Hurunui Coastal Hazards

Hurunui District Coastal Citizen Science Options

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Executive Summary

Citizen Science is the term used for scientific research and monitoring projects where members of the public collect information, categorise, transcribe, or analyse scientific data. Citizen science projects create an opportunity for communities to become engaged with their environment and assist with data collection in their local setting. This provides an opportunity to record more regular data and observations than able to be collected by regulatory authorities, especially changes in the environments due to large natural events.

In March 2021 Jacobs were commissioned by Hurunui District Council (HDC) to undertake a review of citizen science options for coastal information which could be implemented at the communities located on the Hurunui District coast likely to be impacted by hazards associated with future sea level rise.

This project looks at various methods of citizen science which could be adopted at each Hurunui coastal community in the future, based around two key success drivers:

1. Engage with as many members of the community as possible, and for this engagement to be ongoing for years to come.

2. Collect valuable data which can be used to help with better understanding of the extent and magnitude of local coastal hazards in the future.

This review identified that there are a number of citizen science opportunities which could be employed in the Hurunui District. Based on the two success drivers, the highest ranking options included:

- **Measuring Pole –** Recordings of the beach elevation on a permanent, surveyed measuring pole installed at the back of the beach, which would provide information about the dynamic and changing volume of the beach at a more stable area, especially in regards to post storm recovery.
- **Photographs (e.g. CoastSnap)** – An app based method where participants take photographs from a reference point, and photographs can be utilised to build up a long term record of beach condition and to analyse changes to the beach position over both the long and short term.
- **Pre and Post Storm Change –**Residents of the community could be alerted as to when a storm is likely to occur (e.g. 1-2 days notice) so that comparable pre-storm data could be collected, and data following the event could be collected at a relevant time. Method of collection could vary (e.g. measuring pole, photographs).
- **Water levels in large events -** Installation of a water gauge which members of the public could read and record in both large rainfall and beach overtopping events.

No specific recommendations have been made regarding which options to use in each community. The scope of Jacobs work has been to identify a range of suitable methods for HDC to consider further and discuss with the community. It is noted that while some methods may rank well overall on these two success drivers, other limitations, such as number of permanent residents, may prevent them from being the preferred option for an individual community.

Employing some/all of these options within the communities in the Hurunui District would also provide additional and valuable data to Environment Canterbury, as well as benefitting broader research which occurs on the Hurunui Districts unique mixed sand and gravel and composite beach systems.

Important note about your report

The sole purpose of this report and the associated services performed by Jacobs is to undertake review of coastal citizen science options for the Hurunui District in accordance with the scope of services set out in the contract between Jacobs and Hurunui District Council ('the Client'). That scope of services, as described in this report, was developed with the Client.

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1. Introduction

Citizen Science is the term used for scientific research and monitoring projects where members of the public collect information, categorise, transcribe, or analyse scientific data. Citizen science projects create an opportunity for communities to become engaged with their environment and assist with data collection in their local setting. This provides an opportunity to record more regular data and observations than able to be collected by regulatory authorities, especially changes in the environments due to large natural events.

In March 2021 Jacobs were commissioned by Hurunui District Council (HDC) to undertake a review of citizen science options for coastal information which could be implemented at the communities located on the Hurunui District coast likely to be impacted by hazards associated with future sea level rise.

This Citizen Science review is part of a wider coastal hazards adaptation project being undertaken by Hurunui District Council (HDC) for their coastal communities. Within this wider project, it follows a coastal hazard and risk assessment for the communities undertaken by Jacobs in 2020, and council engagement with the communities to discuss the nature of the hazards at their individual settlements and conversations around potential hazard adaptation options going forward. It was clear from these initial conversations with the communities that Citizen Science was a favourable option for them to remain engaged with the wider coastal adaption project by assisting with the monitoring of the condition and changes in their beaches.

This project looks at various methods of citizen science which could be adopted at each Hurunui coastal community in the future, based around two key success drivers:

3. Engage with as many members of the community as possible, and for this engagement to be ongoing for years to come.

4. Collect valuable data which can be used to help with better understanding of the extent and magnitude of local coastal hazards in the future.

The following report provides an overview of the concept of citizen science and its place in a coastal setting, as well as highlighting some global case studies. The review identifies what information would be useful for coastal communities to collect from a technical perspective, what tools communities would need to successfully implement programmes to collect this information, and summarises the possible citizen science options that could be adopted at different communities within the Hurunui District.

2. Citizen Science Case Studies

In a coastal setting, citizen science projects have a range of purposes, from monitoring species (e.g. vegetation cover), to monitoring physical beach health. The following discusses some global examples of citizen science projects in a coastal setting.

2.1 CoastSnap

CoastSnap has recently been developed by the University of New South Wales to utilise photographs of a study beach by members of the public to build up a long term record of beach condition and to analyse changes to the beach position over both the long and short term. Coast Snap is a smart phone App that is free to download and allows reference photo positions to be set up at local, accessible locations so that members of the public can provide photographic data at any time from specific locations. All that is required at each reference position is a camera cradle for a smartphone to ensure that the field of view from images is consistent, and the time of the photo to be recorded in the app so can be referenced back to tide level at that time.

