ASSESSING THE APPLICABILITY OF AUSTRALIAN LANDSLIDE DATABASES FOR HAZARD MANAGEMENT

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Abstract
In order to assess the applicability of Australian landslide databases as a hazard management support system, current hard and soft literature and data sources were screened and finally four main data bases including national landslide database (A), Peril Aus II (B), the Cities project (C), and analytical paper of Fell (D) have been selected. In this study applicability of databases was evaluated using two different methods: numerical model (objective) and AHP model (subjective) and their results are combined after statistical test. Due to shortage of a definite standard, a simple numerical model has been developed with 4 main complex parameters (each one contains 4 minor parameters) includes: graphical-statistical, geo-spatial, physico-temporal, and techno-management, value scale of 0-3 and 4 applicability classes, and relative importance of the databases has been evaluated. Also relative priority of the databases as competitor alternatives was determined using analytical hierarchy process (AHP) technique as a math-logical tool for decision making in uncertainty, by expert based pair-wise comparison (CR= 0.0296) and finally its value was normalized to the scale of numerical model for comparison. According to obtained results, in both two models applicability classes of databases range from II to IV with only one class difference. With merging numerical outputs of two models by a 80%. rank correlation in a single paradigm, the applicability class improve from II to III only in database A, but for others remain constant. Rank correlation between databases in different levels imply to different relationships, so that some of them such as R_{AB}, R_{AC}, R_{AD}, and R_{BC} can be explained with the inductive theorems of genetically statistic-thematic multi-relations of databases. As a result, applicability of Australian landslide databases is of class III (High) and still needs further development and complementary actions especially in geo-technical, geometric, impact (damage) data, and map scale.

Additional Keywords: applicability class; numerical model; analytical hierarchy process (AHP)

Introduction
Developing digital and spatial data bases of natural hazards (as landsliding and soil erosion, namely soil cancer, CSIRO, 2003) and easy access of data users, is of vital role for hazard management and reduction of natural tax in land use planning and sustainable development (NHCR, 1999; Ownegh, 2002a & b). In recent decades some of the countries such as Australia and Canada have established national databases of natural hazards as landsliding and applied as a spatial decision support system in the management of environment and society both in regional and national scale (Geological Survey of Canada, 1999).The new wave of this trend is globalization of natural hazards digital databases for organised and online data service for wide spectrum of data users with different objectives. Trends in setup of long-term landslide databases by reconstruction of historical document and event records (as Australian and Canadian national databases along more than 160 years period) represent the necessity of historical and statistical approaches in landslide hazard behavior analysis and forecasting based on principle of uniformitarianism (Geological survey of Canada, 1999; AGSO,1999 & 2001).

From the endemic problems of landslide database developing in Australia can be implied to vast and continental area, absence of population in large central, northern and western parts, lack of people and landowners trend to cooperation, non-coverage of damage insurance, and close spatial and temporal overlay of landsliding and other triggering hazards especially earthquakes, cyclonic storm and flooding; the problem of real hazard and risk estimation and presentation of landslide management program (Fell, 1995; NHRC, 1999; 2000; AGSO, 2001). The main purpose of this paper is to evaluate applicability of Australian landslide databases in landslide hazard and risk management with merging of two objective and subjective models.

Materials and Methods
At present due to the difference in landslide databases structure and variety of their users, there is not any special standard for assessing landslide database applicability from the point of hazard management and land use planning (Ownegh, 2002b). A logical method for this kind of assessment is matching of recorded and estimated amounts of physical, geometrical and socio-economic key factors expected from event and management necessities of landslide. This practice needs an objective numerical model, supporting with analytical hierarchy process (AHP, subjective model) and merging of their data results (Bantayan and Bishop, 1998; Saaty, 1980). For reduction of text, the successive stages of this research are summarized as following flowchart (Figure 1).

