Eurobodalla Coastal Environmental Capacity Planning Project

Integrated Strategic Environmental Assessment Utilising Multi Criteria Evaluation Techniques

Eurobodalla Shire Council

November 2001

Prepared by Jeff Morgan
Strategic Planning Unit

Table of Contents

Table of Figures

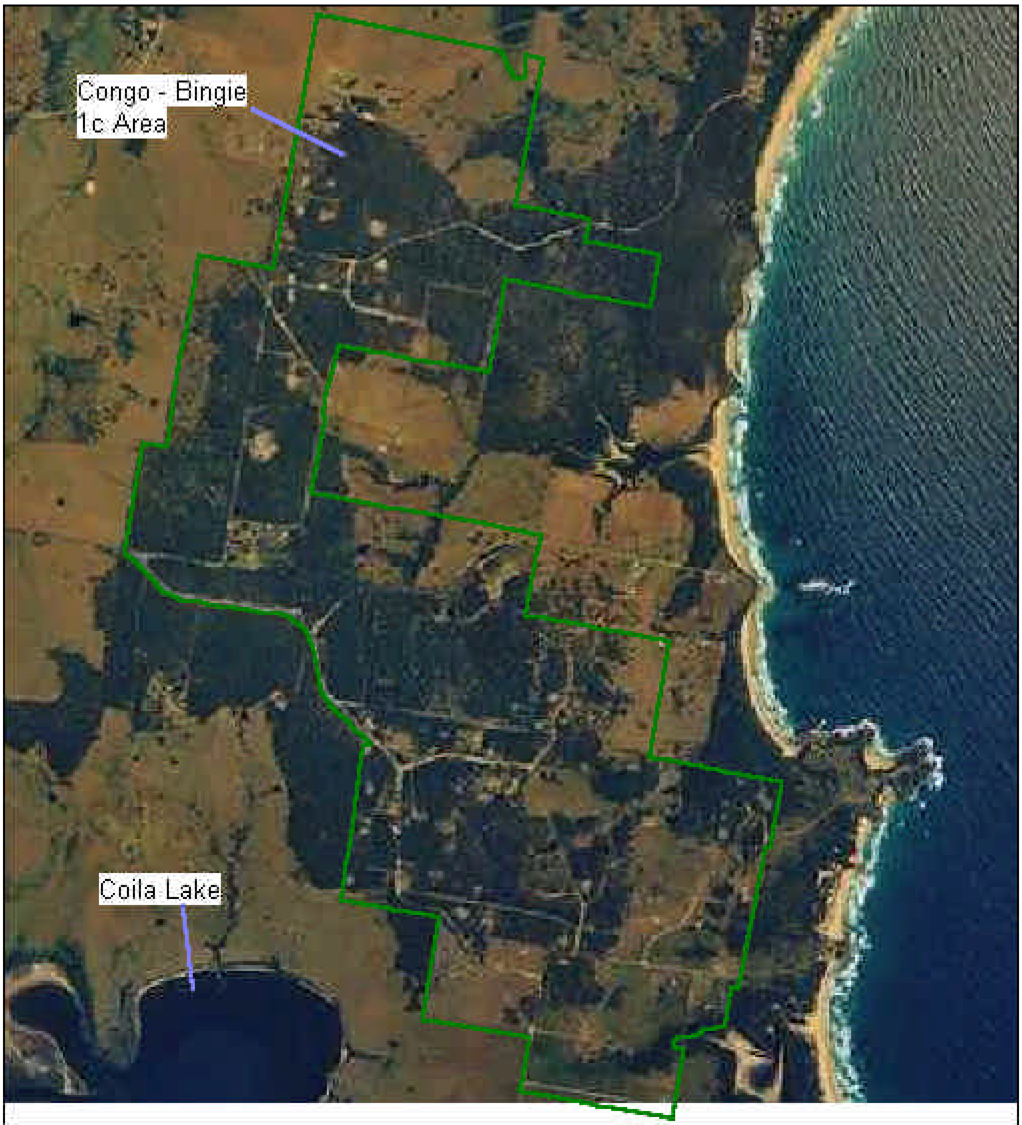
1 Introduction

The identification of land suitable for rural residential development is a complex task that must consider a wide range of information before making informed decisions. Often various environmental criteria must be weighed up and assessed against each other in an often subconsciously subjective manner to arrive at a decision. A challenge to strategic planners and decision makers is to carry out such assessments in a transparent and repeatable manner where levels of subjective decision making are low.

To date the most commonly practiced form of land suitability analysis (analysing land for its suitability for a particular use – such as rural residential development in this case) in local government has been based upon the McHarg approach (McHarg, 1969). In this approach separate maps displaying particular landscape information, such as vegetation type, slope, agricultural soil classification etc are overlain to determine areas that meet certain requirements which may be suitable for a specific purpose (Boolean Overlays). This approach has evolved from hand drawn maps to modern day Geographic Information Systems, often involving data derived from remote sensing and complicated modelling procedures.

The need to develop a transparent and repeatable system for assessing land suitability has arisen primarily from the large amount of data that is at the disposal of Local Government today. Eurobodalla Shire Council under the Eurobodalla Coastal Environmental Capacity Planning Project has gathered the data for use in the "Integrated Strategic Environmental Assessment Utilising Multi-Criteria Evaluation Techniques". Trying to consider all the data that ESC possesses as a result of this project in a map overlay or Boolean approach similar to that defined by McHarg would in most circumstances be confusing and any decision reached will not be justifiable due to this approach's subjective nature. The McHarg or Boolean approach will not deliver a continuous map of suitability, but only a map indicating areas suitable or unsuitable due to the factors or constraints underlying a site. Only in relatively simple cases such as Mystery Bay does this approach work. The reason for this is that there are areas of land that are unconstrained in terms of environmental criteria occurring at the site. More complicated areas such as the Congo - Bingie Rural Residential Area examined in this paper require an approach that can weigh up and assess various environmental criteria in a transparent and repeatable land suitability analysis. A technique that allows this is Multi-Criteria Evaluation combining both the Analytical Hierarchy Process (AHP) (Saaty, 1980) and the Weighted Linear Combination (WLC) (to be referenced).

Figure 1 The Congo – Bingie Rural Residential Area



2 Methodology

2.1 Key Definitions

Analytic Hierarchy Process

- A process which assists complex decision making by comparing factors which are difficult to quantify by building a hierarchy (ranking) of factors and then making comparisons between each possible pair in each cluster (as a matrix). This gives weighting for each factor within a cluster (or level of the hierarchy). The end result when integrated with GIS data is a continuous map of suitability.

Absolute Constraints

- A criterion that limits the alternatives under consideration. These may be certain features such as wetlands or slopes that are too steep.

Boolean overlays (sieve analysis)

- Separate maps displaying particular landscape information, such as vegetation type, slope, agricultural soil classification etc are overlain to determine areas that meet certain requirements that may be suitable for a specific purpose.

Criterion

- A basis for a decision that can be measured and evaluated or queried. Criteria may be absolute constraints or environmental factors.

