An Initial Establishment Sustainable Development Map by Using Geographical Information System: A Case Study in Dong Ha Town, Quang Tri Province

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Abstract: Sustainable development (SD) planning is of paramount importance and necessary at both global and local aspects. It has to be analysed and valued basically on a general valuation of environmental and socio - economic sides with institutional aspect. Human beings (putting people at the centre of development) play an important role in SD, as the goal of the sustainable development strategy (SDS) is developmental well being of the society.
Vietnam is a poor and developing country, so insufficient and less scientific basis to define SD at all levels and in particular at local level. We do need strong enough instruments as a decision making for SD.
Nowadays, Geographical Information System (GIS) is a powerful tool for studying and analyzing space and decision making. But in the country, it is under or not used-putting in a question?
Keywords: Sustainable development (SD), sustainable development indicators (SDIs), sustainable development strategy (SDS) and Geographical Information System.

1. Introduction

Sustainable development (SD) is of paramount importance for Vietnam in particular. It has to be analysed and valued basically on a general valuation of environmental and socio - economic components. It implies, for example, that progress in poverty reduction is lasting, rather than fleeting [1].

GIS (Geographical Information System) technology provides a flexible environment to store, analyze, and display digital data on SD [5]. Spatial data could be used for problems and opportunities analysis; and could show the situation and size of problems and development opportunities for the case study as well as Quang Tri province.

A map is a universe and characters medium of communication in the area (to show the thematic maps). Nowadays, beside other instruments, GIS is a tool, progress technology to provide support for planning and decision - makers.

***GIS** = Databases + Software + Equipments + Experts*

Dong Ha town is the heart of Quang Tri province. After the end of the war, Dong Ha's economy is developed well but it faces many unsustainable factors, such as fast population growth, dramatic environmental degradation, complex socio-economic development issues and so on. In my opinion, SD is a unique social choice and as such extremely important for the area, Quang Tri province and Vietnam's future as well. Sustainable development indicators (SDIs) are various statistical values that collectively measure the capacity to meet present and future needs [6]. In particular, the case study aims to establish a SD map from sustainable thematic maps and from an appropriate set of SDI by using GIS application to contribute and support planning and decision - making at a local level.

2. Application of GIS analysis as a tool to study and analyse SD

In fact, SD has many indicators. Each indicator can convert to a map and use GIS. Application of GIS analysis as a tool to study and analyse the SD for Dong Ha town which rely on a basis of the SDIs. In the first step, 6 sector maps will be established from these correlative indicators (the map of arable land per capita from the indicator of arable land per capita, the map of distance from health care centre from the indicator of distance from health care centre, the map of distance from school from the indicator of distance from school, the map of flood area per person from the indicator flood area per person, the map of population density from the indicator of population density and the map of soil erosion from the indicator of soil erosion); then 6 sustainable thematic maps were established from the above maps; finally a SD map was built from theses sustainable thematic maps. (See Flow. 1)

Some methods in GIS to analyse and evaluation values of socio - economic and natural conditions were used into indicator such as putting scores, weight on evidence and then overlay analysis from multi-layer maps.

* *Putting scores into indicator (map) overlay:* An important component of the site selection process applied in GIS is the interactive progression from identification of relevant site characteristics or "*evaluation factors*", through decisions on how much factors affect site suitability (scoring), and finally how much important a factor should be among other factors and the site selection process (weighting) [2]. The ranking has 10 scores, ranging from very unsustainable (0 score) to very high sustainable (10 scores) and each score is reflecting factors to sustainability to the objective.