The analysis of the images is via Photogrammetry software to pinpoint the position of the coastline from the images to a similar accuracy as can be provided by physical survey teams. Currently this post-processing of the images requires using a Matlab license, however it is thought that eventually this algorithm for shoreline detection will become open-source. From a setup/operational perspective, there are initial establishment costs (site set-up, yearly surveying of ground truthing points) as well as current ongoing costs for the analysis of the data.

This is an excellent example of a simple method that multiple community members can partake in without any training, which provides very useful information about physical beach health and responses over a time period that is difficult to capture by regular physical beach surveying. This method of data collection is now being used across the globe, including two sites located in Christchurch (New Brighton Pier and Taylors Mistake) by Christchurch City Council.

More information about CoastSnap can be found at https://www.coastsnap.com/

2.2 Coastal Observation Program – Engineering (COPE)

The COPE data collection system, was initiated by the former Queensland Beach Protection Authority (BPA) in the early 1970's to use citizen science to collect basic data on the behaviour of Queensland beaches at over in areas where extensive investigations are not practical and where otherwise little or no data existed. The project was based around the recruitment of volunteer observers who were trained to record a series of basic wind, wave, and beach change parameters on a daily basis for a period of at least three years. The BPA produced regular reports of the observations and interpretations from the data at each site.

Under the programme, at each observation site a surveyed reference pole was installed at the back of the beach where the measurements were recorded from, and each volunteer was provided with a 30m measuring tape, a wind meter, stopwatch, 2m measuring stick, and a form to record their observations of the following parameters:

- Wave period, height, direction, type;
- Surf zone width;
- Presence of offshore bar;
- Wind speed and direction;
- State of tide;
- Distance to berm and berm elevation;
- Distance to vegetation line;
- Sand level at the COPE reference measuring pole;

- Slope; and
- Longshore current speed and direction.

Unfortunately, the BPA was disbanded in 1996, resulting in the COPE programme being discontinued. However, in some areas, such as the Gold Coast, there has been moves to re-establish the observations programme, in recognition of their benefits. However, this programme is an excellent example of how a significant amount of beach data can be captured through the use of citizen science when the correct equipment and training is provided. Although the way that the programme was run required significant commitment from volunteers, it highlights that consistently collecting data over a long period of time can create a very valuable dataset.

2.3 Citizen Science Drones for Coastal Climate Change Resilience by the Victorian Coastal Monitoring Program

Since 2018, the University of Melbourne and Deakin University have utilised citizen science for the monitoring of beaches in the coastal management programme for the Great Ocean Road. In this project, citizens were equipped with drones which were programmed to fly a pre-determined path once every six weeks. The Universities then turns the data collected by the drone into a 3D model using photogrammetry software, and analyses the state of the coastline. The project especially gave light to more information around pre and post storm environments than before, as volunteers could go out following a storm to collect the survey data, and help scientists have a better understanding of how these beach systems responded and recovered following storm events. This project has won several innovation prizes across Australia for its large engagement and high quality data capture.

2.4 Coastal Restoration Trust – Dune Monitoring Guidelines

The Coastal Restoration Trust of New Zealand is an organisation that focusses largely on coastal dune restoration. They have set up various community monitoring programmes across all regions in New Zealand and have established community based guidelines for assessing the state of coastal dune systems. The surveying uses simple equipment including a 50-100m measuring tape, clipboard, survey sheets, a 2m high pole with 10cm markings, a GPS, and a smartphone with the compass app, used for collecting the dune slope along the transect. The guidelines include identifying plants, surveying vegetation cover using rapid-point sampling, record dune profiles (using the inclinometer app) and take photos at fixed points on the transects. The programme currently only has one registered site in the Canterbury Region (Woodend Beach), however it could be successfully implemented at Leithfield Beach to monitor dune vegetation and stability there.

For more information on this example, see https://www.coastalrestorationtrust.org.nz/resources/monitoring-coastal-dunes/

2.5 Coastwatch Project (Ferreira et al., 2012)[1] – Community beach profile monitoring

The Coastwatch beach profiling project was based in Portugal, and aimed to collect beach profiling data using citizen science to collect more regular information about the physical health of the beach. This project required the use of a simple and inexpensive profile, which captured straight forward data and could be undertaken by several kinds of users and level of education. Eight workshops were held for approximately 140 participants, which included an explanation of the method, the construction of the profiler, the actual profiling of the beach, and a classroom session on data processing and graphing.

This project is an example of upskilling members of the community to collect useful data which could inherently help monitor the long term physical beach health, as well as record changes which are event driven (e.g. coastal storm) or which there is currently limited data.