Factors

- A criterion that influences the suitability of the decision, according to its value.

Multi Criteria Evaluation

- A decision making aid that can weigh up and assess various environmental factors and constraints to produce a continuous map of suitability. Techniques of MCE include the analytic hierarchy process and weighted linear combination.

Weighted Linear Combination (WLC)

- Continuous criteria are standardised to a common numeric range, and then combined by means of a weighted average. The result when integrated with GIS data is a continuous map of suitability.

The *"Integrated Strategic Environmental Assessment Utilising Multi-Criteria Evaluation Techniques"* uses two techniques of Multi-Criteria evaluation – AHP and WLC. Both techniques have their respective strengths and weaknesses and when used together they complement each other well.

AHP is especially suitable for complex decisions which involve the comparison of criteria which are difficult to quantify. It is based on the assumption that when faced with a complex decision the natural human reaction is to cluster the criteria according to their common characteristics.

It involves building a hierarchy (ranking) of criteria and then making comparisons between each possible pair in each cluster (as a matrix). This gives a weighting for each criterion within a cluster (or level of the hierarchy) and also a consistency ratio (useful for checking the consistency of the data). The AHP model was designed by TL Saaty as a decision making aid.

WLC is a technique where criteria are standardised to a common numeric range and then combined by means of a weighted average to produce a continuous mapping of suitability.

WLC is particularly good when weighting similar criteria. Where there are many criteria that are not all that similar, the sole use of WLC will increase levels of subjectivity in the decision making process. AHP is used as well to break up criteria into clusters with common characteristics. The WLC is then used on each cluster. This combination approach utilises the best features of each MCE technique to improve the decision making process.

2.2 Procedures for AHP

In many situations it may not be possible to assign weights to the different criteria involved in making a decision. Therefore it is necessary to adopt a technique that allows an estimation of the weights. One such technique is the Analytical Hierarchy Process and involves a pairwise comparison between the various criteria.

Step 1: Define the focus

The focus is the pinnacle of the decision hierarchy which will be constructed in Step 3 and is the ultimate outcome that is desired from the AHP.

Step 2: Identify the criteria to be used in the AHP

The criteria to be used in the AHP is limited only by the data at hand related to the decision making process. All data can be used and the AHP does not intrinsically discriminate according to accuracy or quality of data.

Step 3: Creation of Value Tree (Decision Hierarchy)

The decision hierarchy is structured with the focus at the top and with each lower level of the tree more detail appears. Criteria at lower levels of the hierarchy should be grouped into clusters with common characteristics. There should be between 5 to 9 criteria in each cluster within the hierarchy. The hierarchy allows for the assessment of the contribution individual criterion at lower levels make to criterion at higher levels of the hierarchy. The hierarchy is iterative in that it can be reviewed and modified.

Step 4: Pairwise Comparisons (Weighting of the Criteria)

A set of questions is posed between pairs of criteria within clusters at each level of the hierarchy to establish relative importance between criteria. The principle of the AHP relies on this pairwise comparison and is carried out using a scale from 1 to 9 as follows:

1 – Equally preferred
2 – Equally or Moderately preferred
3 – Moderately preferred
4 – Moderately to Strongly preferred
5 – Strongly preferred
6 – Strongly to Very Strongly preferred
7 – Very Strongly preferred
8 – Very Strongly to Extremely Strongly preferred
9 – Extremely preferred

This process, carried out with the aid of a matrix, allows for weightings of criteria to be estimated. Weightings within each cluster or at each level of the hierarchy are then standardised and sum to 1.

Step 5: Check Consistency of Evaluation

For each cluster in the hierarchy it is necessary to know whether the pairwise comparison has been consistent in order to accept the results of the process. The parameter that is used to check this is called the Consistency Ratio. The consistency ratio is a measure of how much variation is allowed and must be less than 10%.

2.3 Procedures for WLC

WLC allows for each criteria to display its potential because of the criteria weights. Criteria weights are very important in WLC because they determine how individual criteria will aggregate. Therefore deciding on the correct weighting becomes essential. The advantage of this method is that all criteria contribute to the solution based on their importance. The aggregation of individual weights is prone to be very subjective, even when pairwise comparison is used for ensuring consistent weights. When coupled with AHP, there are a few points to be considered. Firstly, the aggregation of individual weights becomes less subjective due to criteria with common characteristics being clustered in the value tree of the AHP. Secondly, weights have already been assigned through the AHP steps carried out previously. The key aspect that WLC adds to the analysis is the standardisation of individual criteria scores from a range of 0 to 1. For example, extreme bushfire hazard may be standardised to a score of 1 while minor bushfire hazard could be standardised to a score of 0.

Step 1: Identify the criteria to be used in the WLC

This step is identical to Step 2 in the Procedures for AHP.

Step 2: Standardisation of criteria scores

This is the key step that WLC adds to the overall analysis. Occurring at the lowest level of the hierarchy created in step 3 of the procedures for AHP, the various values of each criteria are standardised by assigning scores of between 0 and 1 to the values of each criteria.

Step 3: Allocation of weights to criteria

This step is completed as part of the AHP (step 4 of procedures for AHP)

Step 4: Apply the WLC algorithm to attain the suitability index

The suitability index for a site is the sum of the products of the standardised score for each criterion multiplied by the weight of each criterion. The equation is:

$$S = \Sigma Xi.Wi$$

Where S = Suitability index

Xi = Standardised score for value of criteria i

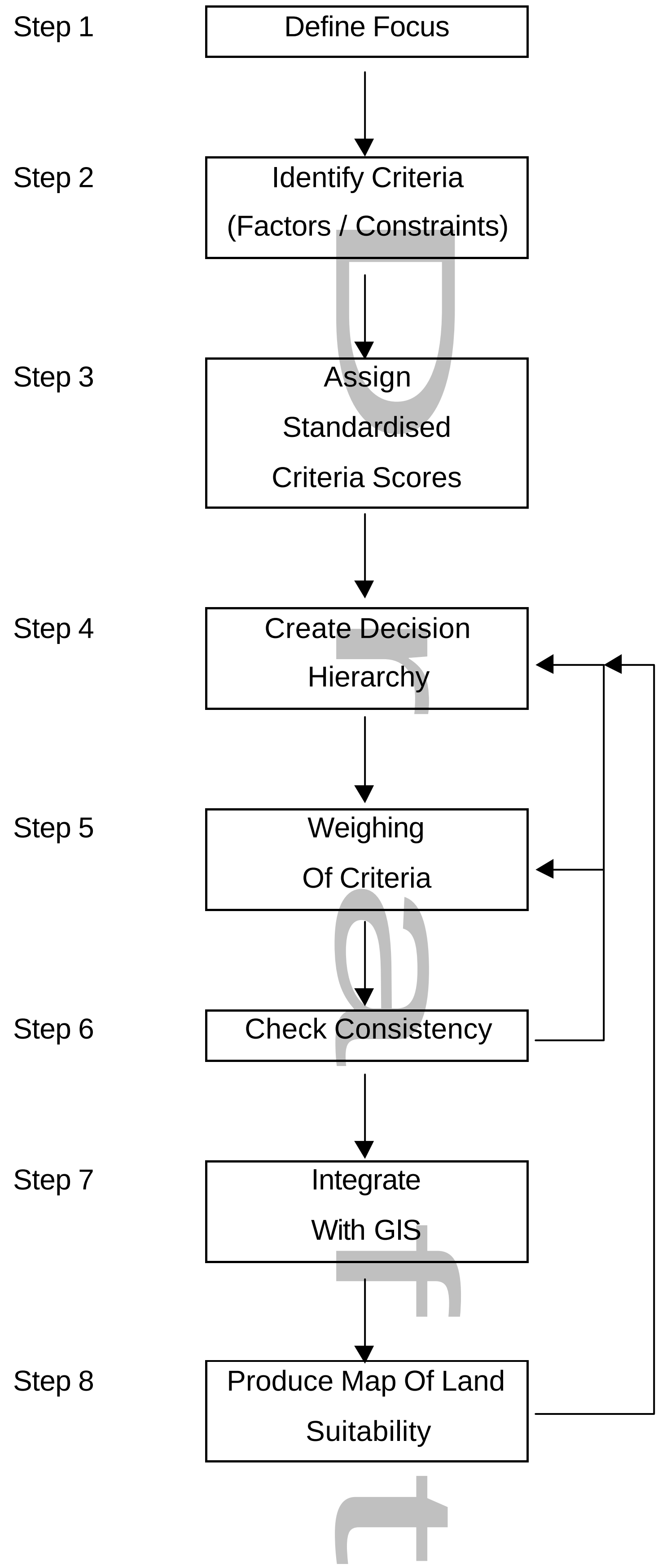
Wi = Weight of criteria i

2.4 Integrating AHP & WLC into GIS

The key to using AHP and WLC for meaningful land suitability analysis requires integration of the AHP & WLC results with a GIS. This is done through the mapped data, by assigning standardised WLC scores for the values of each criterion in the map overlays. GIS is then used to perform the equations required – multiplying standardised WLC scores by AHP weightings and summing the maps together for each level of the hierarchy to produce a final, continuous map of land suitability.

Figure 2 displays the steps involved in completing the procedures of AHP, WLC and integration with GIS.

Figure 2 Steps involved



3 Results

3.1 Step 1: Define Focus

The focus of this land suitability analysis is to determine the development suitability of the Congo - Bingie Rural Residential Area while protecting catchment and estuarine values.

3.2 Step 2: Identify Criteria

The following criteria are used in the land suitability analysis:

Criteria	
Absolute Constraints	**Factors**
Bushfire Hazard (Extreme)	Aboriginal Sites
Riparian Vegetation (DLWC 100m buffer)	Acid Sulphate Soils
SEPP 14 Wetlands (Present)	Agricultural Land Classes
Slope (> 25%)	Bushfire Hazard
Soil Wetness (>0.8 Average rainfall year)	Contaminated Land
	Fauna Habitat
	Regolith Stability
	Riparian Vegetation
	Rural Residential Building Capability
	SEPP 14 Wetlands
	Slope
	Soil Wetness (1 in 5 year rainfall)
	Surface Application of Effluent
	Vegetation Ecosystems

3.3 Step 3: Assign Standardised Criteria Scores

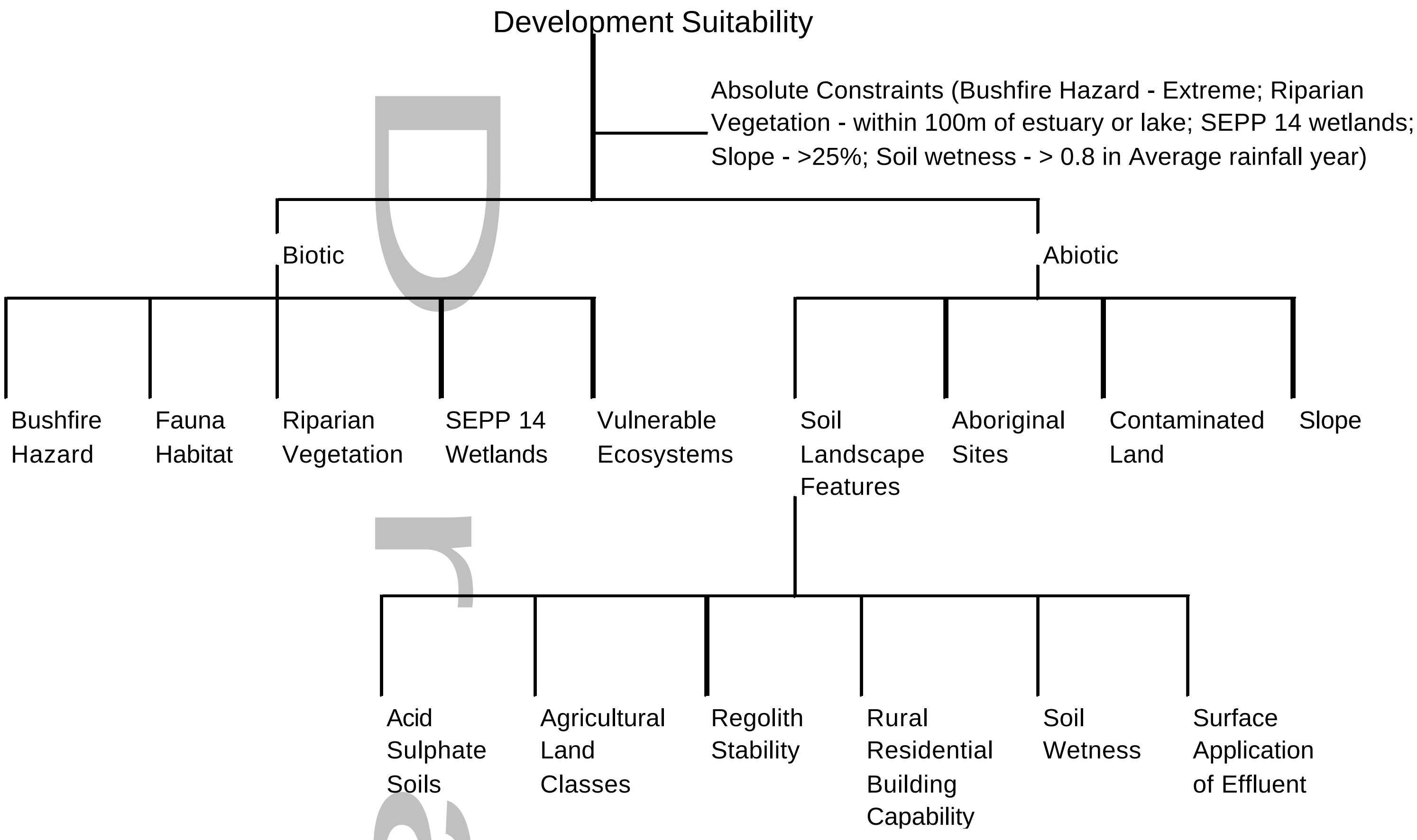
Criteria	Value	Standardised Score	Suitability class
Aboriginal Sites	Site within 50m	1	Low
	Site within 50m – 100m	0.2	Medium
	Site further than 100m	0	High
Acid Sulphate Soils (ASS)	High probability of ASS	1	Low
	Low probability of ASS	0.8	Medium
	No ASS	0	High