* *Weight on evidence in indicator (map) overlay:* This method applies for indicators when they have unequal important situations. Weight of evidence is the method of combining subjective evidences on the basis of their bearing towards a process quantitatively [2]. Weights are estimated from the measured relation between known socio - economic and natural conditions and the exploration model for the area, which depend on how evidences are and its

relationship with a particular element (e.g. soil erosion, flood and among other). The weight on evidence is a hypothesis (ranking from 1 to 3 weights) which involves a set of exploration dataset (maps). This hypothesis then repeatedly evaluates all possible location of the maps using the weight and in turn produces a sustainable map in which the evidences of several map layers are combined by a map combination rule, say indicator overlay method [4]. The suitability sectors can be combined by a weight system or simple addition of the suitability scores into a composite suitability map.

* *GIS overlay analysis from multi-layer maps:* This step provides a method assignment for weight or score between different elements to the multi-layer maps. In the indicator overlay method, each input map (layer of evidence) to be used as evidence is assigned a different score (weight), as well as the maps themselves are receiving a different weight [3] depending on the exploration model. Different scores are assigned on each input map classes occurring.

After defining the score by statistical (data driven) or by knowledge driven approach for elements or maps, the average score (index weight) is then defined by:

$$S = -\frac{\sum_{i}^{n} SijWi}{\sum_{i}^{n} Wi}$$

Where S is the weighted score for an area object, Wi is the weight for the i-th input map, and Sij is the score for the j-th class of the i-th map, the value of j depending on the class actually occurring at the current location [3].

3. Map analysis by using GIS

3.1. Map of sustainable arable land per capita

Basis on the original map of arable land in Dong Ha town, the map of the arable land per capital in 1998 was established that depending on how much arable land per capita (ha/person) are at a precinct we put score(s), (see Flow. 1). Table 1 shows the arable land per capita in the case study area in different precincts.

Table 1. The arable land per capita, their cores and justification in 1998

Nr.	Location	Arable land per capita (ha/person)	Justification	Scores
1.	Dong Thanh	0.1241	Moderate high satisfy for cultivation agriculture	8
2.	Trieu Luong	0.1108	High satisfy for cultivation agriculture	7
3.	Trieu Le	0.1060	Moderate satisfy for cultivation agriculture	6
4.	Dong Giang	0.0892	Moderate satisfy for cultivation agriculture	5
5.	Phuong 2	0.0209	Low satisfy for cultivation agriculture	3
6.	Phuong 3	0.0155	Very low satisfy for cultivation agriculture	2
7.	Phuong 4	0.0125	Very low satisfy for cultivation agriculture	2
8.	Phuong 5	0.0014	Not satisfy for cultivation agriculture	1
9.	Phuong 1	0.0002	Not satisfy for cultivation agriculture	1

Arable land per capita reflects current land conditions and it is related to the land resources and with other social and economic issues, such as population growth rate, population immigration and population density. The population in the area is increasing and it is putting in question society's food security capability and increasing pressure on available agricultural land.

3.2. Map of sustainable distance from health care centre

The map of distance from health care centre was established from the original health care centre points in Dong Ha town in 1998 that depending on how different distances from health care centre are put score(s), (see Flow. 1). Table 2 shows different distances from health care centre and including a justification.

Table 2. The different distance from health care centre, their cores and justification

Nr.	Distance from health care centre (m)	Area (ha)	Justification	Scores
1.	0 - 500	570.90	Very high convenience to assess health care centre	10
2.	500 - 1,500	2,548.71	High convenience to assess health care centre	9
3.	1,500 - 2,500	1,836.64	Convenience to assess health care centre	8
4.	2,500 - 3,500	1,079.89	High moderate to assess health care centre	7
5.	3,500 - 4,500	623.71	Moderate to assess health care centre	4
6.	Over 4,500	699.21	Immoderate to assess health care centre	2

SD in the areas will be easy access to health care centre systems, especially for children and women groups.

3.3. Map of sustainable distance from school

Basis on the original school points in Dong Ha town in 1998, the map of distance from schools was established that depending on how different distances from school are put score(s), (see Flow. 1). Table 3 shows distances from schools and including a justification.