[1] Ferreira, M. A., Soares, L., & Andrade, F. (2012). Educating citizens about their coastal environments: Beach profiling in the Coastwatch project. Journal of Coastal Conservation, 16(4), 567-574

2.6 ShoreUPDATE (Dawson et al., 2020)[2] – Monitoring storm damage to important coastal sites

ShoreUPDATE is a project based in the UK, where citizens use a web-based interactive map accessed via a mobile app to help monitor 12,500 high risk coastal archaeological sites which are located in very isolated locations and require monitoring. The app has site records for each location, which act as a 'portal' where members of the public can upload photos and enter information easily into a survey form about the sites condition. After members of the public have uploaded new information, it is validated before being added into the project database. Over a 5 year period between 2012-2017, more than 1000 records were updates by members of the public, and allowed for the revision of sites 'priority' status' (e.g. destroyed, stabilised, excavated).

This project is an excellent example of utilising citizen science to provide information which was not readily accessible through a small group of people. It is also a great example of using a web-based application to record information and build on the project database.

[2] Dawson, T., Hambly, J., Kelley, A., Lees, W., & Miller, S. (2020). Coastal heritage, global climate change, public engagement, and citizen science. Proceedings of the National Academy of Sciences - PNAS, 117(15), 8280-8286

3. Citizen Science Methods

3.1 Hurunui District Council Objectives

Based on discussions with HDC throughout the course of this project, we established that a there are two main success drivers within this project:

1. Engage with as many members of the community as possible, and for this engagement to be ongoing for years to come.

2. Collect valuable data which can be used to help with better understanding of the extent and magnitude of local coastal hazards in the future.

Table 1 below presents a possible ranking criteria of citizen science methods based on both community engagement (potential number of people it would involve), and ability to collect useful information on a technical level for input into future hazard assessments and broader research.

Table 1: Criteria for ranking of methods based on Community Engagement and Technical Value of the data.

Community Engagement (Number of people engaged)

3	Engages with a wide range of people non-exclusive to the community. Anybody visiting the site will be able to be involved. No training is required.
2	Engages with the whole community. Easy execution of method for all ages. Some awareness of the project and methods is required to take part. Small amount of training required.
1	Small group of dedicated volunteers, training and equipment required, data collected requires external quality control and processing. Higher level of technical ability required.

Technical

3	Produces high quality data that can be used in future assessments and to inform broader research.
2	Produces some quantitative data which could be used in future assessments
1	Produces some qualitative data which could be used in future assessments

In discussions with HDC, it was determined that keeping communities engaged with the coastal adaptation project and maintaining a healthy coastal environment was the highest priority, with the number of people engaged with the citizen science options adopted at the respective communities being a measure of success of the programme. However, it was also recognised that community members would need a sense of purpose in the data that they were collecting, with them being able to see the value and use of the data in the future.

3.1.1 Useful Data Collection

Discussions were undertaken with Environment Canterbury and the University of Canterbury in combination with HDC, to determine what information would be useful for coastal monitoring from both a regional council and district council perspective, and as part of broader research on the unique mixed sand and gravel beach types along the Hurunui coast. The following information was identified as being useful across all of these areas:

- Record of physical beach health parameters measured on a regular and on-going basis to provide input into a longer-term record of beach condition and change. These parameters include Beach width, height, slope, runup, distance to berms and berm elevations.
- Record of basic ocean conditions measured on very regular basis (e.g. daily) to explain changes in the physical beach health parameters. These would include water levels, wave height, wave period, wave direction, current direction and speed, surf zone width, presence of offshore bars, wind speed and direction.

- Monitoring of vegetation cover on the dunes and beach ridges to determine whether this cover is increasing or decreasing, which influences beach stability, and to interpret why changes in cover are occurring.
- Monitoring of tension cracks behind cliff environments to examine relationships between tension cracks and cliff failure.
- Quantify storm induced beach changes with pre-post storm surveys and records of water level and wave events during these events.
- Records of multi-flood hazard water levels at Leithfield beach, Amberley Beach and Gore Bay.
- Monitoring of coastal protection structure conditions

The following will discuss possible methods which could be used to collect this data.

3.2 Methods for data collection

3.2.1 Physical beach health parameters

3.2.1.1 Physical Measurements

Equipment:

- Installation of permanent measuring pole (by surveyors)
- Measuring tools (beach profile equipment – measuring rods, tape measure, inclinometer)

Method: The measurement of physical beach health parameters can range in complexity, depending on the community commitment and ability of community members. The most simplified method for members of the public to record a physical beach health parameter is recording the beach elevation on a permanent, surveyed measuring pole which has been installed at the back of the beach. This method would give information about the dynamic and changing volume of the beach at a more stable area, especially in regard to post storm recovery. This was method was used as part of the COPE monitoring programme (See Section 1.1.2). An example of a measuring pole used in the COPE programme is presented below in Figure 1. The measuring pole could also be used as a reference point to take other beach parameter measurements and photographs from. Measurements such as beach width, beach slope, distance to berms and berm elevations, and distance to vegetation line could all be recorded using simple tools such as measuring rods, tape measures and inclinometer. A useful position for the measuring pole to be installed would be in line with Environment Canterbury beach profile monitoring sites, so that the information could add value to the longer term (20-30 year) record.