Agricultural Land Classes	Class 1	1	Low
	Class 2	1	Low
	Class 3	0.5	Medium
	Class 4	0	High
	Class 5	0	High
Bushfire Hazard	Extreme	Absolute constraint	Nil
	Major	0.8	Low
	Moderate	0.2	Medium
	Minor	0	High
	Cleared	0	High
Contaminated Land	Present	1	Low
	Within 100m	0.2	Medium
	Further than 100m	0	High
Fauna Habitat	High value fauna habitat	1	Low
	Moderate value fauna habitat	0.7	Medium
	Other habitat	0.2	High
	Cleared	0	High
Regolith Stability	Class 4	1	Low
	Class 3	0.2	Medium
	Class 2	0.2	Medium
	Class 1	0	High
Riparian Vegetation	Dense	Absolute constraint	Nil
	Present	0.75	Low
	Sparse	0.5	Medium
	Absent	0	High
Rural Residential Building Capability	Class 3	1	Low
	Class 2(3)	0.5	Medium
	Class 1(3)	0.2	High
	Class 2	0.2	High
	Class 1(2)	0	High
	Class 1	0	High
SEPP 14 Wetlands	Present	Absolute constraint	Nil
	Within 100m	0.5	Medium
	Further than 100m	0	High
Slope	Slope > 25%	Absolute constraint	Nil
	15% < Slope < 25%	0.5	Medium
	0% < Slope < 15%	0	High
Soil Wetness (Average rainfall year)	Wetness > or = 0.8	Absolute constraint	Nil
Soil Wetness (1 in 5 rainfall year)	Wetness > or = 0.8	1	Low
	0.6 < Wetness < 0.8	0.5	Medium
	0.4 < Wetness < 0.6	0.3	High
	0.2 < Wetness < 0.4	0	High

	0 < Wetness < 0.2	0	High
Surface Application of Effluent	Class 3	1	Low
	Class 2(3)	0.5	Medium
	Class 1(3)	0.2	High
	Class 2	0.2	High
	Class 1(2)	0	High
	Class 1	0	High
Vegetation Ecosystems	Vulnerable Mgt. Cat. 1	1	Low
	Vulnerable Mgt. Cat. 2	0.9	Low
	Vulnerable Mgt. Cat. 3	0.8	Low
	Other vegetation	0.2	Medium
	Cleared	0	High

3.4 Step 4: Create Decision Hierarchy

Figure 3 Decision Hierarchy



3.5 Step 5: Weighting of Criteria

The principle of the AHP relies on pairwise comparison and is carried out using a scale from 1 to 9 as follows (where each criteria is related to each other and a comparison made):

1 – Equally preferred

2 – Equally or Moderately preferred

3 – Moderately preferred

4 – Moderately to Strongly preferred

5 – Strongly preferred

6 – Strongly to Very Strongly preferred

7 – Very Strongly preferred

8 – Very Strongly to Extremely Strongly preferred

9 – Extremely preferred

The pairwise comparison is carried out within each cluster at each level of the hierarchy. To simplify the process only odd numbers may be used if desired.

3.5.1 Hierarchy Level 3 Pairwise Comparisons : Soil Landscape Features

	Acid Sulphate Soils	Agricultural Land Class	Hydrology (Soil Wetness)	Regolith Stability	Rural Residential Building Capability	Surface Application of Effluent
Acid Sulphate Soils	1	1	1/2	8 ***	7	6
Agricultural Land Class	1	1	1/2	8	7	6
Hydrology (Soil Wetness)	2	2	1	9	8	7
Regolith Stability	1/8	1/8	1/9	1	1/2	1/3
Rural	1/7	1/7	1/8	2	1	1/2

Residential Building Capability						
Surface Application of Effluent	1/6	1/6	1/7	3	2	1

*** example – Acid sulphate soils is Very Strongly to Extremely Strongly preferred (or more important) than Regolith stability in determining development suitability.

3.5.2 Hierarchy Level 3 Weighting: Soil Landscape Features

Acid Sulphate Soils	0.247
Agricultural Land Class	0.247
Hydrology (Soil Wetness)	0.377
Regolith Stability	0.028
Rural Residential Building Capability	0.041
Surface Application of Effluent	0.060
SUM	**1.000**

3.5.3 Hierarchy Level 2 Pairwise Comparisons : Biotic Features

	Bushfire Hazard	Fauna Habitat	Riparian Vegetation	SEPP 14 Wetlands	Vulnerable Ecosystems
Bushfire Hazard	1	5	7	1/2	2
Fauna Habitat	1/5	1	2	1/5	1/3
Riparian Vegetation	1/7	1/2	1	1/8	1/6
SEPP 14 Wetlands	2	5	8	1	3
Vulnerable Ecosystems	1/2	3	6	1/3	1

3.5.4 Hierarchy Level 2 Weighting: Biotic Features

Bushfire Hazard	0.280
Fauna Habitat	0.063
Riparian Vegetation	0.039
SEPP 14 Wetlands	0.431
Vulnerable Ecosystems	0.187
SUM	**1.000**

3.5.5 Hierarchy Level 2 Pairwise Comparisons : Abiotic Features

	Aboriginal Sites	Contaminated Land	Slope	Soil Landscape
Aboriginal Sites	1	5	1/4	1/4
Contaminated Land	1/5	1	1/9	1/9
Slope	4	9	1	1
Soil Landscape	4	9	1	1

3.5.6 Hierarchy Level 2 Weighting: Abiotic Features

Aboriginal Sites	0.132
Contaminated Land	0.039
Slope	0.414
Soil Landscape	0.414
SUM	**1.000**