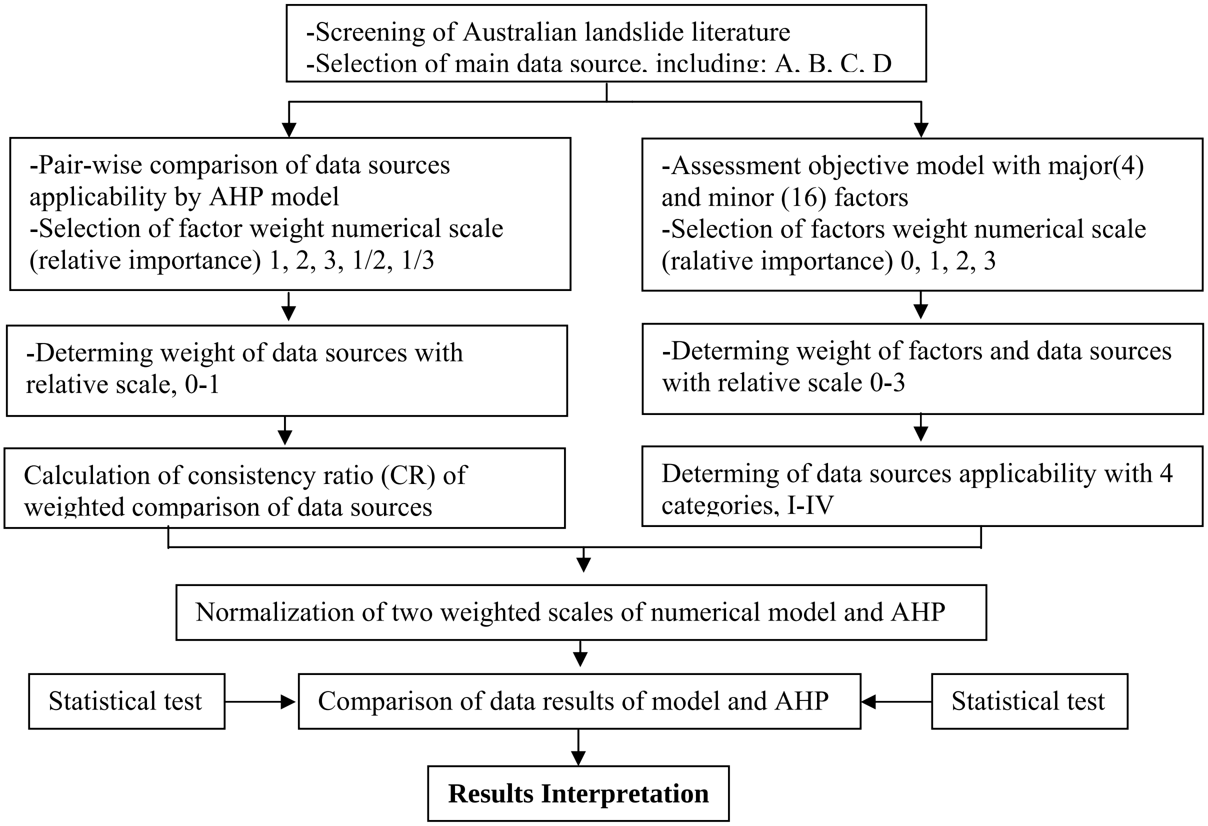

Figure 1. Stages of assessing the Australian landslide databases

Results and Discussion

Due to variety, the results of this research were presented in separation of numerical model, AHP technique, and their combination as follow :

Numerical value of key parameters varies between zero (none), 1 (low, class I) to 3 (high, very high class IV) in A and D, and 1 to 3 in B and C databases. Average value of parameters for all databases varies from 1.5 to 3 . Least SD and CV of values (both are zero) belongs to cause parameter, and the most of them (1.24 and 86%) to geotechnical data and technico-management comments parameters (Table1). Average value of databases varies between 1.5 (in A) and 2.75 (in C) and their applicability classes are II in A, III in D, and IV in B and C total average value of all databases is 2.2 and class II (Table1). Difference of parameter frequency between numerical value classes is relatively high and varies from zero to 13 in C. Parameter density in value 3 (high, very high class IV) is considerable and are 4, 9, 13, and 6 in A to D respectively (Table2). In total average of databases, difference of parameter frequency between applicability classes is very high and its mode lies in class III (Table3).According to statistical test (Ho= no difference in repeated measurement) there is high level confidence (p=0.0078) that difference of observation (expert judgment) is not random and imply on high thematic resolution of model and inherent difference of databases applicability (Table1).

