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Application of **Clue** Model for Analysis and Quantification of Changing Land Use Pattern-A Case Study of Kankuram Basin, Ghatshila

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Abstract: The present research paper is concerned about the changing nature of land use and application of CLUE Models for reviewing the pattern. Land-use change models should represent part of the complexity of land use systems. The present paper also bespeak about the utility of RS and GIS technique for the preparation of Land Use changing Modelling. The source of the river is near Netrabera and meets Subarnarekha river near Moubhandar. This quantitative method is put forwarded by using the satellite data and with the help of correlation co-efficient, the relation land use, land cover changes is being calculated. Regarding the sensitivity analysis this model has defined how much this model is applicable in small basin area and it is based on some calculations and mathematical modeling and mapping to find the post land use changing probability.

Keywords: CLUE model; land use change; sensitivity analysis.

1. Introduction

Land use change modeling, especially if done in a spatially-explicit, integrated and multi-scale manner, is an important technique for the projection of alternative pathways into the future, for conducting experiments that test our understanding of key processes in land use changes. Land-use change models should represent part of the complexity of land use systems. They offer the possibility to test the sensitivity of land use patterns to changes in selected variables. They also allow testing of the stability of linked social and ecological systems, through scenario building. It is an empirical detail study that how we can quantify the land uses changing data. This technology is very useful for monitoring the physical elements as well as cultural elements. The Kankuram river is a right hand side tributary of Subarnarekha river being a part of Middle Subarnarekha basin. This small area basin is situated in the block of Purbi Singhbhum district in the state of Jharkhand. The source of the river is near Netrabera and meets Subarnarekha river near Moubhaner. This quantitative method is put forwarded by using the satellite data and with the help of correlation co-efficient the relation land use ,land cover changes is calculated. Regarding the morphological scenario, Kankuram basin mainly deals with the magnificent account of geology, geomorphology, hydro-geomorphological analysis, which is influenced by both endogenetic and exogenetic process in spatial and temporal scale. Regarding the dimension of scale variation, the Kankuram river basin considered under micro level basin analysis, broadly under the Subarnarekha river system of east Chhotonagpur plateau. The river basin offered various land use variations from source to mouth.

2. Location

The Kankuram basin is a tributary of river Subarnarekha in its middle course, which is joining the river Subarnarekha near Moubhander, Ghatsila. It's latitudinal extension is from 22°33'17" N to 22°34'1"N and longitudinal extension from 86°22'48" E to 86°25'58" E. The total basin area is about 22.90 sq km. (Fig no. 1) The selected study area is situated in East Singhbhum district of Jharkhand and originates from the southern Singhbhum Granite zone and flow on the hills of Singhbhum Shear Zone, a place of paleotectonic activities between Chhotonagpur plate and Singhbhum Micro plate and this reason is responsible for the evolution of the river by structural control land use changes of that area.