3.5.7 Hierarchy Level 1 Pairwise Comparisons : Development Suitability Features

	Abiotic	Biotic
Abiotic	1*	2*
Biotic	½*	1*

3.5.8 Hierarchy Level 1 Weighting: Development Suitability Features

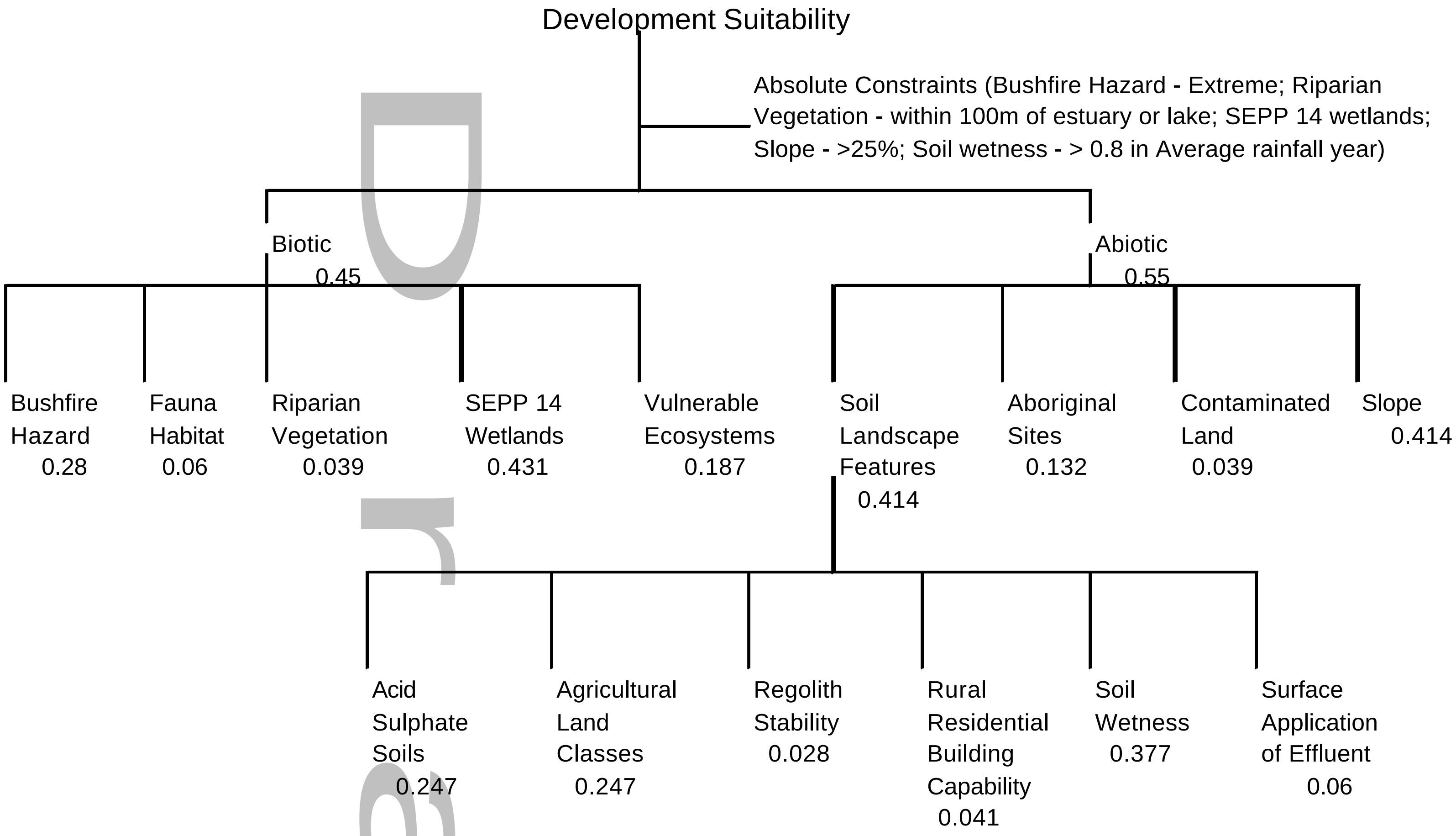
Abiotic	0.667*
Biotic	0.333*
SUM	**1.000**

* The weighting of abiotic & biotic factors is too coarse using the scale for pairwise comparison. The weighting assigned to abiotic and biotic features is therefore 0.55 and 0.45 respectively.

Abiotic	0.550
Biotic	0.450
SUM	**1.000**

3.5.9 Final Weighting of Criteria

Figure 4 Decision hierarchy & final weightings



3.6 Step 6: Checking of Consistency

Table of values of RI given n number of criteria, used in calculating Consistency Ratio (CR).

n	RI
2	0
3	0.58
4	0.9
5	1.12
6	1.24
7	1.32
8	1.41

3.6.1 Hierarchy Level 3 Consistency : Soil Landscape Features

Weighted Sum Vector =	Consistency Vector =
1.554	6.294
1.554	6.294
2.366	6.274
0.172	6.052
0.245	6.015
0.363	6.076

Average the Values

λ = average of consistency vector = 6.167

Consistency Index (CI) = $(\lambda - n)/(n-1)$

=(6.167-6)/(6-1)

=0.033

Consistency Ratio (CR) = CI/RI

=0.033/1.24

=0.027

CR is less than 0.1 therefore consistency can be accepted.

3.6.2 Hierarchy Level 2 Consistency: Biotic Features

Weighted Sum Vector =		Consistency Vector =	
	1.455		5.189
	0.315		5.025
	0.195		5.034
	2.239		5.194
	0.954		5.102

Average the Values

λ = average of consistency vector = 5.109

Consistency Index (CI) = (λ-n)/(n-1)

=(5.109-5)/(5-1)

=0.027

Consistency Ratio (CR) = CI/RI

=0.027/1.12

=0.024

CR is less than 0.1 therefore consistency can be accepted.

3.6.3 Hierarchy Level 2 Consistency: Abiotic Features

Weighted Sum Vector =		Consistency Vector =	
	0.536		4.056
	0.158		4.009
	1.712		4.132
	1.712		4.132

Average the Values

λ = average of consistency vector = 4.082

Consistency Index (CI) $= (\lambda - n)/(n-1)$

$=(4.082-4)/(4-1)$

$=0.027$

Consistency Ratio (CR) $= CI/RI$

$=0.027/0.9$

$=0.031$

CR is less than 0.1 therefore consistency can be accepted.

3.7 Steps 7 & 8: Integration With GIS & Production of Maps

The key steps in the AHP and WLC have now been completed. Standardised WLC scores are multiplied by AHP weightings for each criteria and map overlays are summed together for each level of the hierarchy to produce a final, continuous map of land suitability.

The resultant maps for each level of the hierarchy and a final development suitability map are displayed in figures 5 to 8 overleaf.