Figure 1: Example of a beach measuring pole from the COPE monitoring programme[3]

Engagement: The more complex the method used, the less community members likely to be involved. Measuring rod may be used by whole community with low training, other measurements taken may be by a smaller group of dedicated volunteers to ensure it is done consistently, and will require training.

Data Collection: Flexibility in how data is recorded, could be done in a notebook or via an online form.

Costs: The following costs should be considered:

- Establishment costs:
  - Site identification
  - Installation of Reference Measuring Pole and establishment survey
  - Additional measuring tools (e.g. measuring tape, measuring rods, inclinometer)
  - Training/Workshop
  - Set-up method to record information (e.g. digital or manual)
- Operational Costs:
  - Data input into database
  - Data Analysis
  - Resurveying/maintenance of reference measuring pole
  - Database management
  - Feedback to the community

3.2.1.2 Photographs

Equipment:

- Private Smartphone
- Cradle installation (Figure 2)

Method: Taking photographs is an effective way to measure physical beach health using an application such as CoastSnap (See Section 1.1.1). CoastSnap uses images taken from a single reference point to overlay and measure shoreline changes over time. The only requirements for the public is to have is a mobile phone which can take images from the standardised cradle at the reference point and access to the CoastSnap App, Images can be uploaded immediately if there is 3G/4G available, or can be uploaded retrospectively from a camera roll

[3] https://www.griffith.edu.au/__data/assets/pdf_file/0020/213365/Caring-for-our-coast-COPE.pdf

if they have an indicative time of when the image was taken. In order to use the information for shoreline change analysis, the images need to be post-processed involving being rectified to align with surveyed reference points, then run through an algorithm which automatically detects the shoreline for measurement. This post-processing work would likely need to be outsourced from council (e.g. to university).

Requirements for establishing a successful CoastSnap site for shoreline change analysis include:

- (Preferably) an alongshore view;
- Sufficient elevation above the beach (New Brighton pier is kind of a minimum for decent shoreline tracking, however that does not detract from the interesting work that could be collected from lower elevations on other beach types such as the cusp spacing or vegetation surveys);
- A field (minimum of ~4) of (semi) permanent features in the image from which to rectify the image. These could be posts, houses, lampposts, bins, signs etc, as long as they are fixed in position;
- Good foot traffic (or a dedicated local team able to regularly upload snaps);
- Local survey capability who are able to annually survey physical points being used to rectify the images.

While some sites within the Hurunui District may not fit all of the above criteria, it was recognised in discussions with HDC, ECan and the University of Canterbury that additional information could be sourced from the images beyond shoreline tracking, including the option of installing the measuring poles (section 3.2.1.1) in the foreground of the photo, or focussing on the tracking of vegetation cover in the foreground.

Using a method such as CoastSnap would also provide useful and engagement content for the council through the development of time-lapse videos produced from the photos.

Figure 2: CoastSnap mobile cradle at the New Brighton Pier.

Engagement: Photographs could be taken by anyone with a smartphone visiting the site with the App. Could engage with lots of people if there is good foot traffic, or if there is a smaller group of dedicated locals.

Data Collection: Can only be done using a smartphone.

Costs: The following costs should be considered:

- Establishment costs:
  - Site visits to establish appropriate sites for reference points
  - Surveying of reference points

- Mobile cradle purchase/manufacture and installation

- Operational costs:
  - License fee (NZ wide for cloud space, currently CCC own the license however after 12 months costs likely to be redistributed across all users – total approx. $2000)
  - Yearly surveying of reference points
  - Database management
  - Post processing to rectify images
  - Development of time lapse videos for community engagement
  - Using rectified images to run through shoreline detection algorithm (likely to be outsourced from council) to get information on shoreline change

3.2.1.3 Sediment Sampling

Equipment:

- Camera
- Cradle/Box device (Figure 3)

Method: Sediment sampling data would be useful to collect from a scientific/research perspective to provide more information around what changes in sedimentology occurred following large events on the beach face. This could be done using the Digital Grainsize Analysis tool, in which images of sediment samples in-situ from a known elevation can be analysed digitally and automatically to give sediment sampling results.

This method would require a 'box' to be constructed which a device could rest on to take images of the sediment (facing down), and the elevation of the camera from the ground was known. An example of this is shown in Figure 3 below. A profile site would be established, and a picture of the sediment would be taken at key features of the profile (e.g. backshore, upper foreshore, lower foreshore). The profile site could link into other observation sites such as measuring pole site in section 3.2.1.1. or photo reference site in section 3.2.1.2. This method would also require a database for images and information about the images to be stored. It would also need a technical expert or a trained member of the community to run the images and information through the DGA tool, and interpret the results.