In the AHP technique, the priority of landslide databases was calculated by very high consistency rate (CR=0.0296) that is more accurate than the result of run out project (CR=0.0300) (Barredo *et al*., 2002). Difference in applicability of relative weight of database is very high and varies between 0.1256 in D and 0.3320 in C. Applicability priority or ranks of C, B, A and D are 1 to 4 respectively (Table 4). By converting weight value of AHP to numerical model value scale (indeed merging and calculation of weight value ratio from sum value of relative importance in numerical model, 8.81), it is possible to equivalency of partial and total (average) values of two models.

Table 1.Weight value of factor relative importance for landslide databases by model

Main parameter *	Databases ** / Parameter	A	B	C	D	Sum	Ava	Class ****	SD	CV %
Graphicostatistical	1-Lineage	1	2	3	3	9	2.25	III	0.96	42.49
	2-Data format	3	3	3	1	10	2.5	IV	1	40
	3-Analysis method	1	3	3	2	9	2.25	III	1.06	47.75
	4-Informative level	1	2	2	3	8	2	III	0.81	40.82
Geo spatial	5-Geometric dimension	1	2	3	3	9	2.25	III	0.9	40.08
	6-Type(class)	2	2	3	3	10	2.5	IV	0.58	23.08
	7-Positional accuracy	2	2	3	2	9	2.25	III	0.5	22.22
	8-Spatial coverage	3	3	1	2	9	2.25	III	0.96	42.49
Physico temporal	9-Statistical time period	3	3	3	2	11	2.75	IV	0.5	18.18
	10-Cause	3	3	3	3	12	3	IV	0	0
	11-Velocity/Intensity	2	3	3	2	10	2.5	IV	0.28	11.13
	12-Geotechnical data	0	1	2	3	6	1.5	II	1.29	86.06
Technico managemental	13-Sustained damage	2	3	3	0	8	2	III	1.22	61.23
	14-Potential risk (probable)	0	3	3	1	7	1.75	III	1.5	85.56
	15-Potential hazard (repeat)	0	3	3	2	8	2	III	1.22	61.23
	16-Teechnico-manage.Comments	0	2	3	1	6	1.5	II	1.29	86.06
	Sum	23	40	44	33	141	2.2	III		
	Ava	1.5	2.5	2.75	2.06	2.2				
	Class	II	IV	IV	III	III				
	SD	1.15	0.63	0.5	0.76	0.76				
	CV%	76.98	25.29	18.76	36.94	39.49				

Rsm=0.1968 between all rows indicate to relatively differences among parameters (rows) and databases
*Main parameters are classified as:Graphico--statistical, Geo--spatial, Physysico-temporal, and Technico-- managemental.
**A=National landslide database, B=Peril Aus II, C=Cities project, and D=Analytical paper of Fell.
***Value scale:None=0, Low=1, Medium=2, High=3 .
****Applicability classes:Low I (<0.75), Medium II (0.76--1.5), High III (1.51--2.25), Very High IV (2.26--3).

Table 2.Comparison of parameter numerical value for landslide databases

	0(None)	1(Low)	2(Medium)	3(High)
A	12-14-15-16	1-3-4-5	6-7-11-13	2-8-9-10
B	----	12	1-4-5-6-7-16	2-3-8-9-10-11-13-14-15
C	----	8	4-12	1-2-3-5-6-7-9-10-11-13-14-15-16
D	13	2-14-16	3-7-8-9-11-15	1-4-5-6-10-12

Table 3. Comparison of parameters applicability class for landslide databases (Average for country)

Class	I	II	III	IV	Sum
No.of para	----	12-16	1-3-4-5-7-8-13-14-15	2-6-9-10-11	16
%	----	12.50	56.25	31.25	100