Figure 5 Biotic Features of the Congo – Bingie Rural Residential Area

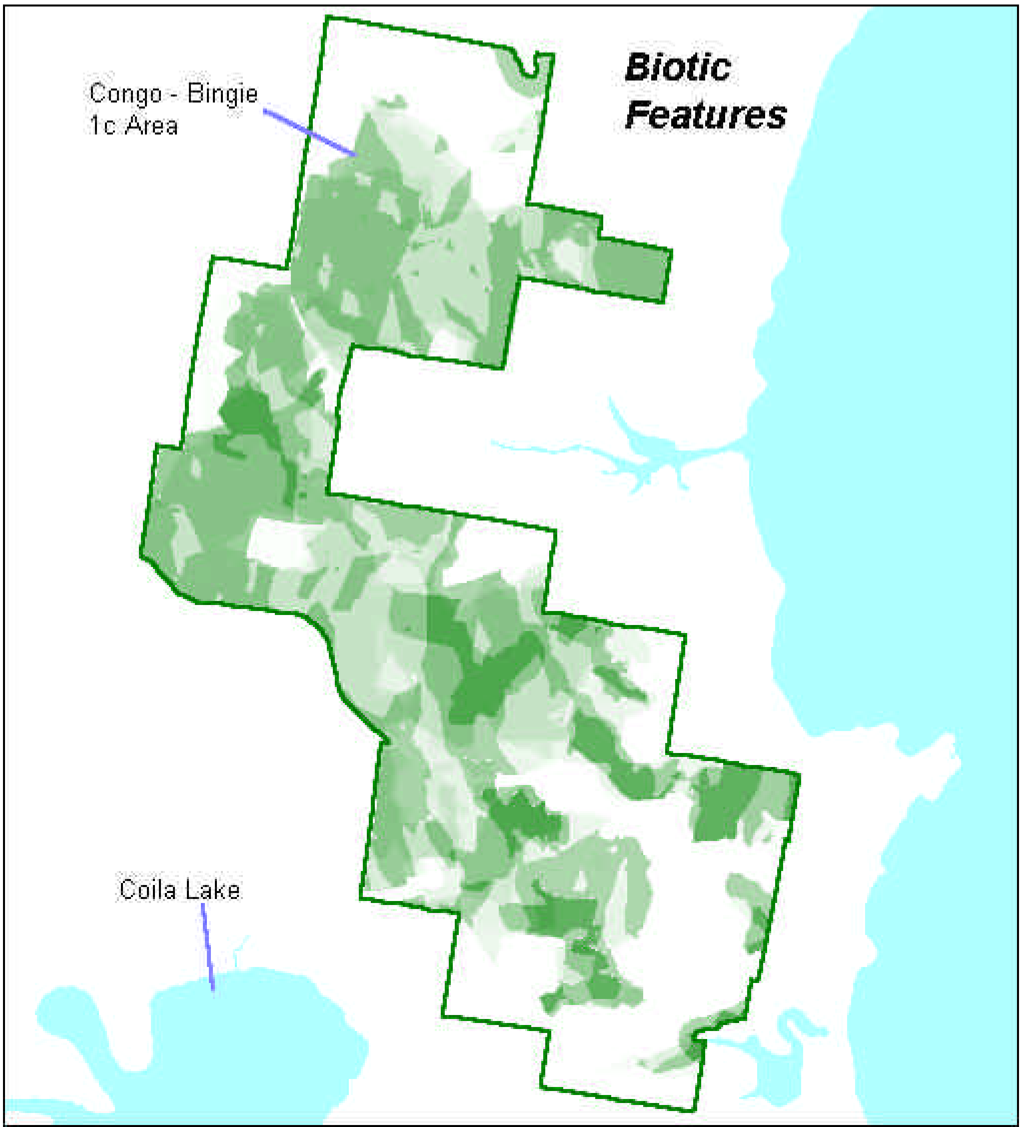


Figure 6 Soil Landscape Features of the Congo – Bingie Rural Residential Area

