6. Indicator Theme 1-6 Protocols and Protocol on Aggregation and Integration of Indices

The indices are all calculated to generate values between 1 and 0. The scores are allocated into bands, which are described and summarized in Table 1. The bands follow a colouring scheme, which is also displayed in Table 1.

6.1 Catchment disturbance

6.1.1 Data requirements

To calculate the Catchment Disturbance Index CDI, a spatial map of the wetlands of interest and their catchments needs to be available. This is at present a major restriction to calculate catchment disturbance anywhere in the Northern Territory, although the other data are available. Summary of data layers required:

- Wetland boundary layer
- Wetland catchment layer
- Land use (eg. LUMP) layer
- Vegetation clearing layer.

6.1.2 Land use sub score

Land use information in the catchment is calculated using the intersect function in GIS software after categorising the land uses according to Table 3.

The land use indicator LU is calculated using the equation:

LU = 1 – (fraction category 1 land use * category 1 weight) + (fraction category 2 land use * category 2 weight) + … + (fraction category 6 land use * category 6 weight).

With LU = Land use and the weights for each category being taken also from Table 3.

6.1.3 Land use change sub score using vegetation clearing

Vegetation clearing in the catchment is calculated using the intersect function in GIS software. The land cover change score is then calculated according to this equation:

Land cover change measure LCC = 1 - (Area cleared*weight / Catchment area)

using the value of 0.68 for the weight.

6.1.4 Infrastructure sub score using the road network

The road area in the catchment was calculated using the category 5.7.2 ‘Roads’ of the Land use data and intersecting with the catchment layer in GIS software.

The infrastructure indicator I is calculated using the following equation:

I = 1 – (Fraction of catchment covered by roads * weight for roads)

The weight of 0.7 is to be used.

6.1.5 Integration of sub scores to Catchment Disturbance Index CDI

For integration the sub scores are added and 2 is subtracted according to this equation:

CDI = I + LC + LU – 2

CDI = Catchment Disturbance Index, I = Infrastructure sub score, LC = Land Cover Change sub score, LU = Land Use sub score.

A negative score value is set to 0.

6.2 Physical form and processes

6.2.1 Data requirements

For the calculation of the Physical Disturbance Index PDI the following data layers are required:

- Wetland boundary layer
- Land use (eg. LUMP) layer.

6.2.2 Proximity sub score

The distance to the nearest wetland is calculated in GIS software and then scored according to Table 8. The 'proximity to adjacent ecosystems' is calculated using the perimeter of the wetland boundary and calculating how much of it is adjacent to natural ecosystems using land use categories 1, 6.3 (River), 6.5.0. and 6.5.1 (Marsh/wetland conservation). The percentage of perimeter neighbouring natural ecosystems is scored according to Table 8.

The proximity sub score is obtained by adding the 'distance to nearest wetland' score to the 'proximity to adjacent natural ecosystems' score.

6.2.3 Road sub score

The road area within the wetland complex boundary is calculated by using the category 5.7.2 'Roads' of the Land Use data set and intersecting in GIS software. The percentage of the area of the wetland covered by roads is converted to the road sub score using Table 9.

6.2.4 Area sub score

The area of the wetland, calculated in GIS software, is converted into a score using Table 10.

6.2.5 Integration of the sub scores to Physical Disturbance Index PDI

The proximity, road and area sub scores are added and divided by 20.

6.3 Hydrological Disturbance Index HDI

6.3.1 Water Extraction Indicator to be used for Hydrological Disturbance Index HDI

6.3.1.1 Data requirements

The following data are required to calculate the Water Extraction Indicator:

- Percentage of water extraction in relation to amount of water present at the time. This information should be obtained from the water extraction licensing institution.

6.3.1.2 Calculation of Hydrological Disturbance Index using Water Extraction Indicator

The percentage of water extraction per amount of water available is calculated as the median of the data over a year.

The Hydrological Disturbance Index is calculated as Water Extraction Indicator WEI:

WEI = 1 – (% water extraction / 20).

The division of the percentage value by 20 ensures the indicator to have a score between 1 and 0. If the percentage of water extraction is larger than 20%, the score becomes negative and has to be set to 0.