Table 3. The different distance from school, their cores and justification

Nr.	Distance from school (m)	Area (ha)	Justification	Scores
1.	0 - 100	15.00	Very high convenience to assess school	10
2.	100 - 500	384.48	High convenience to assess school	9
3.	500 - 1,500	2,412.04	Convenience to assess school	8
4.	1,500 - 2,500	2,262.03	High moderate to assess school	7
5.	2,500 - 3,500	1,260.76	Moderate to assess school	4
6.	3,500 - 4,500	622.14	Immoderate to assess school	3
7.	Over 4,500	402.60	Inconvenience to assess school	1

SD in the areas will be easy access to school systems, especially for the primary school.

3.4. Map of sustainable flood area per person

The map of flood area per person in 1999 was established from the original map of flood area of IG that depending on how different flood area per person grades is at a precinct we put score(s) by using the flood area divided the population number of each precinct in Dong Ha town, (see Flow. 1). Table 4 shows different flood grades and including a justification.

Table 4. The different flood area per person grades, their cores and justification

Nr.	Location	Flood area per person	Justification	Scores
1.	Phuong 5	0 (ha)	Not influence human beings by flood	10
2.	Phuong 1	0.0005 (ha)	Almost not influence human beings by flood	10
3.	Phuong 3	0.0106 (ha)	Low influence human beings by flood	8
4.	Phuong 4	0.0132 (ha)	Low influence human beings by flood	8
5.	Phuong 2	0.0184 (ha)	Low influence human beings by flood	8
6.	Dong Thanh	0.0598 (ha)	Influence human beings by flood	5
7.	Trieu Luong	0.0764 (ha)	High influence human beings by flood	4
8.	Trieu Le	0.0782 (ha)	High influence flood	4
9.	Dong Giang	0.1002 (ha)	Very high influence flood	2

Flood area per person indicator is a major issue in selecting areas sustainability for building housing and infrastructure. Flood grades are very important to decide where can be site for human beings and infrastructure construction in Dong Ha town. The author used the flood map and databases of the year 1999 to apply and analysis for SD map in 1998.

3.5. Map of sustainable population density

From the original map of administration boundary of Dong Ha town in 1998, the map of population density in 1998 was established depending on how much different population density grades are at a precinct we put score(s) by using the population number divided the total area of each precinct in Dong Ha town, (see Flow. 1). Table 5 shows different population density and including a justification in the case study.

Table 5. The different population density grades, their cores and justification

Nr.	Precincts	Population density (people/km^2)	Justification	Scores
1.	Trieu Luong	209	Very low impact by human activities	8
2.	Trieu Le	550	Low impact by human activities	7
3.	Phuong 3	560	Low impact by human activities	7
4.	Dong Giang	655	Low impact by human activities	7
5.	Phuong 4	701	Moderately low impact by human activities	6
6.	Dong Thanh	715	Moderately low impact by human activities	6
7.	Phuong 2	2,497	Moderately high impact by human activities	3
8.	Phuong 5	4,714	High impact by human activities	2
9.	Phuong 1	7,667	Very high impact by human activities	1

This map (indicator) measures the concentration grades of people in Dong Ha town area. Because it in limited area related with supply and demand for housing, number of people per unit of habitable, employment, social security and service, environmental infrastructure for management and treatment waste and sanitation.

3.6. Map of sustainable soil erosion

Soil erosion was effected in the case study almost by human activities. It will reflect and affect to human beings (e.g. crop yields and ecosystem health). The author used the map of soil erosion and databases of the year 1999 to apply and analysis for SD map in 1998 that depending on how different soil erosion grades are put score(s), (see Flow. 1). Table 6 is shown different soil erosion grades and including a justification in the case study.