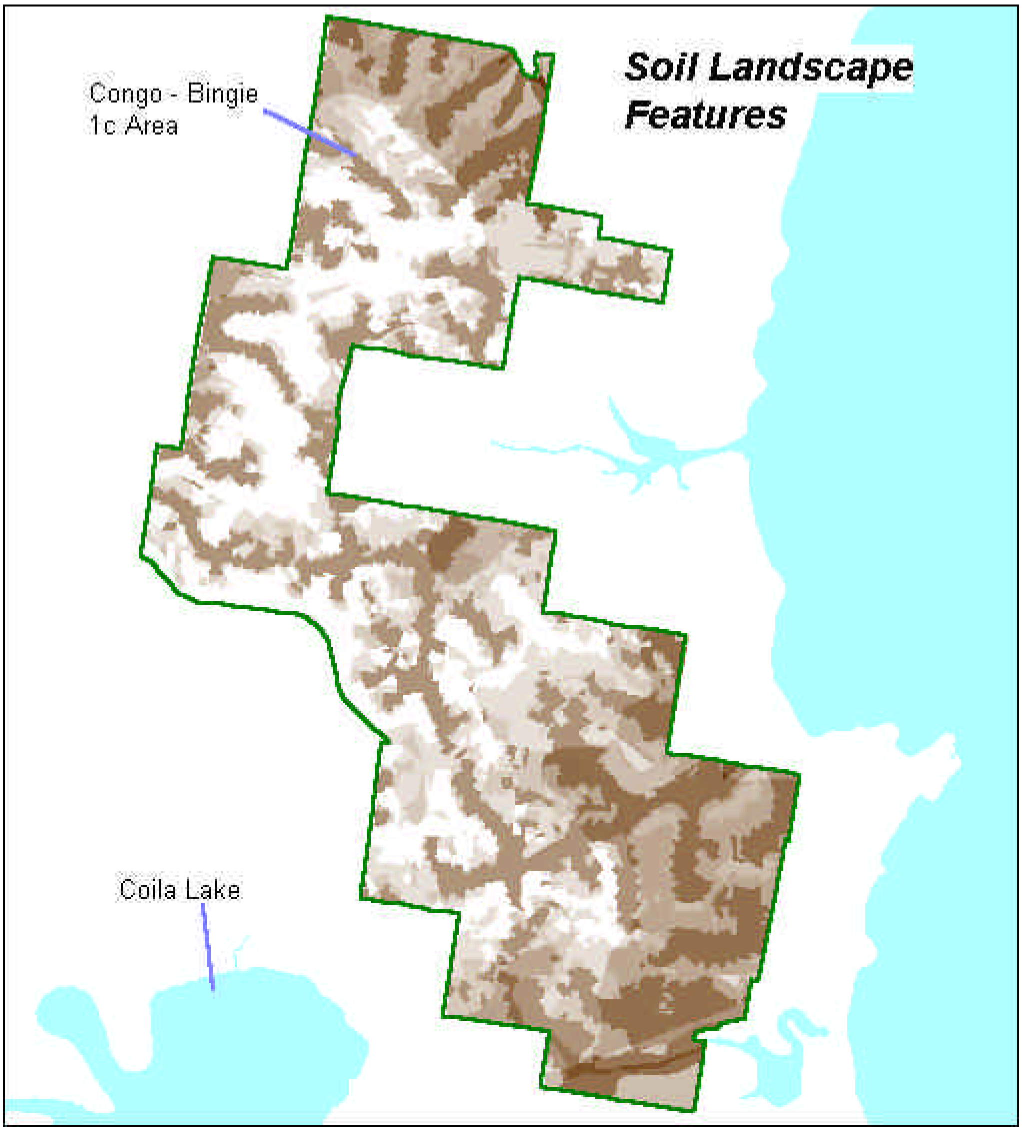


Figure 7 Abiotic Features of the Congo – Bingie Rural Residential Area

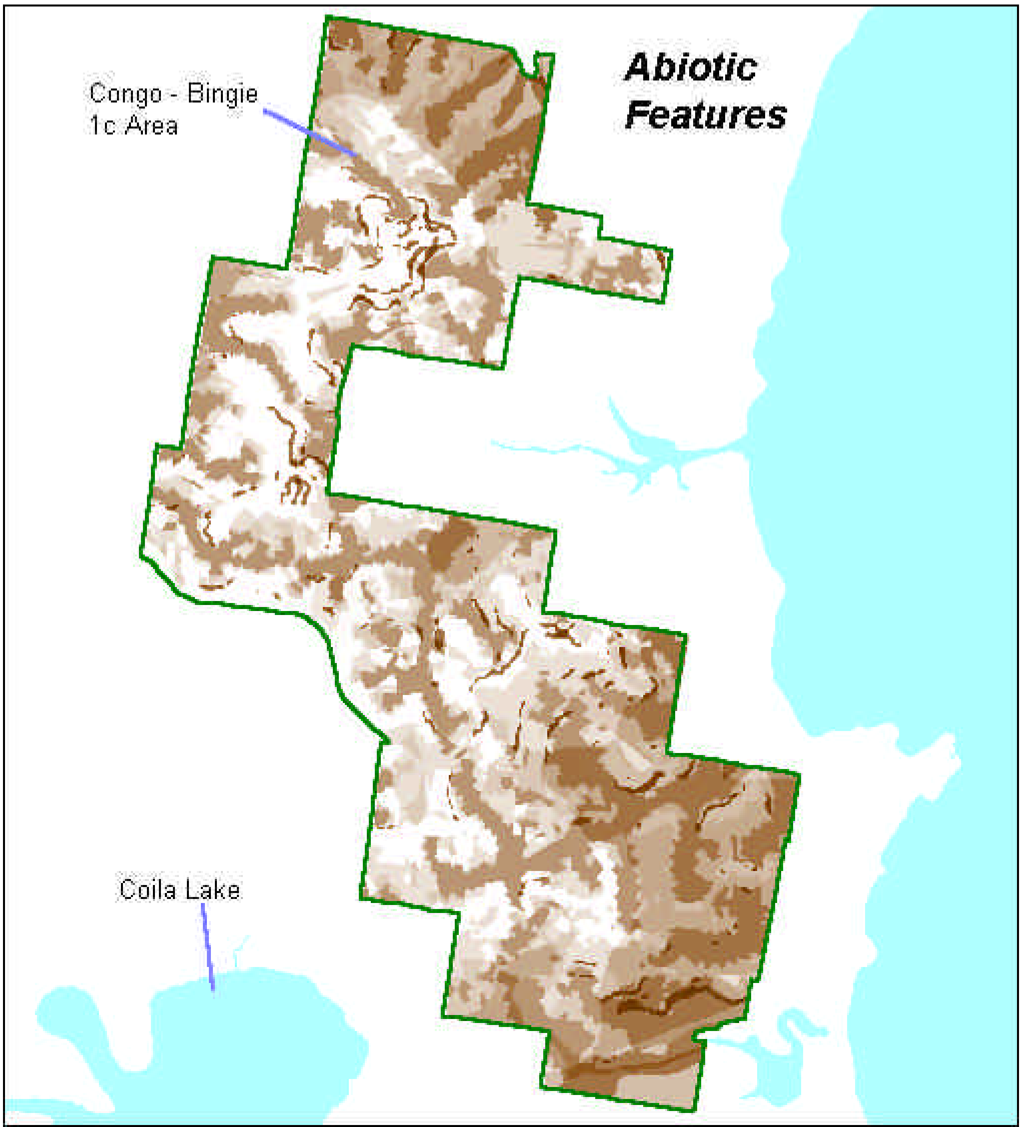
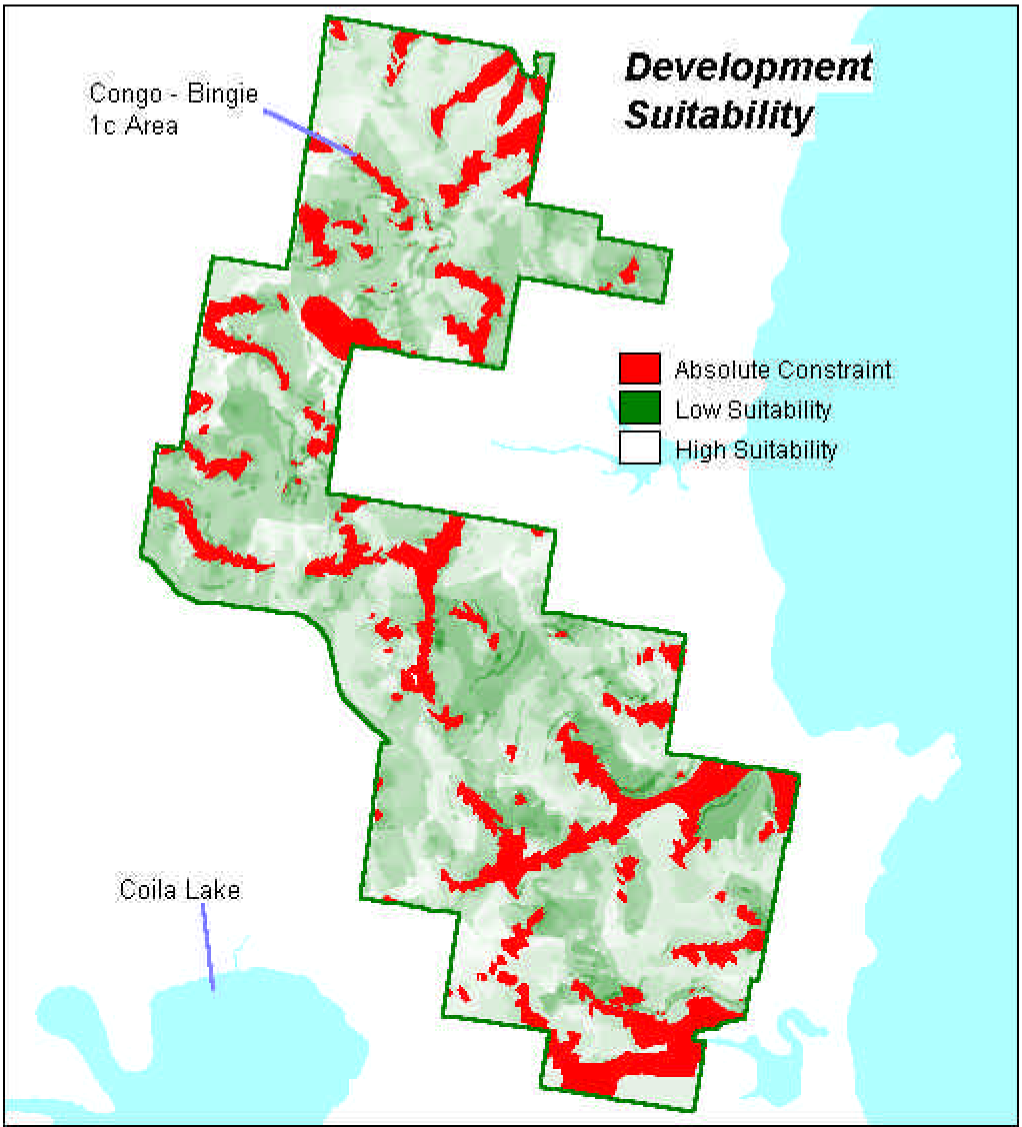