6.4 Fringing Zone Index FZI

Due to discussions on the fringing zone definition, two areas were used as a basis for this index in the main part of the report (see section 5.6). In this protocol section, only the fringing zone according to the national definition is covered, called FZ100 in section 5.6.

6.4.1 Data requirements

For the calculation of the Fringing Zone Index FZI using GIS software the following data layers are required:

- Wetland boundary layer
- Wetland catchment layer
- Data layer to determine remnant native vegetation, e.g. NVIS

Or:

- Land clearing data layer.

6.4.2 Calculation of the Fringing Zone Index FZI

A 100 m buffer zone is created outside the wetland boundary. This buffer zone might need to be clipped to remain inside the respective wetland catchment. This clipped 100 m buffer is called the fringing zone.

The Fringing Zone Index FZI can be calculated using remnant vegetation or land clearing data. Both ways to obtain the index are valid and only one of them needs to be calculated.

6.4.2.1 Remnant vegetation in Fringing Zone

The percentage area of remnant vegetation in the fringing zone is calculated using the intersect function in GIS software. The percentage value divided by 100 provides the Fringing Zone Index FZI score.

6.4.2.2 Land clearing in Fringing Zone

The percentage area of land clearing in the fringing zone is calculated using the intersect function in GIS software. The percentage value is subtracted from 100 and this figure divided by 100 to obtain the Fringing Zone Index FZI score.

6.5 Water Quality Index WQI

6.5.1 Data requirements

The Water quality Index WQI is based on the field measurement of water quality parameters. In its current state, it is therefore only applicable to wetlands when holding water, such as the lagoons in the Darwin region. For ephemeral wetlands, the water quality measurements for the WQI have to be taken when the wetland is well filled, data collected during the one or two months prior to drying up are not to be used to calculate the WQI. The best period for field measurements in the Top End is the late wet to early dry season. For permanent wetlands in the Top End field measurements can be taken throughout the year.

Water quality parameters used for the WQI:

- pH
- Electrical Conductivity (µS/cm)
- Turbidity (NTU)
- Total Phosphorus TP (mg/L)
- Chlorophyll a (µg/L)
- Total Nitrogen TN (mg/L)

The reduction of the number of water quality parameters to three or four instead of the listed six is possible as long as turbidity and total nitrogen are part of them. The recommended reduced suite of water quality parameters needs a larger data base for finalisation.

The data used for this indicator trial project by Schult & Welch (2006) revealed considerable variability of water quality data and respective scores over the nine months sampling period. It is therefore optimal to have field data from at least three visits in order to obtain a reasonable reliable data set to calculate the WQI.

6.5.2 Calculation of the Water quality Index WQI

For each of the six water quality parameters the median of the data collected per wetland is calculated and allocated a score according to Table 18. The Water Quality Index WQI is obtained by multiplying the scores for each of the (currently) six parameters.

6.6 Biota Index

6.6.1 Fish taxa number indicator

6.6.1.1 Data requirements

Fish survey data have to be available for each lagoon the indicator is being calculated for. The experience form the wet season electro-fishing survey has revealed that data need to be collected at least on two days, preferably using two different collection methods, one of which is recommended to be electro-fishing if the indicator is calculated based on wet season surveys.

Field trials need to establish, whether the sampling has to be carried out at a specific time of the year, ie. the dry season, and also whether a single sampling is enough to recover a suitable number of fish.

The fish survey data have to produce as fish taxon list, which is then used to calculate the indicator.

Due to a lack of data, it is open whether there has to be several reference conditions for different types of lagoons or there can be one reference condition for the lagoons in the trial area.

It is considered not meaningful to establish an indicator on a taxa number lower than 10.

6.6.1.2 Fish indicator score

To this end the Fish Indicator score was only calculated for one lagoon in the trial area, namely Girraween Lagoon, as this was the only lagoon with suitable baseline data to establish a reference condition. For Girraween Lagoon the Fish Indicator score is obtained using Table 24 in this report.

For other lagoons the Fish Indicator score will be obtained in a similar way as for Girraween Lagoon, as soon as there is enough data to establish a reference condition.