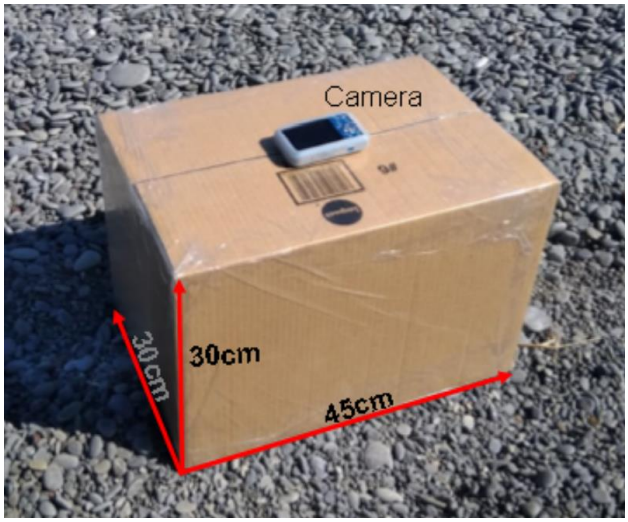

Figure 3: Example of device which would be required for DGS analysis (MacDonald, 2019[4]).

Engagement: Likely to be a smaller group of volunteers who would be trained up and dedicated to collecting data consistently.

Data Collection: Images would need to be taken using a camera, then submitted via email with notes attached (e.g. the profile, feature on profile)

Costs: The following costs should be considered:

- Establishment costs:
  - Site visit to determine appropriate profile
  - Camera
  - Box device
  - Training/workshops
  - Set-up of survey to record information (e.g. digital or manual)
- Operational costs:
  - Outsourcing of data analysis to run images through DGS tool (Matlab license required) and report back to council
  - Database management
  - Feedback to the community

3.2.1.4 Drone Surveys

Equipment:

- Drone
- Tablet/iPad
- Georeferenced points/markers

[4] MacDonald, K (2019). The geomorphological response of uplifted unconsolidated coastal environments, Kaikoura, New Zealand. MSc Thesis, University of Canterbury, NZ.

Method: This method could be adopted from the project described in Section 2.3. This method involves providing a drone to a small group of volunteers in a community to complete aerial imagery surveys on a pre-determined flight path. This imagery can be processed using photogrammetry analysis software and a 3D model of the beach can be developed. Once a series of these surveys have been undertaken, they can then be compared for shoreline change and volume loss, which becomes particularly useful in assessing the response of beaches post-storm. This method is a high cost method due to the equipment required and the post-processing involved, which would need to be outsourced from the council, however it is the 'gold standard' for collecting high quality imagery which can be used in future hazard assessments, and contribute to larger research projects investigating mixed sand and gravel and composite beach types. It is our understanding that drone surveys are semi-regularly taken at Motunau (by Environment Canterbury) and Amberley Beach (by University of Canterbury), and it could be possible to link these two programmes together.

Engagement: Small group of dedicated volunteers who can manage drone technology.

Data Collection: All data collected digitally.

Costs: The following costs should be considered:

- Establishment costs:
  - Cost of equipment (Drone approx. $2000; Tablet approx. $500-$1000, georeferenced markers could be made at low cost (<$100))
  - Set-up of drone and software (e.g. determining flight path)
  - Training/Workshops
- Operational costs:
  - Data processing and analysis (likely to be outsourced from council)
  - Database management
  - Feedback to the community

3.2.2 Basic ocean parameters

Equipment:

- Wind measuring device (e.g. Kestrel)

Method: Basic ocean parameters could be collected using the methods outlined in the COPE program (Section 1.1.2). This would involve using tools provided to record windspeed and direction (e.g. Kestrel), as well as training individuals to confidently record observations such as wave height, period, current direction, and speed. This would likely involve a small workshop with keen community members who would be willing to commit to taking regular measurements to make the dataset worthwhile. This could also involve creating an online form/app for community members to record the information and storage in a database. Information collected from this method could be useful for verifying the Environment Canterbury wave buoy data for how it relates to the local beaches in the Hurunui District.

Engagement: Likely to be a smaller group of volunteers who would be trained up and dedicated to collecting data consistently.

Data Collection: Flexibility in how data is recorded, could be done in a notebook or via an online form.

Costs: The following costs should be considered:

- Establishment costs:
  - Equipment (Kestrel)
  - Set-up of survey to record information (e.g. digital App or manual)

- Workshop/training
- Operational costs:
  - Database management
  - Data analysis
  - Feedback to the community

3.2.3 Vegetation Cover

Measuring vegetation cover across a dune environment could be done using the following methods:

3.2.3.1 Ecological surveys

Equipment:

- Quadrant
- Tape measures

Method: An ecological survey would be undertaken using a quadrant to measure the coverage at randomly selected sites across the dune or on a mixed sand/gravel beach ridge. This survey could be undertaken monthly to quarterly to build up a database on changes to the coverage of vegetation. This would require communities to be provided with a 1m x 1m quadrant, and to have a short workshop on how to undertake a survey, and resources to be provided around how to identify species (e.g. from Coastal Restoration Trust Website https://monitoring.coastalrestorationtrust.org.nz/guidelines/identifying-plants/).

