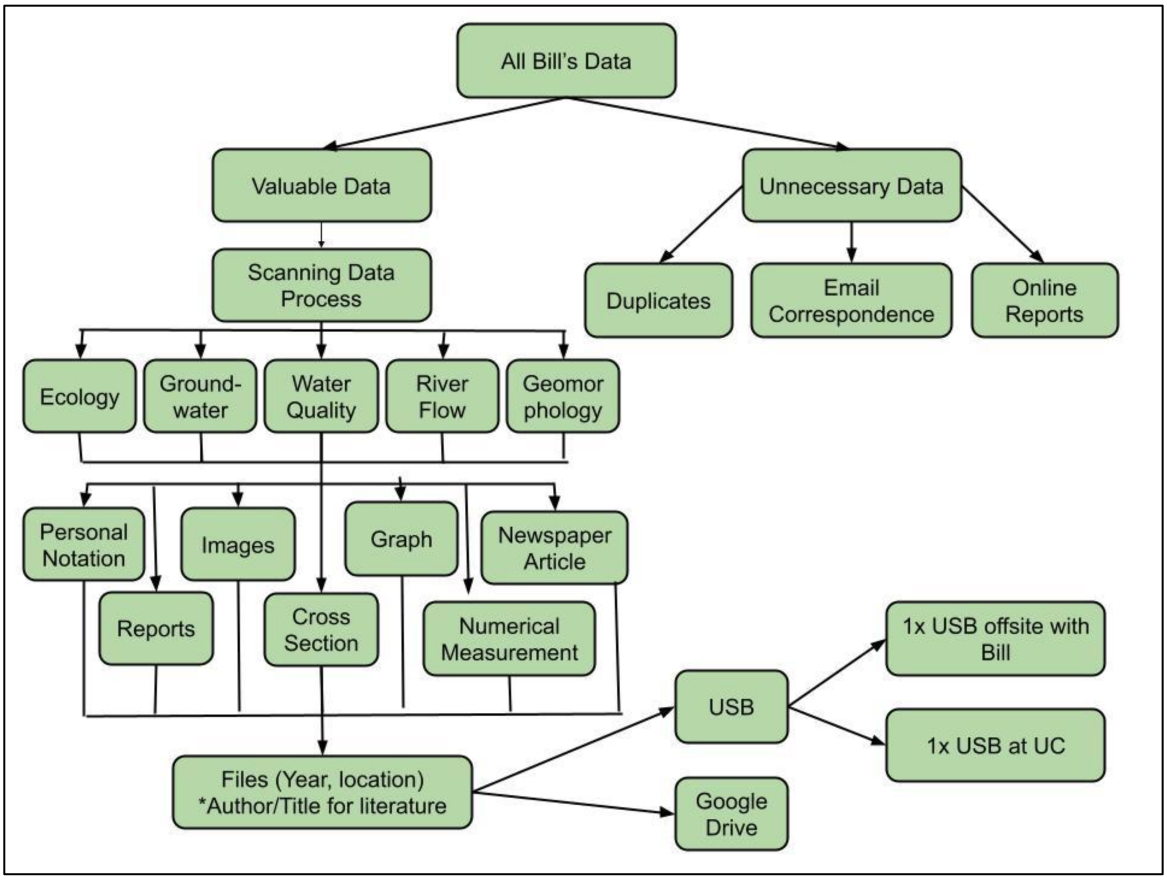

Figure 2: Flow diagram of the digitisation process. Mr Southward's data was split into subtopics and then into content type and stored on two USBs and in Google Drive.

Figure 3 provides an example of how the repository functions have been displayed (as a screenshot). The folder topics are listed e.g., Ecology, Water Quality and River Flow. Within these topics, data is arranged into more folders based on datatype e.g., Images, Graphs, Reports.