6.6.2 Macrophytes taxa number indicator

The macrophyte taxa number indicator has not been developed due to a lack of data to trial it.

6.6.3 Integration of fish indicator and macrophyte indicator to Biota Index

Integration of fish and macrophyte indicator is expected to be a simple unweighted average of both scores.

6.7 Aggregation of indices for individual lagoons to indices for the wetlands in the study area

6.7.1 Catchment Disturbance Index CDI aggregation

The aggregation of the Catchment Disturbance Indices of individual lagoon catchments is calculated on an area weighted average based on the catchment area (Norris et al. 2007b). The area of all lagoon catchments is added up and set to 100%. The percentage of each individual lagoon catchment area is multiplied with the individual CDI score. This value is calculated for each lagoon catchment, summed and divided by 100 to bring the score back from a percentage value to a value between 1 and 0.

6.7.2 Physical Disturbance Index PDI aggregation

Aggregation of the Physical Disturbance Indices of individual lagoon complexes is calculated on an area weighted average based on the wetland complex area (Norris et al. 2007b). The area of all lagoon complexes is added up and set to 100%. The percentage of each individual lagoon complex area is multiplied with the individual PDI score. This value is calculated for each lagoon complex, summed and divided by 100 to bring the score back from a percentage value to a value between 1 and 0.

6.7.3 Hydrological Disturbance Index HDI aggregation

Aggregation of the Hydrological Disturbance Indices of individual lagoon complexes is calculated on an area weighted average based on the wetland complex area (Norris et al. 2007b). The area of all lagoon complexes is added up and set to 100%. The percentage of each individual lagoon complex area is multiplied with the individual HDI score. This value is calculated for each lagoon complex, summed and divided by 100 to bring the score back from a percentage value to a value between 1 and 0.

6.7.4 Fringing Zone Index FZI aggregation

Aggregation of the Fringing Zone Indices of individual lagoon complexes is calculated on an area weighted average based on the wetland complex area (Norris et al. 2007b). The area of all lagoon complexes is added up and set to 100%. The percentage of each individual lagoon complex area is multiplied with the individual FZI score. This value is calculated for each lagoon complex, summed and divided by 100 for range standardisation to a value between 1 and 0.

6.7.5 Water Quality Index WQI aggregation

Aggregation of the Water Quality Indices of individual lagoons is calculated on an area weighted average based on the lagoon water body area (Norris et al. 2007b). The area of all lagoon water bodies is added up and set to 100%. The percentage of each individual lagoon water body area is multiplied with the individual WQI score. This value is calculated for each lagoon water body, summed and divided by 100 to bring the score back from a percentage value to a value between 1 and 0.

6.7.6 Biota Index BI aggregation

Aggregation of the Biota Indices of individual lagoons is anticipated to be calculated on an area weighted average based on the lagoon water body area (Norris et al. 2007b). The area of all lagoon water bodies is added up and set to 100%. The percentage of each individual lagoon water body area is multiplied with the individual BI score. This value is calculated for each lagoon water body, summed and divided by 100 to bring the score back from a percentage value to a value between 1 and 0.

6.8 Calculation of Wetland Condition Index

The integration method to combine the individual indices per wetland to a Wetland Condition Index WCI for each wetland follows Norris et al. (2007b) using the standardised Euclidean distance:

$$WCI = 1 - \sqrt{(1-CDI)^2 + (1-PDI)^2 + (1-HDI)^2 + (1-FZI)^2 + (1-WQI)^2 + (1-BI)^2} \;/\; \sqrt{N}$$

With WCI: Wetland Condition Index,

CDI: Catchment Disturbance Index,

PDI: Physical Disturbance Index,

HDI: Hydrological Disturbance Index,

FZI: Fringing Zone Index,

WQI: Water Quality Index,

BI: Biota Index,

N: Number of indices used, in this example N=6.

This method is also used to calculate the spatially aggregated WCI for the study area by using the spatially aggregated index values for all of the 6 indices if available.

A Wetland Condition Index can be calculated using a minimum of 3 indices from 3 themes.

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