3. Methods

3.1 Aerial photography and change detection

Remote sensing and geographical information systems methodologies were applied to determine the historical change of the mangrove, salt marsh and saltpan in a spatial and numerical sense. The following will explain the processes applied.

3.1.1 Flow Chart

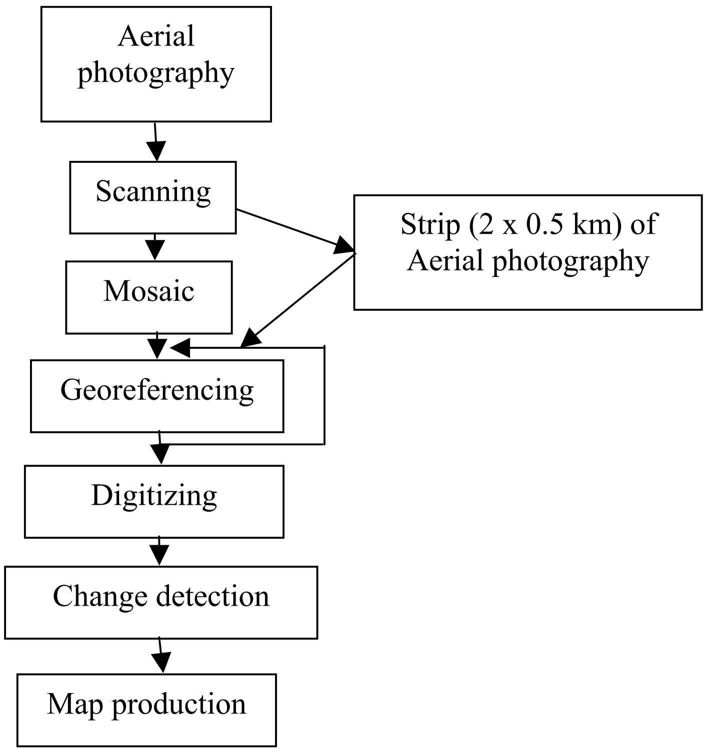

Figure 19. Analytical methods applied to produce the mosaic and tidal wetland maps, and calculate change of surface area over time, as seen in this report.

3.1.2 Acquisition

Historical aerial photographs were acquired for each area studied in this project, with the specific sources for each area and year listed in the relative chapters.

Historical aerial photo libraries were searched at local and national government and non government agencies such as: Department of Natural Resources and Mines (DNRM), Geoscience Australia and Central Queensland University. These agencies acquired the photos for a variety of purposes (e.g. vegetation mapping, beach protection, town planning)

The search prerequisites were that the aerial photos:

- Covered the complete or parts of the area of interest;
- Had a scale of at least 1:25000 so that single trees could be determined;
- Covered a large time period (e.g. 1940 till 2003); and
- Were in good condition.

3.1.3 Scanning

Scanning of the aerial photographs was needed to digitize the different vegetation types in the Areas Of Interest (AOI). The acquired images were scanned in at a resolution of 600 or 1200 dots per square inch (dpi).

Scanning resolution depended on a balance between;

- High quality digital imagery (for example, single trees were just visible) and
- Reduced image size so that image processing was still suitable with a desktop computer.

Images were scanned in using standard flat bed scanners such as the Canon D1250 U2 or Scanmaker Pro.

3.1.4 Mosaicing

Mosaics of the aerial photographs were made for the areas of interest or study areas that were covered by more than one photo. For some study areas, the area of interest was covered by one photo only, and thus a mosaic was not required for that area.

The electronic versions of the photos were imported into Adobe Photoshop (version 6.0). With this program's imaging tools a mosaic was created. The photos were then saved and reduced to below 150 mega bytes to keep an acceptable quality but also image processing speed. Desktop computers, such as a Pentium 4 with a 2 GHz CPU, 512 Ram and 40 Gigabytes hard drive, were shown to be sufficient for the processing. However, computers with less capabilities could still process the images, just with a delay in processing.

The photos were not corrected for flying height, pitch and roll of the plane. This was not conducted for a number of reasons:

- Appropriate camera and flying details were not available;
- And/or sufficient funding was not available for orthorectification;
- And/or no digital elevation model was available for the areas of interest;
- And/or insufficient skills and time were available to conduct a more thorough job.

As a result of the photos not being fully corrected, some mosaics did not have a perfect match between neighbouring photographs. Those areas of interest which had no high elevation differences were less affected.

3.1.5 Georeferencing

Images are georeferenced to calculate and compare changes in vegetation over time. This process required referencing the imagery to an earth coordinate system.