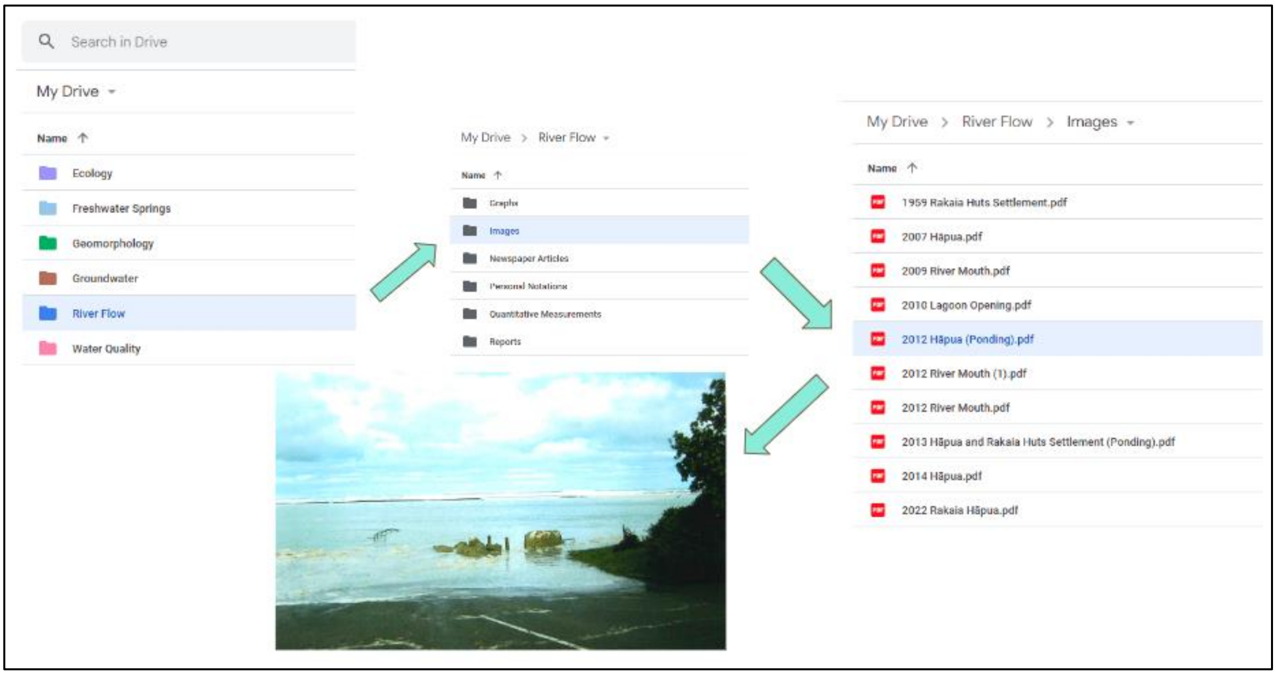

Figure 3: Shows an example of the file/folder pathway for Mr Southward's digitised data. By selecting the river flow folder, folders containing a range of data types on river flow can be accessed. By selecting images, a range of images are displayed. The photograph is an example of one of the images extracted from the file of ponding in the Hāpua in 2012.

Changes seen in the data are compared to Mr Southward's observations in Table 1. Much of the local knowledge he possesses links up with changes observed within his data. There is more tacit knowledge from Mr Southward that cannot be displayed due to the format that it is delivered in e.g., conversational.

Table 1: Primary analysis results showing links between changes observed by Mr Southward and changes identified in his data.

Changes Observed by Bill Southward	**Changes Identified in Data**
Increased muddiness/murkiness of adjoining streams	Sediment becoming more silt dominated (versus sand and gravel dominated)
Thinning and increased turbidity of Hāpua	20–30-day cycle of mouth formation
Increase in flood intensity and frequency	Increased intensity and frequency of major flooding events
Chaotic flow directions	Temporal changes to morphology as a response to energy within the system
Loss of biodiversity, particularly fisheries and bird life	Increased roughness to the shoreside bank of the Hāpua
Blockages in adjoining streams through farming waste	Changes in vegetation cover and land use
Reduction in freshwater stream size	Reduction in stream size, both width and depth

Figure 4 visually demonstrates some of the changes that Mr Southward has observed in the environment and where they are occurring.