Table 6. The different soil erosion grades, their cores and justification

Nr.	Soil erosion (ton/ha/year)	Area (ha)	Justification	Scores
1.	0 - 50	5,769.77	Low impacts on environment by human activities and natural conditions	6
2.	50 - 300	1,180.93	Moderately low impacts on environment by human activities and natural conditions	5
3.	300 - 700	235.35	Moderate impacts on environment by human activities and natural conditions	4
4.	700 - 1,000	104.67	Moderately high impact on environment by human activities and natural conditions	3
5.	1,000 - 4,500	59.10	High impacts on environment by human activities and natural conditions	2
6.	Over 4,500	9.03	Very high impact on environment by human activities and natural conditions	1

3.7. Weight and classification sustainable evidence maps

SD map can be combined from factor maps by using the multi-overlay method. 6 thematic maps have different influence on distribution, impact and development, which are relationship close with SD issues in the case study. Hence, the importance of the sustainable maps for SD map is very different.

In view of the foregoing, depend on the importance of the sustainable maps for the case study we put weight(s). This table below shows the weight allocated and justification for doing it.

Table 8. Weight of factor maps and justification for SD map

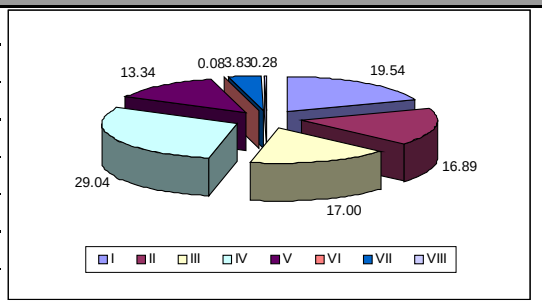
Nr.	Maps	Justification	Weights
1.	Map of sustainable arable land per capita	Reflect influence the impact by human activities and natural resource	1.5
2.	Map of sustainable distance from health care centre	Create buffer zone to access health care centre	1
3.	Map of sustainable distance from school	Create buffer zone to access school	1
4.	Map of sustainable flood area per person	Reflect influence the impact of flood issue on human beings	3
5.	Map of sustainable population density	Reflect influence the impact by human activities	2
6.	Map of sustainable soil erosion	Reflect influence the impact by human beings and natural conditions	2.5

Combining the sustainable thematic maps by using indicator - overlay method: SD map is produced by applying indicators overlaying with multi-class map method. The sustainable scores for SD site are ranging grades from I (the lowest grade of sustainable site) to VIII (the highest grade of sustainable site). SD map is displayed (see Flow. 1).

Table 9 shows the total area in different grades of SD map in Dong Ha town in 1998; the total area (the 2nd column) and percentage (the 3rd column) in different grades of SD (from grade I to grade VIII) in Dong Ha town are shown.

Table 9. Total area and percentage in different grades of SD in Dong Ha town in 1998

The grades of SD	Area (ha)	Percentage (%)
I.	1,372.92	*19.54*
II.	1,186.86	*16.89*
III.	1,194.18	*17.00*
IV.	2,040.01	*29.04*
V.	937.05	*13.34*
VI.	5.56	*0.08*
VII.	268.73	*3.83*
VIII.	19.66	*0.28*



4. Conclusions

GIS is a power tool to apply into many aspects for decision making such as SD. The study gives an example of the application of a new method to SD that is based on SDIs.

GIS used and applied for analysing and creating a SD map by 3 main steps:

1/ 6 sector maps, which are based on 6 correlative SDIs;

2/ 6 sustainable sector maps were created from 6 above sector maps by putting different scores and weights.

3/ Finally, a SD map was built from 6 sector maps by using GIS overlay analysis.

The establishment of SD map should have more than one scenario, which based on different scores of factor maps, different weight on evidences of sustainable factor maps.

Need more indicators to apply GIS for studying and analysing. That means, more factor maps and more sustainable factor maps should be analysed and established for the case study area. The establishment of SD map should have more than one scenario, which based on different scores of factor maps, different weight on evidences of sustainable factor maps.

In the cut-off viewpoint of the author, the results of above studies are not "*ended-up*" but "*opened-up*" and as such open to discussion and refinement.