The digital images were imported into the image processing software package ERDAS Imagine 8.5. For this process, characteristic features were determined in the digital image and a reference image. The referenced image was fixed to an earth coordinate system, which was described by datum and projection (in this project AGD 84 and Universal Transfers Mercator Projection). The characteristic features consisted of approximately 20 control points (for example, jetties or houses and natural features, single trees or jetties) evenly spread across the base image. The program calculated a second order polynomial through these points to get the best match. Route mean square errors were improved by adding and/or deleting control points. After this iterative process, the polynomial was used to resample the base image to a new and more refined georeferenced image.

The most recent aerial images were georeferenced to appropriate reference satellite images (Landsat ETM 5 or 7). The resulting georeferenced image was then used to georeference the older aerial images. The aerial photographs had higher resolution than the satellite imagery (25 x 25 m) and satellite imagery did not show single trees, where aerial photographs did. Therefore, by georeferencing the older aerial images with the youngest georeferenced image (showing single trees), the error between these images was reduced.

3.1.6 Digitizing

Size and location of the mangrove, salt marsh and saltpan areas was determined after the boundaries of these areas were digitized using the georeferenced imagery.

The georeferenced images were imported into a GIS software package (Arcview 3.3). Polygons were drawn using the digitising options in the package and then labels were assigned to them. Labels varied from detailed (species level) to general (for example, mangrove). The labels consisted chiefly of three vegetation classes: mangrove, salt marsh plus saltpan). The location of the polygons were made with the help of the digital image as a backdrop on the screen and comparing with the hard copy aerial and terrestrial photographs. Field knowledge and experience about what mangrove, salt marsh and saltpan look like was essential for this process, and was backed up with selected ground observations. Depending on the quality of the images and the need, labels were assigned to each polygon.

3.1.7 Change analysis

Change analysis focussed on the actual number of changes in surface area and where these changes occurred spatially over the different time periods.

Surface area per polygon was calculated using ArcView tools. Total surface area per vegetation type was calculated in Excel by summarizing totals of surface area for those polygons with the same vegetation type. These total values were then compared over time with the results of aerial photographs from other time periods.

3.1.8 Strips

Strips (2 by 0.5 km) were extracted from the aerial photography. The strips characterise the areas of interest and do not have high elevation differences. The advantage of these strips was the higher accuracy achieved in these images.

The advantages with this technique when georeferencing the strip to another strip were:

- more details were visible as the strips could be scanned at higher resolution;
- the area size was smaller, which will contribute to a better fitting projection model; and
- the relief differences were small and the lack of ortho rectification had less influence.

These strips went through the same process as discussed in paragraphs 3.1.1 to 3.1.6.

3.1.9 Map production

Maps were produced using the GIS software package (ArcView 3.3). The digitised vegetation areas and areas of interest were presented on top of available aerial photography or satellite imagery. This was done to help understand the location of each vegetation type in relation to characteristic features in the imagery. All maps presented are in projection Universal Transverse Mercator and datum Australian Geodetic Datum 1984.

3.1.10 Accuracy assessment

Accuracy assessment was conducted on the georeferenced imagery from a large mosaic (1000 km^2), small area (~13 km^2) and a small strip (~0.6 km^2). These areas were chosen to demonstrate the influence of the size of the mosaic and scale on the georeferenced imagery. In each image, 10 natural control points (for example, trees) were located and the coordinates were recorded. The Root Mean Square Error (RMSE) was calculated for these points relative to a base image. The base image was the image used to georeference all the other images to, of the same area (see section 3.1.5).

Table 3. Accuracy assessment of an ad hoc selection of imagery used in this project. Root Mean Square Errors were calculated measuring the position of 10 different locations in the imagery for each time frame and image set.

Fitzroy Estuary				**Luggage Point**				**Cobby strip**			
Ave RMSE (m)	115.3	Area size (km2):	1142.0	Ave RMSE (m)	8.5	Area size (km2):	14.0	Ave RMSE (m)	2.6	Area size (km2):	0.6
Year	**RMSE (m)**	**Images**	**Image scale**	**Year**	**RMSE (m)**	**Images**	**Image scale**	**Year**	**RMSE (m)**	**Images**	**Image scale**
1999	Base	36	1:25000	1991	Base	1	1:25000	1997	Base	1	1:12500
1941	115.3	96	1:10000	2002	4.2	1	1:25000	1987	2.5	1	1:12500
				1981	6.0	1	1:25000	1974	2.0	1	1:12500
				1960	11.9	2	1:15000	1955	3.0	1	1:12500
				1951	10.4	2	1:15000	1944	2.7	1	1:12500
				1946	9.9	2	1:15000				

The results demonstrate that detailed imagery and the smaller area images had the greatest accuracy and were favoured in the assessment of change over time (Table 3).