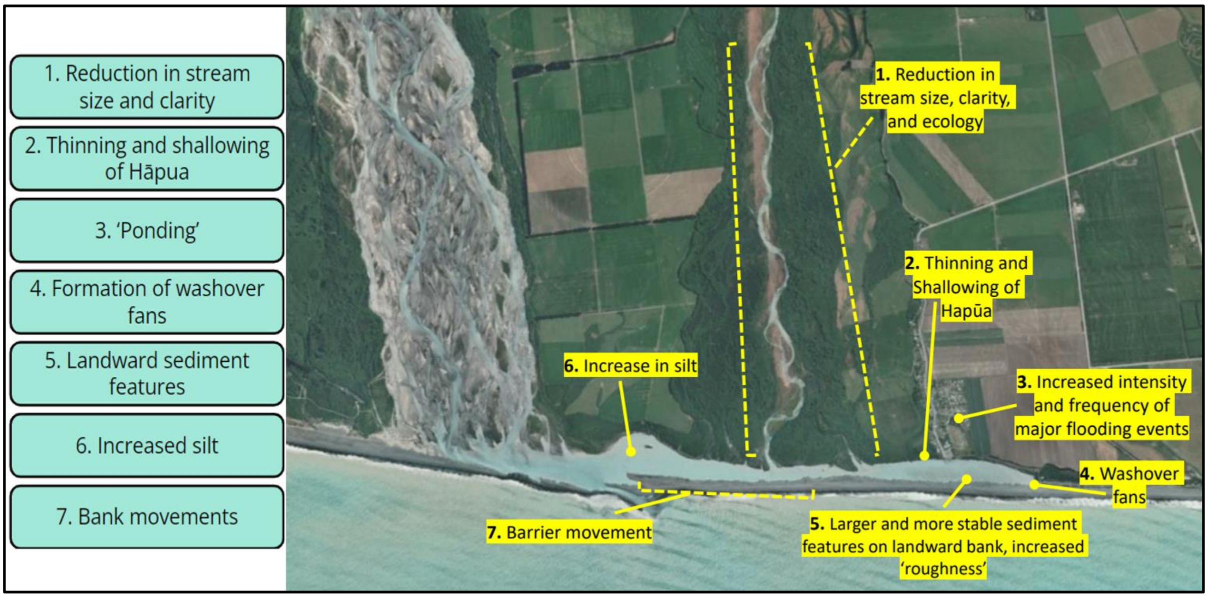

Figure 4: An annotated map with information about the changes observed by Mr Southward over the time he has been collecting data, including; increase in silt, reduction in stream size, bank movement, increase in ponding events, and thinning/shallowing of the Hāpua.

The temporal changes in land use and water abstraction can be seen in Figure 5. Results within this figure have been gathered from existing literature and reports.