5. References

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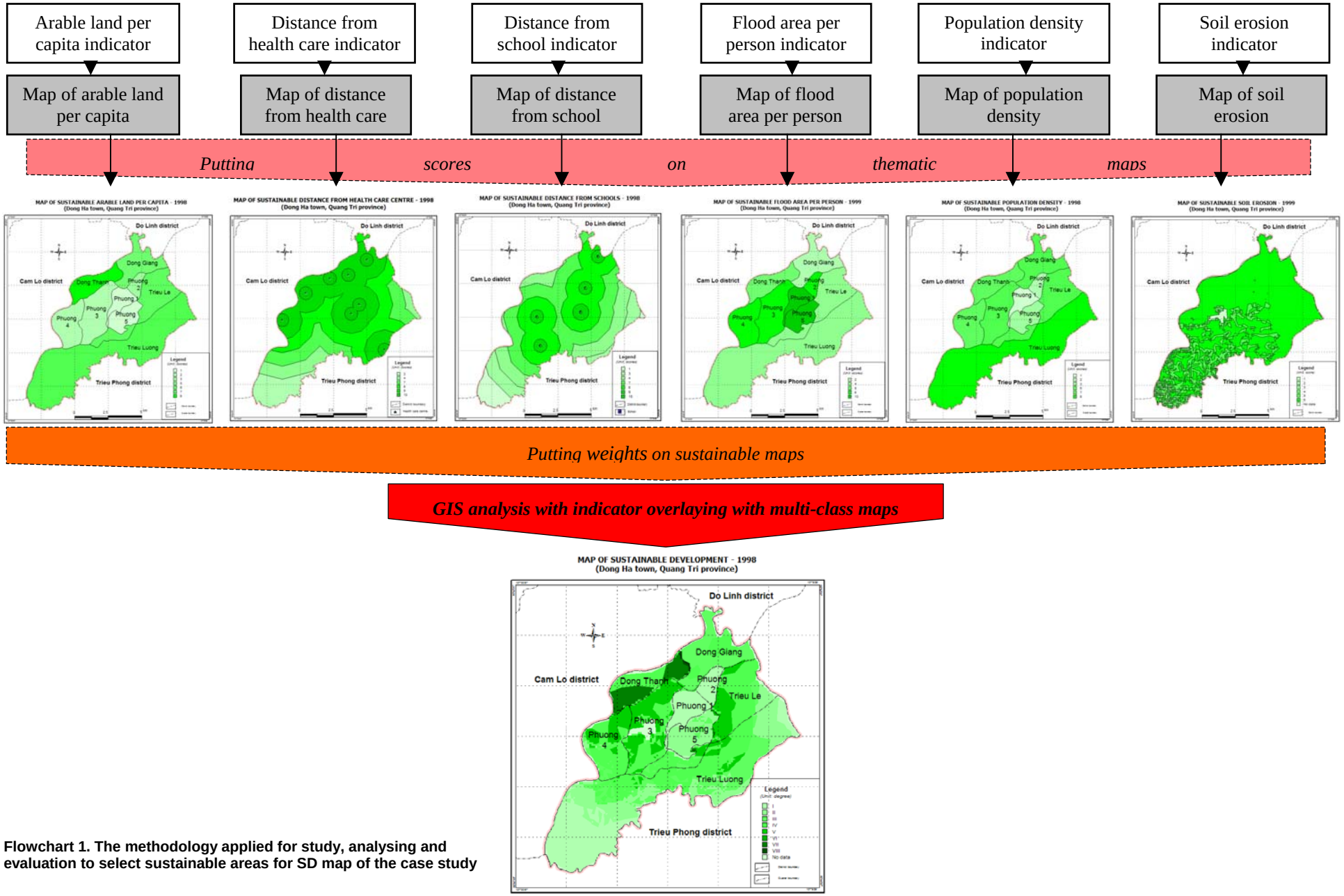

Flowchart 1. The methodology applied for study, analysing and evaluation to select sustainable areas for SD map of the case study