This information would not contribute highly technical information which could be used in a future hazard assessment; however it is a common method used for educational purposes (e.g. with schools) to raise awareness around the importance of dune health.

Engagement: Likely to be a smaller group of volunteers who would be trained up and dedicated to collecting data consistently.

Data Collection*:* Flexibility in how data is recorded, could be done in a notebook or via an online form.

Costs: The following costs should be considered:

- Establishment costs:
  - Equipment (Quadrant, tape measure)
  - Set-up of survey to record information (e.g. digital or manual)
  - Establishment of sites (e.g. transects, sites)
  - Workshops/training
- Operational costs:
  - Database management
  - Data analysis
  - Feedback to the community

3.2.3.2 Dune profiles – Coastal Restoration Trust Guidelines

Equipment:

- 50-100m plastic tape
- Clipboard and printed survey forms
- 2m high, 1cm diameter fibreglass pole
- GPS unit
- Smartphone with compass app

Method: The community guidelines established by the Coastal Restoration Trust monitor and record various aspects of dune health. The key steps/methods which could be adopted within their monitoring guidelines are as follows:

- Rapid-point surveying method which takes a sample at 1m intervals across a dune/beach transect, identifying the species which is the 'uppermost touching the pole' and the 'tallest species within a 30cm radius'.
- Across the same transect, use the compass app on a smartphone to access the 'inclinometer'. Record the angles between each sample point at each major change in dune slope along the transect for input into the Coastal Monitoring Database on the trusts website.
- Take photographs at pre-determined fixed 'photo points' which can systematically capture the changes in vegetation and dune morphology over time.

Some or all of these methods could be adopted and would provide useful data both for the council and for the coastal restoration trust project. Photo points for this method could be tied in with CoastSnap sites or Measuring poles to capture multiple forms of information with small effort.

Engagement: Likely to be a small group of dedicated volunteers, but could appeal to all ages.

Data Collection: Flexible, could manually record the measurements. Would require inclinometer from smartphone.

Costs: The following costs should be considered:

- Establishment costs:
  - Equipment (Measuring tape, fibreglass pole, GPS)
  - Site visit to establish profiles/transects
  - Communication with coastal restoration staff to register the site
  - Training/workshops
  - Set-up of survey to record information (e.g. digital or manual)
- Operational Costs
  - Database management
  - Data analysis
  - Feedback to the community

3.2.4 Tension Cracks and Cliff Failure

Equipment:

- Workshop/training
- Pegs and string

- Smartphone for images
- Survey form and database to store information collected

Method: A record of the development of tension cracks in cliff environments, and the eventual cliff failure would be useful in communities located around cliff environments (e.g. Motunau). Useful information around this would likely be a record of qualitative data which could include:

- Records of increased in tension crack width. This could be measured by installing a peg on either side of the tension crack and tying a piece of string between them. The tension crack would be remeasured when the string snapped and had to be re-tied.
- Records of cliff failure events and estimates of cliff retreat following failure. This would be done by a volunteer recording where and when the cliff failed (locating this on a map), and giving an estimate of how far the cliff retreated as a result of the failure.

Engagement: Likely to be a smaller group of volunteers who would be trained up and likely to be close by in an event to capture post-event data.

Data Collection: Flexible, could be manually recorded in a notebook or recorded on a digital form.

Costs: The following costs should be considered:

- Establishment costs:
  - Any equipment (pegs, string)
  - Set-up of survey to record information (e.g. digital or manual)
  - Training/workshop
- Operational Costs
  - Database management
  - Data analysis
  - Feedback to the community

3.2.5 Pre and post event monitoring

3.2.5.1 Pre-Post Storm change to beach profile

Equipment: Would require the same training/equipment as adopted methods to measure other parameters beach health, but with an additional 'warning system' which could alert the community when a storm may be coming so that can capture pre and post storm data.

Method: In addition to any methods adopted, residents of the community could be alerted as to when a storm is likely to occur (e.g. 1-2 days notice) so that comparable pre-storm data could be collected, and data following the event could be collected at a relevant time. Both HDC and ECan have a coastal storm alert system with Met service that gives them 1-2 days notice prior to a likely storm occurring. This information could be relayed to members of the community who are collecting information, so they are aware of when it is a useful time to collect pre and post storm data.

Engagement: Dependent on the method applied. Giving volunteers notification of when to collect data may encourage/ prompt more collection.

Data Collection*:* Dependent on the method adopted. Notification of storm would need to be digital (e.g. via text or email).

Costs: The following additional costs for notification of storm events should be considered:

- Establishment costs:
  - Set-up of notification system
  - Collating community members details
- Operational costs
  - Costs of ongoing alert/notification system

3.2.5.2 Water-levels during large events

3.2.5.2.1 Water Gauge

Equipment:

- Water gauge
- Notebooks/survey form

Method: A record of actual water level in lagoons/river mouths near settlement would be useful to verify flood modelling. This would require the installation of a water gauge which members of the public could read and record in both large rainfall and beach overtopping events. This would require the gauge to be both accessible and easy to read. For example, the water gauge could be coloured in 50cm intervals, so when reading the gauge in a large event, residents could record that the water was at 'blue' which referred to a water level of 3.5-4m (we understand a similar gauge is already in place at the Amberley north lagoon). Residents would be able to make a quantitative assessment from a distance without being in contact with the hazard.