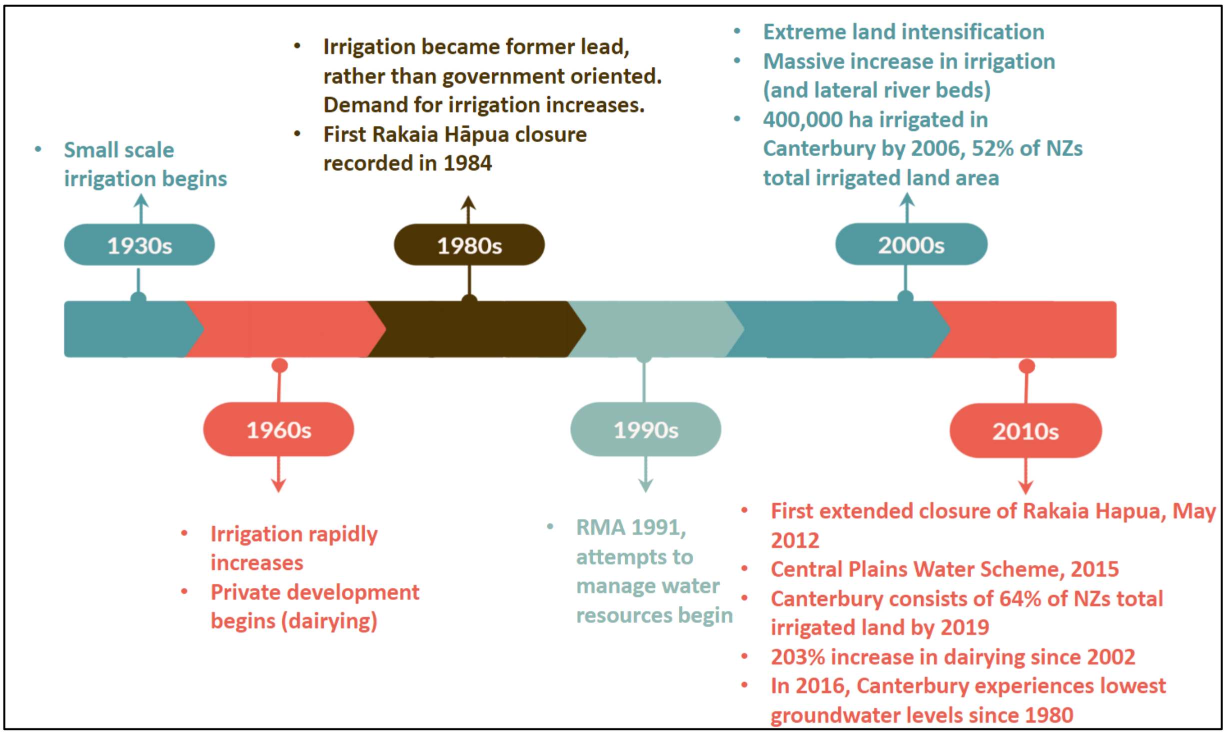

Figure 5: A timeline of land use change and changes in irrigation demand on the Canterbury Plains. Irrigation can be seen as an ongoing process throughout the last 90 years which has become more intensified in the 90s and 00s. This can be correlated with an increase in negative effects in the Rakaia River and Hāpua environment in the 2010s such as extended mouth closures, and lowest recorded groundwater levels.

4.0 Discussion

4.1 Importance of Digitising Data

Digitising data is important as science progresses to ensure the security, longevity, and accessibility of data in the future. Digitised data allows for people now and into the future to track and respond to global change (Albani et al, 2020). Within this project's research, Mr Southward's analogue data has been digitised and stored on appropriate mediums in a way that will minimise potential reductions in accessibility as time and technology progresses

(Berman, 2008). A consistent file structure and format, storage in multiple locations, and one copy stored on an easy to share storage medium in the form of Google Drive will help to ensure the data can be passed through the generations. Similarly structured repositories have been established for other data in the past, such as weather observation data and bird surveys from the early 1800s, with much of this still accessible online to this day (Njue, et al., 2019). Digitising Mr Southward's data in this way will help to ensure access continues in the future so groups and individuals can benefit from the data. The data could be used to provide baselines of environmental conditions for future research, or to assist in better environmental management. Flow data in particular, will help to provide evidence of how human influence and overdevelopment upstream is impacting flow regimes, and how this is affecting the Hāpua.

4.2 How the Digitised Data Can Be Used and Accessed

Mr Southward's data is accessible either through Google Drive or USB. One USB will be kept at The University of Canterbury, and one will be kept offsite with Mr Southward. Google Drive will act as the primary source for data sharing and will be password protected. To access any of Mr Southward's data, the password will need to be requested. The purpose of this exclusivity is to ensure that Mr Southward's intellectual and academic property is protected. It will also help to reassure Mr Southward that his information is used responsibly. The USB kept at the university will also be able to be requested and accessed based on Mr Southward's wishes. This USB will be stored within the School of Earth and Environment and issued out by staff members who understand Mr Southward's desired uses for the data.

River flow was chosen as a case study as it is a keystone indicator to the wider processes that are occurring and the mauri of the river (Jenkins, 2018). The data was organised for this case study by sorting primary observations such as river flow, water quality, ecology, geomorphology etc. Primary observations from compiling the digitised data were completed by identifying key environmental features. These features included morphology, which indicates energy within the lagoon system (Hart, 2009). Here, energy can be linked directly to water flow.