The accuracy of the mosaics would have been improved if the images had been orthorectified appropriately before producing the mosaics. Such an extra process would have taken into account the position of the airplane, its pitch and roll.

3.1.11 Limitations

- Imagery was georeferenced with Landsat ETM 7 images, which had a pixel size of 25 m. The pixel size influenced the resolution and therefore how accurate features were used as natural control points. This influenced the quality of the georeferencing of the base aerial image. Using high resolution imagery or additional field control points would have improved the accuracy of the georeferencing.
- Size (bytes) of the images needed to be reduced to speed up image processing on the computer. However, this reduction in size caused the loss of accuracy leaving some features not clearly visible.
- Older aerial photographs were sometimes of poor quality. Therefore, some details may have been missed or inaccurately delineated.
- The operator who digitized the aerial imagery needed personal experience in field interpretation of mangrove, salt marsh and saltpan habitats. Since the drawing of lines delineating vegetation types depended on the operator's visual interpretation, this may also have affected comparability of the maps produced. This applies both within this project, and comparing among other studies.

3.1.12 Software, hardware and computer skills

Ability of equipment and skills may be a limiting factor to the work described above. The following is a list of minimum requirements for equipment required:

Software and Hardware	**Task**	**Minimum Requirements**	**Used in this project**
Computer	Conduct the processing	Windows based, Desktop or laptop, 250 Mb ram, 1 GHz processor, 20 Gb Hard drive	Pentium 4 with a 2 GHz CPU, 512 Ram and 40 Gigabytes hard drive
Flat bed scanner	Scan the aerial photographs	A3 size scans at 1200 dpi	Canon D1250 U2
Photo imaging software	Produce a mosaic of the scanned aerial photographs	Adobe Photoshop 6.0 or equivalent	Adobe Photoshop 6.0
Georefencing Software	Georeferencing of scanned aerial photographs	Basic GPS software such as FUGAWI 3.0 or equivalent	ERDAS Imagine 8.5 (high end remote sensing program)
Geographical Information System Software	Digitizing the imagery, calculate change detection and producing maps	ESRI ArcView 3.3 or equivalent	ESRI ArcView 3.3 with spatial analist and change detection extensions
Spreadsheet software	To calculate total surface area resulting from digitizing.	Microsoft Excel	Microsoft Excel

The following is a list of minimum requirements for skills and knowledge needed:

Task	**Skill levels and knowledge needed**	**Qualification level**
Acquisitioning	Basic knowledge of geographic area of interest for aerial photographs to be acquired. Basic knowledge and skills in aerial photograph interpretation.	BSc. major in botany and minor in GIS and Remote Sensing
Scanning	Basic scanning skills with standard flat bed scanner.	BSc. or equivalent
Mosaic production	Basic knowledge of the area of interest to identify overlapping imagery and basic skill using the imaging mosaic software.	BSc. major in botany and minor in GIS and Remote Sensing
Georeferencing	Advanced knowledge of wetland habitats to: Identify (natural) control points and understand how much natural control points can change over time in appearance. Advanced knowledge and skills in the principle of georeferencing software and analyzing the quality of the georeferencing.	BSc major GIS and Remote Sensing equivalent
Digitizing	Advanced knowledge of and experience in wetland vegetation and basic principles in digitizing using GIS software.	BSc.(Honours) major in botany and minor in GIS and Remote Sensing
Change detection	Advanced knowledge of and experience in wetland vegetation and advanced skill GIS software	BSc.(Honours) major in botany and minor in GIS and Remote Sensing
Analysis	Advanced knowledge of and experience in wetland vegetation and advanced skill GIS software	BSc.(Honours) major in botany and minor in GIS and Remote Sensing

In this project the team to conduct the process described above consisted of:

Title	Degree	Experience
1 x Principle Investigator	Post doc. in wetland vegetation	100 years
2 x Research Assistance in digitizing and aerial photo interpretation	BSc. (Honours) wetland vegetation mapping	1 year
1 x Research Assistance GIS and Remote Sensing	Masters in Remote Sensing and GIS and pgdip. in marine science	8 years
2 x BSc. (Honours) Students	BSc. Botany and/or Environmental Science	No experience