Table 4. Comparison of model and AHP value for landslide databases

	A	B	C	D	Wi	Rank*
A	0.2222	0.3003	0.1666	0.2501	0.2348	3
B	0.2222	0.3003	0.3333	0.3751	0.3077	2
C	0.4444	0.3003	0.3333	0.2501	0.332	1
D	0.1111	0.1001	0.1666	0.1251	0.1257	4
Sum	1	1	1	1	1	

*Rank of weight or applicability

Table 5. Matrix of normalised cofficient of landslide databases

	A	B	C	D	Ava	Class	SD	CV%
Model	1.5	2.5	2.75	2.06	2.2	III	0.8797	39.49
Class	II	IV	IV	III	----	III	----	----
AHP	2.07	2.71	2.92	1.11	2.2	III	0.7874	35.77
Class	III	IV	IV	II	----	III	----	----
Ava	1.785	2.605	2.82	1.585	2.2	III	0.8335	37.63
Class	III	IV	IV	III	----	III	----	----
d%	+38	+8.4	+6.18	-46.11	0	0	10.49	9.44

Table 6. Correlation matrix of landslide databases

	A	B	C	D
A	1	0.514	0.3154	0.1706
B	0.514	1	0.5434	-0.164
C	0.3154	0.5434	1	0.2301
D	0.1706	-0.164	0.2301	1

According to statistical test, there is not high level confidence ($p<0.1414$) on the merging of numerical model (SD=0.8797 and CV=39.49) and AHP (SD=0.7874 and CV=35.77) (each one was assumed as a replication or judgment) and rejection of Ho (no difference between applicapibility average ranks of databases in two model), but with attention on high coefficient of correlation ($r=0.8$, $z=1.3856$ and $p=0.0829$), their results are combinable (Saaty, 1980; Nie *et al*., 2001). In combined state, applicability class in database A increases from II to III (in numerical model lies on boundary limit of II and III) and remain constant in other databases and their total average state (Table 5).

The intensity and kind of genetic relation and overlaps of Australian landslide databases is different according to the spearman rank correlation coefficient (based on values of numerical model). The reality of some of them can be well explained by the following:
1-correlation of $R_{AB}>R_{AC}>R_{AD}$ shows data, thematic and spatial relation between databases.
2-correlation of $R_{BC}>R_{BA}>R_{BD}$ shows data, relation between A and B, thematic relation of B and C, but unknown for possible relation between B and D.
3-corelation of $R_{CB}>R_{CA}>R_{CD}$ shows strong data relation between B and C, medium data relation of A and C, and low to medium thematic (geotechnical) relation between C and D.
4-correlation of $R_{DC}>R_{DA}>R_{DB}$ shows mainly data and spatial relations between A and D databases.

Database A contains very long statistical time period (more than 160 years) and all over Australia, therefore adequate to the study of landslide temporal and spatial pattern. But, two main gaps in event data (26.81% out of 519 landslides) and movement type or class (49.12%) recording, reduce somewhat its analytical capability and hazard management applicability. Database B that counted incomparable in the world from the points of study intensity, area coverage and data combination (total risk of 9 main natural hazards on buildings) shows high applicability for landslide risk management. Database C in spite of high class (IV) of applicability, still needs further detailed studies, spreading of operational circle, and coverage of other city centers for better implementation of society and environment management projects. Database D, although is main source of geometrical and geometrical and geotechnical data and affected engineering structures, but still needs further presentation of classified data and mapping of landslide hazard management programs.

Conclusions

Finally, not all of the available information technology capabilities have yet been used in the setup and development of a comprehensive landslide spatial database in Australia. Current databases need further development and complementary measures especially for compensation of deficiencies in event data, geomorphological type, geometrical and geotechnical characteristics and map scale.

Acknowledgements

I thank Dr. R. Drysdale for supervision, and the assistance of the University of Newcastle, Australia, during sabbatical leave in 2002. Thanks also due to the organizations and persons who provided data sources for this paper.

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