There are many individuals and groups who could benefit from the data (refer to Figure 6). Braided river communities could greatly benefit from this data, as much of Mr Southward's data indicates the effects of land use change on how braided river systems operate (Piegay et.al, 2006). The data can provide braided river communities with information regarding signals that the river environment is under stress, inform them of changes and what they could expect to see in the future (refer to Figure 9). In association with braided river communities, Mana Whenua and surrounding iwi would greatly benefit from access to this data set. Damage to the river for the purpose of farming or recreation is in violation of the Treaty (Manatu Mo Te Taiao, 2021). As such, the information held in Bill Southward's data could provide a legal backing and allow Māori organisations to hold the responsible groups accountable (Manatu Mo Te Taiao, 2021). Scientific groups, such as universities or NIWA or Environment Canterbury (ECAN) could also benefit from the data set, as information in Mr Southwards data may be able to link several pre-known factors together. Organisations such as ECAN could also benefit by using the data to make informed adjustments to their water allocation processes and monitor how allocation limits are directly affecting the river (Evans, 2004). Due to the nature of this project, the group's role was to digitise Bill Southwards data for future use. As a result, the members of this group have no intellectual or academic rights to any of Mr Southward's work. Therefore, any data sharing must come from Mr Southward.

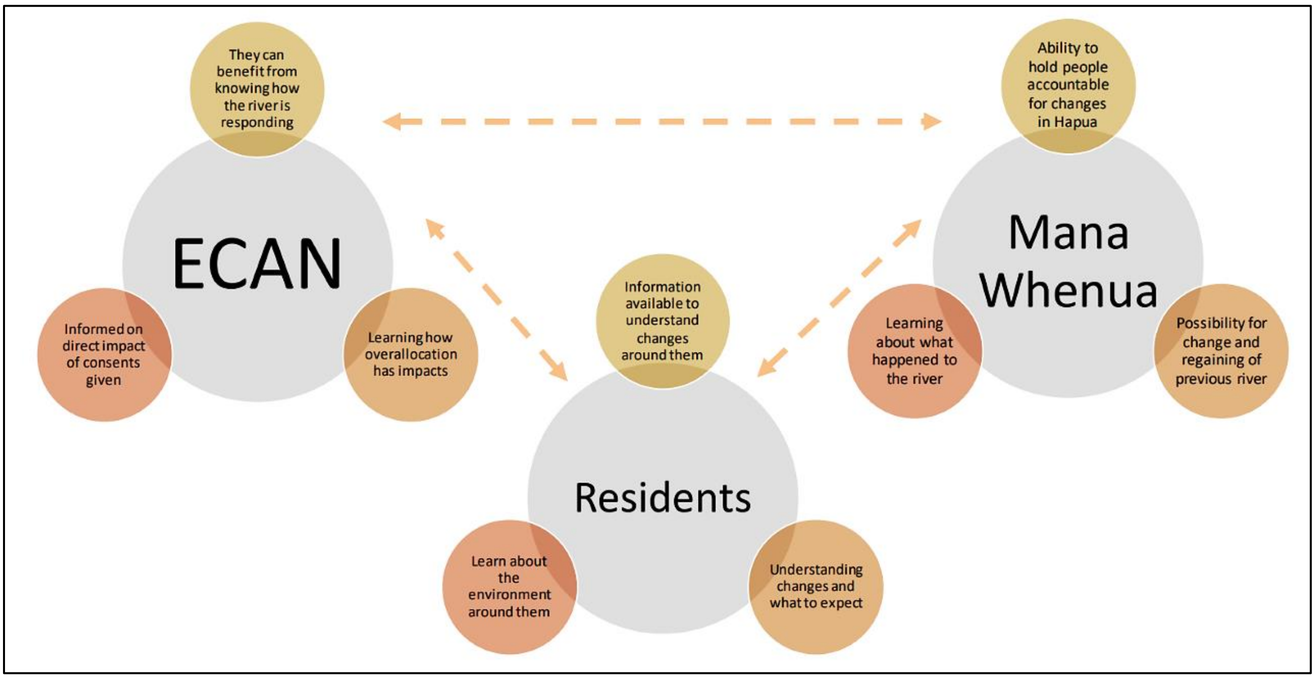

Figure 6: Diagram showing the groups that would be impacted by Bill Southwards data, with arrows showing space for collaboration among these groups.