Figure 8 Development Suitability of the Congo – Bingie Rural Residential Area



4 References

Australian Defence Force Academy, 2000, *Analytical Hierarchy Process Lecture Series*, http://www.cs.adfa.edu.au/teaching/studinfo/da2/lectures/L14html/

College of Geosciences, University of Oaklahoma, 2001, *Spatial Modelling: Suitability Analysis and Decision Making Using GIS*, http://www.geosciences.ou.edu/~bylons/GIS/spatialmodelling99/

Husdal, J., 1999, *Geographical Decision Making : Different Approaches in IDRISI*, http://www.husdal.com/mscgis/gdm.htm

ISNAR, 2001, *Information and Discussion Forum on Priority Setting in Agricultural Research: Measurement Methods – The Analytical Hierarchy Process*, http://www.cgiar.org/isnar/Fora/Priority/MeAnalit.htm

McHarg, I, 1969, *Design with Nature*, Natural History Press, New York

Saaty, T.L., 1980, *The Analytic Hierarchy Process*, McGraw Hill, New York

Sposito, V, 2001, Sustainable Land Resource Assessment, BDP Environment Design Guide

5 Appendix 1: Analytic Hierarchy Process Calculations

Soil Landscape Features

Pairwise Comparisons

	Acid Sulphate Soils	Agricultural Land Class	Hydrology (Wetness)	Regolith Stability	Rural Residential Building Capability	Surface Application of Effluent
Acid Sulphate Soils	1	1	1/2	8	7	6
Agricultural Land Class	1	1	1/2	8	7	6
Hydrology (Wetness)	2	2	1	9	8	7
Regolith Stability	1/8	1/8	1/9	1	1/2	1/3
Rural Residential Building Capability	1/7	1/7	1/8	2	1	1/2
Surface Application of Effluent	1/6	1/6	1/7	3	2	1
Total	4.435	4.435	2.379	31.000	25.500	20.833

Normalised scores

	Acid Sulphate Soils	Agricultural Land Class	Hydrology (Wetness)	Regolith Stability	Rural Residential Building Capability	Surface Application of Effluent
Acid Sulphate Soils	0.226	0.226	0.210	0.258	0.275	0.288
Agricultural Land Class	0.226	0.226	0.210	0.258	0.275	0.288
Hydrology (Wetness)	0.451	0.451	0.420	0.290	0.314	0.336
Regolith Stability	0.028	0.028	0.047	0.032	0.020	0.016

Rural Residential Building Capability	0.032	0.032	0.053	0.065	0.039	0.024
Surface Application of Effluent	0.038	0.038	0.060	0.097	0.078	0.048
Total	1.000	1.000	1.000	1.000	1.000	1.000

Factor	**Weighting**	**Weighted Sum Vector**	**Consistency Vector**
Acid Sulphate Soils	**0.247**	**1.554**	**6.294**
Agricultural Land Class	**0.247**	**1.554**	**6.294**
Hydrology (Wetness)	**0.377**	**2.366**	**6.274**
Regolith Stability	**0.028**	**0.172**	**6.052**
Rural Residential Building Capability	**0.041**	**0.245**	**6.015**
Surface Application of Effluent	**0.060**	**0.363**	**6.076**
	1.000		**Average = 6.167**

Consistency index = (Ave-n)/(n-1)
0.033

Consistency Ratio = CI / Ratio Index =
0.027

CR is less than 0.1 therefore consistency is accepted

Biotic Features

Pairwise comparisons

	Bushfire Hazard	Fauna Habitat	Riparian Vegetation	SEPP 14 Wetlands	Vulnerable Ecosystems
Bushfire Hazard	1	5	7	1/2	2
Fauna Habitat	1/5	1	2	1/6	1/4
Riparian Vegetation	1/7	1/2	1	1/8	1/6
SEPP 14 Wetlands	2	6	8	1	3
Vulnerable Ecosystems	1/2	4	6	1/3	1
	3.843	16.500	24.000	2.125	6.417

Normalised scores

	Bushfire Hazard	Fauna Habitat	Riparian Vegetation	SEPP 14 Wetlands	Vulnerable Ecosystems	**Weighting**	**Weighted Sum Vector**	**Consistency Vector**
Bushfire Hazard	0.260	0.303	0.292	0.235	0.312	**0.280**	**1.455**	**5.189**
Fauna Habitat	0.052	0.061	0.083	0.078	0.039	**0.063**	**0.315**	**5.025**
Riparian Vegetation	0.037	0.030	0.042	0.059	0.026	**0.039**	**0.195**	**5.034**
SEPP 14 Wetlands	0.520	0.364	0.333	0.471	0.468	**0.431**	**2.239**	**5.194**
Vulnerable Ecosystems	0.130	0.242	0.250	0.157	0.156	**0.187**	**0.954**	**5.102**
TOTAL	1.000	1.000	1.000	1.000	1.000	**1.000**		
								Average =
								5.109

Consistency index =
(Ave-n)/(n-1) =
0.027

Consistency Ratio =
CI / Ratio Index =
0.024

CR is less than 0.1
therefore
consistency
is accepted

Abiotic Features

Pairwise comparisons

	Aboriginal Sites	Contaminated Land	Slope	Soil Landscape
Aboriginal Sites	1	5	1/4	1/4
Contaminated Land	1/5	1	1/9	1/9
Slope	4	9	1	1
Soil Landscape	4	9	1	1
Total	9.200	24.000	2.361	2.361

Normalised scores

	Aboriginal Sites	Contaminated Land	Slope	Soil Landscape	**Weighting**	**Weighted Sum Vector**	**Consistency Vector**
Aboriginal Sites	0.109	0.208	0.106	0.106	**0.132**	**0.536**	**4.056**

Contaminated Land	0.022	0.042	0.047	0.047	**0.039**	**0.158**	**4.009**
Slope	0.435	0.375	0.424	0.424	**0.414**	**1.712**	**4.132**
Soil Landscape	0.435	0.375	0.424	0.424	**0.414**	**1.712**	**4.132**
Total	1.000	1.000	1.000	1.000	**1.000**		

Average =
4.082

Consistency index =
(Ave-n)/(n-1) =
0.027

Consistency Ratio =
CI / Ratio Index =
0.031

CR is less than 0.1
therefore consistency
is accepted

Development Suitability

Pairwise comparisons

	Abiotic Features	Biotic Features
Abiotic Features	1	2
Biotic Features	1/2	1

Total	1.500	3.000

Normalised scores

	Abiotic Features	Biotic Features	**Weighting**	**Weighted Sum Vector**	**Consistency Vector**
Abiotic Features	0.667	0.667	**0.667**	**1.333**	**2.000**
Biotic Features	0.333	0.333	**0.333**	**0.667**	**2.000**
Total	1.000	1.000			

Average =
2.000

Consistency index =

(Ave-n)/(n-1)
0.000

Consistency Ratio =
CI / Ratio Index =
0.000

CR is less than 0.1
therefore consistency
is accepted

* The weighting of abiotic & biotic factors is too coarse using the scale for pairwise comparison.
The weighting assigned to abiotic and biotic features are 0.55 and 0.45 respectively.