Engagement: Small group of volunteers to community wide engagement, minimal training required.

Data Collection: Flexible, could be recorded manually or digitally.

Costs: The following costs should be considered:

- Establishment costs:
  - Water gauges and installation
  - Site visit for establishing where water gauge should go
  - Set-up of survey to record information (e.g. digital or manual)
- Operational costs
  - Database management
  - Data analysis
  - Feedback to community

3.2.5.2.2 Photographs

Equipment:

- Smartphone/Camera

Method: Photographs during flood and beach overtopping events provide useful information to validate flood models as they can show the extent of flooding and give an indication of depth where possible. In order to record this data, an app or online database would be required so that members of the public could upload images and write notes associated with the image/event. These records would need to be timestamped to give an indication of the environmental conditions at the time (e.g. tides). This method would require members of the public to have a smartphone which could take images, and for the participant to be collecting the data during a large event.

Engagement: Community wide engagement, minimal training required

Data Collection: Flexible, could be recorded and submitted digitally (e.g. via a form/email) or manually (e.g. printed off with handwritten notes).

Costs: The following costs should be considered:

- Establishment costs:
  - Set-up of survey to record information (e.g. digital or manual)
  - Small workshop/training
- Operational costs
  - Database management
  - Data analysis
  - Feedback to community

3.2.5.3 Structure Damage and Condition

Equipment:

- Smartphone/Camera
- Survey form and database to store information collected

Method: The conditions of the structures could be monitored by the public through observations of change and damage following large events. This could be done through taking images of the structure and damage, recording times when the damage was discovered. This information could be input into a database that the council can have access too, where they can be notified if any damage to the structures has occurred.

Engagement: Community wide engagement, minimal training required

Data Collection: Likely to be more successful if it is done digitally as council will receive the data quicker, however, could be done manually.

Costs: The following costs should be considered:

- Establishment costs:
  - Set-up of survey to record information (e.g. digital or manual)
- Operational costs
  - Database management
  - Data analysis
  - Feedback to community

4. Citizen Science Options for Hurunui District Communities

4.1 Options Matrix

Table 2 summarizes the methods described in Section 3, and shows what communities they could be applied to in the Hurunui District with a tick (✓) where it could be implemented, and a cross (×) where it would likely be unsuccessful or not applicable. The table also shows the high level ranking of the methods based on rankings presented in Table 1 for both community engagement (potential number of people it would involve), and ability to collect useful information on a technical level for input into future hazard assessments and broader research. Methods with the highest 'score" in the 5th column, being the product of the engagement and technical rankings, could be considered to generally be the best options (e.g. photographs and pre & post storm surveys). However, it is noted that while some methods may rank well overall on these two parameters, other limitations may prevent them from being the preferred option for an individual community.

Table 2: Matrix of applicability of citizen science methods to each community in the Hurunui District.

Data Collection	Method	Engagement	Technical	'Score'	Leithfield Beach	Amberley Beach	Motunau	Gore Bay	Conway Flat/ Claverley
Physical beach health parameter	Measuring Pole and physical measurements	2	2	4	✓	✓	Sandy Bay[1]	✓	✓
	Photographs (CoastSnap)	3	2	6	✓	✓	✓	✓	✓
	Sediment Sampling	1	3	3	✓	✓	Sandy Bay[1]	✓	✓
	Drone Survey	1	3	3	✓	✓	✓	✓	✓
Basic Ocean Parameters	Physical Measurements	2	1	2	✓	✓	✓	✓	✓
Vegetation Cover	Ecological Surveys - Quadrant	2	1	2	✓	×	×	×	×
	Dune profiles (CRT Guidelines)	1	3	3	✓	×	×	×	×
Cliff Failure and Tension Cracks	Physical Measurements and estimates	1	2	2	×	×	✓	×	×
Pre and Post Storm Change	Notification of Incoming Storm	Potentially 2[2]	Potentially 3[2]	Potentially 6	✓	✓	✓	✓	✓
Water levels in	Water Gauge (with warning notification)	2	2	4	✓	✓	✓	✓	×

Data Collection	Method	Engagement	Technical	'Score'	Leithfield Beach	Amberley Beach	Motunau	Gore Bay	Conway Flat/ Claverley
extreme events	Photographs (with warning notification)	2	1	2	✓	✓	✓	✓	✗
Structures	Survey with Photographs	2	1	2	✓	✓	✗	✓	✓

[1]This method is appropriate along the Sandy Bay (beach) environment, but not the cliff environment at Motunau.

[2]This method is used in addition to another method (e.g. physical beach measurements), therefore most of its success is based on what method is employed for measuring/recording beach health or water levels.