4.3 Case Study: Land Use and Irrigation

Understanding how anthropogenic influences can alter flow rate are vital to ensuring responsible water management. From the 1930's until present there have been significant changes in the land use around the Rakaia River. Before settlement in the Rakaia area, the environment consisted of dense native forest which had positive impacts on water quality and flow (Glade, 2003). Agriculture was first implemented in the area in the mid-20th century, though intensification was mostly seen from the between the 1980s and early 2000s (refer to Figure 5). There was a 53% increase in the number of dairy cattle on the Canterbury Plains between 2002 and 2018 (KC et al, 2018). Figure 7 demonstrates the drastic change intensification of agriculture to dairying has had on the landscape surrounding the Rakaia River. With intensification came an increased demand for irrigation and water diversion and abstraction from the Rakaia River (KC et al, 2018). 70% of NZ’s total irrigated land is now located on the Canterbury Plains which consumes 58% of the total water allocation for consumptive use in NZ (KC et al, 2018). This research supports the following discussing regarding Mr Southward’s data on ponding.

Figure 7: Satellite images showing the dramatic change in the landscape of the Canterbury Plains surrounding the Rakaia River. Top: Image from December 1984. Rather dry pastures, several tree plantations and shelter belts, significant braiding evident in the Rakaia River. Bottom: Image from December 2020. Land is significantly greener. There are large numbers of central pivot irrigation systems, particularly on the Northern side of the Rakaia River, indicating a shift in land use to more intensive agriculture like dairying. Absence of tree plantations and most shelterbelts seen in the figure from 1984. The riverbed is significantly more constricted, with less obvious braiding. Source: (Google Earth, n.d.).

4.3.1 Case Study: Ponding

Figure 8 shows a collection of images taken by Mr Southward documenting ponding in the Hāpua. Mr Southward has provided the group with detailed explanations as to why ponding is occurring based on what he has witnessed and experienced. He has discussed his concern for land use change and irrigation demand upstream and how this is contributing to lower flows. His verbal accounts of this process are defined as tacit knowledge. Tacit knowledge can be difficult to formalise and transfer to others. It can include personal observations, experience, and intuition (Seidler-de Alwis, 2008). Without this recorded tacit knowledge, it was useful to use academic literature to provide some context and evidence of Mr Southward's claims.

Figure 8: A selection of Mr Bill Southward's images showing ponding in the Hāpua. The bottom right image is of particular interest. It shows the river mouth almost closed over four days after a precipitation flood event. This shows that the Rakaia tends to be in a state of low flows and partial or full river mouth closure events, or flood flows, demonstrating a major lack of variability in fluvial discharge levels. Source: (Mr Bill Southward, 2012; 2013).

Ponding occurs when wave energy dominates over fluvial energy, meaning sediment is reworked by the waves which can block off the river mouth (McSweeney et al, 2017). Ponding tends to be exacerbated by people occurring in an overdeveloped basin (Molle et al, 2010). In this case, overdevelopment would refer to the intensification of land use and increased demand for irrigation upstream (KC et al, 2018). Increased water abstraction contributes to lower flows in the Rakaia, limiting the ability of fluvial discharge to push water and sediment out to sea, keeping the mouth open (McSweeney et al., 2017). Acknowledging that Mr Southward's data and tacit knowledge support academic literature and vice versa is important. It encourages the recognition of how valuable local knowledge can be, regardless of whether a person has received a formal scientific education.

4.4 Limitations / Improvements

During this project, time constraints have been the most significant limitation. Time pressure has reduced the ability to digitise greater amounts of data, as research, analysis and a case study also needed to be achieved. The diversity and volume of Mr Southward's data meant digitisation was time consuming, and not all the data was able to be digitised. It also meant that photographs were scanned as PDF files and not digitised as individual JPEG or PNG files. This means snipping or screenshotting will be required for people wishing to extract individual images.

The large amount of data also meant it was difficult to narrow down on a topic to focus on. Mr Southward's wealth of knowledge on the processes causing changes seen in the data was hard to display because it was more tacit rather than measurable evidence. The diverse nature of Mr Southward's data created another challenge for digitising, making it hard to categorise the different topics within the data. There was not enough literature of the digitisation of mixed data types, qualitative and quantitative, most focused on transcribing quantitative types.

Going through Mr Southward's data, it would have been beneficial to develop a systematic process of deciding on what data was digitised or not. Scientifically defining the approach used and creating a consistent process would produce an even more reliable digitisation process. Specifically identifying which analogue documents have been scanned would also have made the continuation of the digitising process easier for future groups.

Another limitation was that not enough specialists were consulted about data conservation and the digitisation process. There was limited access to software or available literature about other ways of digitising. This, and having little knowledge or experience with digitising and categorising data meant that without any consultation, the methodological options were reduced. In addition, the study site was a significant distance from Christchurch which created a barrier to meeting with Mr Southward and discussing the project with him in person.

4.5 Next Steps for Future Student Groups

Recommendations for future groups include a recorded interviews with Bill Southward. These interviews will allow for Mr Southward's tacit knowledge to be captured, reducing reliance on academic literature for context. This will further assist with keeping Mr Southward's valuable knowledge accessible for future generations. It could also be useful for future groups to put the recorded interviews into a digestible format, such as transcribing them.

Interviews with experts of data preservation and digitisation are also suggested. This along with consultation with GIS experts will aid in having a more digital approach. Using GIS will be an effective way to show the data in a more approachable format for the general public and would be a good way to show spatial changes around the Rakaia River and Hāpua.

Future groups could carry out a case study into a different topic within Mr Southward's data. Specifically, social components would be an important thing to consider. Extracting and making the data more usable such as putting it into excel or RStudio so the data could be manipulated would be useful. This could allow for more in depth quantitative data analysis. The remaining data that could benefit from further digitisation includes topics such as morphology, ecology, groundwater, and water quality.

It would also be recommended that future groups acknowledge and highlight the ability this data has to provide a baseline for climate change and other anthropogenic impacts on the Rakaia catchment. Climate change has the potential to cause significant changes to the Rakaia Hāpua and surrounding area. Changes, such as increasing intensity of storms, changes in wave climate and sea level rise will affect the morphology and dynamics of the Hāpua and river system. This will have flow on effects for the biological and ecological life surrounding the Rakaia River (Measures, et al, 2020). All of these changes will impact human lives around the Rakaia, specifically locals like the Rakaia Huts residents living near the changing coast, and other similar coastal communities around New Zealand.

Students should also consider the longevity of the storage and future accessibility of the data and consider who would be a suitable person to manage access to this data in the long-term. With permission from Mr Southward, the data could be catalogued in The University of Canterbury library providing a digital resource for other students.

4.51 Future of Citizen Science and Local Knowledge

Digitization of data for future use was the main focus of the research. As long as Mr Southward allows for it, access to Mr Southward's data could be widespread due to the simplicity of the medium used for storage. This is useful as citizen science and its potential within the scientific field is now being recognised. There is growing evidence that citizen science increases well-being due to feeling connected with the community and decision making (Bonney et al, 2016). It also gives citizens a better understanding of scientific research and gives more meaning to their hobbies (Bonney et al, 2016). These values are reflected in Figure 6.

The digitisation and preservation of Mr Southward's data recognises the importance of local knowledge. This project could influence other individuals with similar local knowledge to begin recording this and creating their own digital datasets, or to come forward with local knowledge they have collected in the past.