4.2 Training workshops

For some methods, training workshops would be required to ensure that community members know how to collect the data using the tools provided. These training workshops would be best undertaken in person with members of the community.

To provide a wider outreach to the community and to have a training resources available for members of the community, it would be useful to create short videos which could be attached to the survey or uploaded to the HDC website so that members of the public could use them to either train new residents, or refresh themselves on the appropriate methods.

While the workshops are more beneficial as they provide a hands-on experience, short 'how to' videos may be an easier approach for methods which only require basic guidance.

4.3 Databases and Survey Forms

It is recommended that the databases would be held at the council, or the regional council (Environment Canterbury) as a centralised location so that members of the public would know where to access the information.

Any data capture that requires a form/survey could be done through a free service such as google forms where data could be recorded straight into an excel spreadsheet which could be later analysed. It is understood that HDC also has a system in-house they could utilise for survey forms.

A suggestion of how this would work would be through a portal on the HDC website for people to open up the survey forms and submit them. HDC could create a citizen science page on their website for each community which could contain instructions for the data collections and links to survey forms. For methods which required training/workshopping, videos could be recorded of the training and uploaded to the website for easy access to the public.

Alternatively, it could be collected through a paid service such as Fulcrum (https://www.fulcrumapp.com/) or Survey123 (driven by ArcGIS https://survey123.arcgis.com/) where data would be stored on an online database within the website. The paid services are more likely to be used where the data is required to be geospatially interactive, for example if community members needed to navigate to a site using an online map, then click on the point to pull up the survey form.

For most methods, there is an option of recording the information manually, and submitting this to the council for uploading/ digitising into a database. This option may be more resource intensive however may allow for more engagement from members of the community who do not have access to the technology required.

4.4 Feedback to the Community

An important part of keeping communities engaged with a citizen science programme would be to provide feedback to the community on how the programme is going and what the finding are, so that communities maintain a sense of purpose within the programme. This could be done through an annual newsletter/e-newsletter to the community. It could be a simple analysis of the data collected, for example, a time-lapse of the photos collected, or statistics from analysed data (e.g. the beach has retreated 3m this year).

4.5 Health and Safety

It is noted that there is no expectation for the community to be collecting data during extreme events, or in environments (e.g. close to cliff edges) which puts themselves or others at risk.

4.6 Limitations

The main limitation of implementation of citizen science will be the commitment of the communities to undertake these studies, and commit to collecting data for a long timeframe where it will become useful (e.g. 5+ years). In larger communities with more permanent residents (e.g. Leithfield Beach and Amberley Beach), it is more likely that larger datasets will be able to be built using participants from the community. In these communities, both community wide engagement initiatives (e.g. photographs), as well as smaller volunteer groups (e.g. taking physical measurements) may both be successful depending on the enthusiasm from the community.

Settlements such as Motunau and Gore Bay which have more holiday homes than permanent residents may struggle to develop useful and long term datasets if there is not a strong uptake from the holiday home community. Discussions with the community about engagement and what methods would best suit their lifestyle would be encouraged in order to set up a programme which optimised the data which could be collected.

5. Conclusions

The purposed of this report was to conduct a global review of citizen science programmes, and identify appropriate methods which could be implemented at various coastal communities in the Hurunui District. A wide range of methods were identified and ranked based on two success drivers:

1. Ability to engage with as many members of the community as possible, and for this engagement to be ongoing for years to come.

2. Ability to collect valuable data which can be used to help with better understanding of the extent and magnitude of local coastal hazards in the future.

This review identified that there are a number of citizen science opportunities which could be employed in the Hurunui District. Based on the two criteria, the highest ranking options included:

- **Measuring Pole** – Recordings of the beach elevation on a permanent, surveyed measuring pole installed at the back of the beach, which would provide information about the dynamic and changing volume of the beach at a more stable area, especially in regards to post storm recovery.
- **Photographs (e.g. CoastSnap)** – An app based method where participants take photographs from a reference point, and photographs can be utilised to build up a long term record of beach condition and to analyse changes to the beach position over both the long and short term.
- **Pre and Post Storm Change** – Residents of the community could be alerted as to when a storm is likely to occur (e.g. 1-2 days notice) so that comparable pre-storm data could be collected, and data following the event could be collected at a relevant time. Method of collection could vary (e.g. measuring pole, photographs).
- **Water levels in large events** - Installation of a water gauge which members of the public could read and record in both large rainfall and beach overtopping events.

No specific recommendations have been made regarding which options to use in each community. The scope of Jacobs work has been to identify a range of suitable methods for HDC to consider further and discuss with the community. It is noted that while some methods may rank well overall on these two success drivers, other limitations, such as number of permanent residents, may prevent them from being the preferred option for an individual community.

Employing some/all of these options within the communities in the Hurunui District would also provide additional and valuable data to Environment Canterbury, as well as benefitting broader research which occurs on the Hurunui Districts unique mixed sand and gravel and composite beach systems.