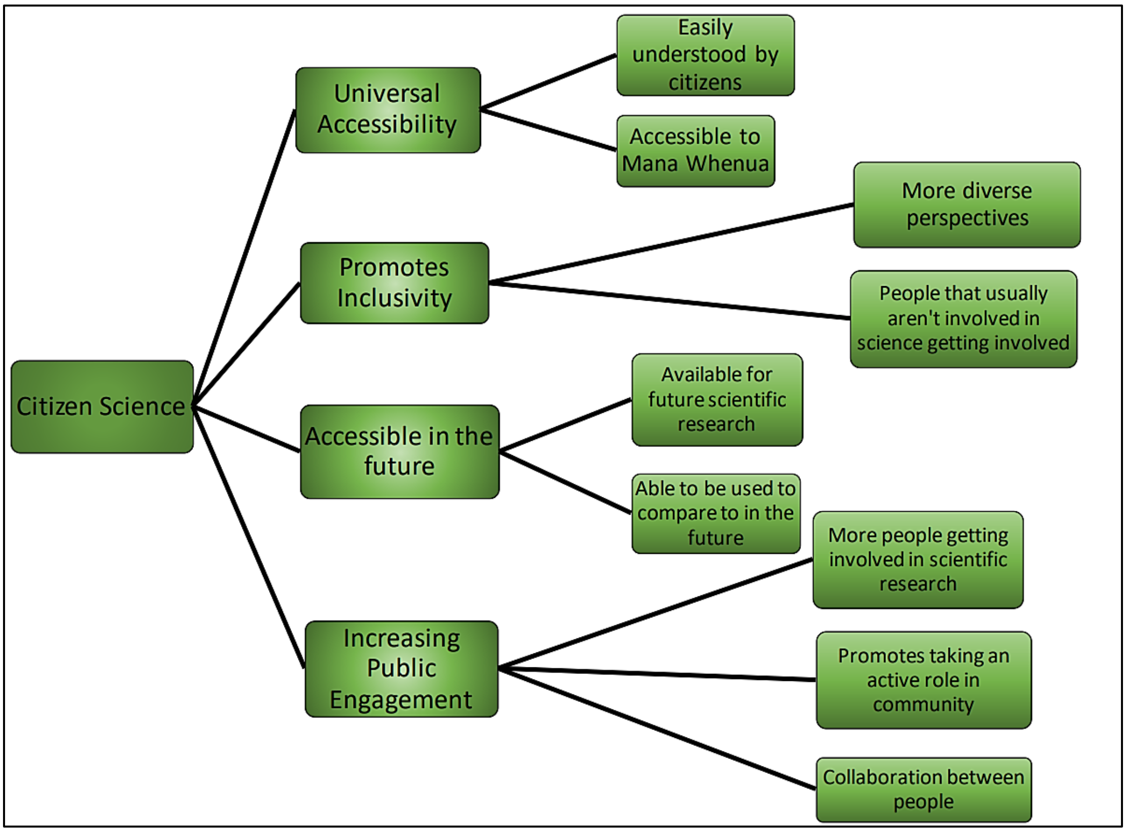

Figure 9: A flow diagram that shows the potential usability of local knowledge and citizen science when it is digitised, including what it can be used for and what it can provide for people.

5.0 Conclusion

The purpose of this report was to explore the importance of digitising locally sourced data for future environmental management. This project allowed for the understanding of how vital Mr Southward's research is to preserve the natural characteristics present within the Rakaia region. It encapsulates the extensive nature of Mr Southward's data, focusing primarily on river flow data and explaining its importance in becoming digitised. Methods to digitise data were also explored to identify the best techniques suited to the various analogous forms of data provided. Digitising the data ensures its security and accessibility are improved ensuring it doesn't get lost or damaged and so it is readily available for future use. This project has immense potential to aid in future environmental management within the Rakaia catchment. Due to the extensive research provided and the increased accessibility of the data it can be applied to various situations to ensure that environments such as Rakaia are preserved and managed well in the future.

6.0 Acknowledgements

Mr Bill Southward

Community Partner, Rakaia Huts

Dr Sarah L McSweeney

Supervisor, University of Canterbury

Dr Justin Stout

Supervisor, University of Canterbury

Mr Nick Scullin

Librarian, University of Canterbury

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