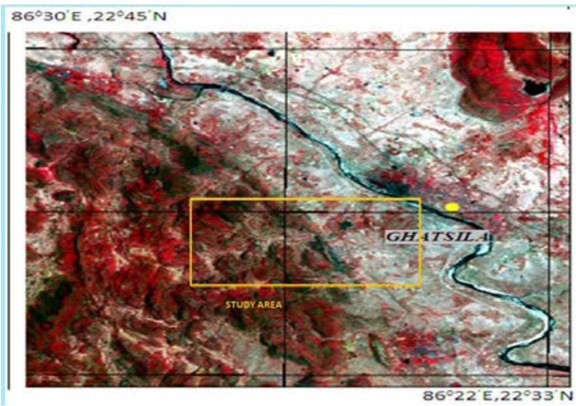

Figure 1: location and terrain character of the area

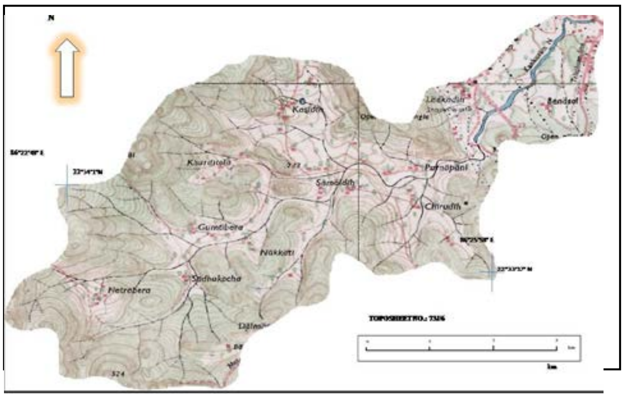

Figure 2: map of Kankuram river basin

Singhbhum district of Jharkhand and originates from the southern Shingbhum Granite zone and flow on the hills of Singhbhum Shear Zone, a place of paleotectonic activities between Chhotonagpur plate and Singhbhum Micro plate and this reason is responsible for the evolution of the river by structural control land use changes of that area.

3. Objectives

Preparation of Land use Land cover map of two respected years using Topographical map and LISS IV Satellite data. Secondly Compare the different categories of land use, with their graphical representation accordinglyand the final objective is to apply CLUE model for sensitivity analysis.

4. Methodology

The analysis of the change of land use includes the study of change of land use and lands cover from topographical map no 73J/6 of scale 1:50000 surveyed in the year 1976. We have also compared these with the satellite images of 2014 using Mapinfo and arcGIS softwares. MapInfo is a desktop geographic information system software product produced by Pitney Bowes Software and used for mapping and location analytics. ArcGIS is a geographic information system (GIS) for working with maps and geographic information. It also included collection of various primary data from fields, and from the journals and papers previously published, to make the work of analysis and correlation more broad and easy. In other part work, the secondary and primary data are analyzed in scientific way to get final layout of the study. There have been created some maps and graphs to represent the objectives of the study in scientific method.

5. Literature reviewed

Pioneering research has been carried out by Sing (1958, 1969) . He has analyzed the evolution of Chhotonagpur highland and has referred to the development of landforms of the Singhbhum plain areas. A very comprehensive study of Singhbhum region , specially the vast Subarnarekha basin and the variety of parameters used to analyze the region . The complexity of land-use systems calls for multidisciplinary analyses (Clayton and Radcliffe, 1996).Initial efforts aimed at modeling land-use change have focused primarily on biophysical attributes (e.g. altitude, slope or s oil type), given the good availability of such data. Incorporation of data on a wide range of socio-economic drivers of change is however required (Turner et al., 1995; Musters et al., 1998; Wilbanks and Kates, 1999). Most case studies highlight for instance the important role of policies in driving land-use changes (Lambin et al., in press), e.g. international environmental treaties such as the Kyoto Protocol may drive significant changes in land-use in the future.

6. Drivers of land use change

Incorporation of social, political and economic factors is however hampered by a lack of spatially explicit data and by methodological difficulties in linking social and natural data. For example, the relevant spatial units for biophysical processes may be different from the spatial units of decision making by actors. Proxy variables, which are easier to measure spatially, (e.g. distances to a road or a town) are often used for deeper underlying driving forces. This shift from driving forces to proximate causes, for data convenience, might obscure causality. Subtle land-cover or land-use modifications, e.g. related to changes in cropping patterns, input use or tree density of forests, also need to be taken into account in addition to the more easily measurable land-cover conversions. Moreover, land-use change models need to account for the endogeneity of variables such as land management technologies, infrastructures or land-use policies.

Fundamental difference in modeling tradition between different disciplines concerns the use of process-based (or structural) models versus statistical (or reduced form) models. Regarding the different Land use modeling we have considered two factors composition in respect of its spatial character; one is geo-climatic nature and another one based on some calculations and mathematical modeling and mapping to find the post land use changing probability.

6.1. Geo climatic factors

The area is a part of southeastern Chhotonagpur terrain, a greater part of which consists of a very old continental block that was not submerged since early Paleozoic period. The Singhbhum area is similar to the various Precambrian shield area of the world. The major rock formations underwent different geological eras and prolonged periods of earth movements and the resultant igneous activity, and the predominance of igneous and metamorphic rocks. Fig no. 4 A.N. Sarkar (1982) proposed a model of converging micro plates to interpret the tectonic evolution of the Singhbhum and Chhotonagpur plate. In this model the Chhotonagpur block represents an overriding plate and the Singhbhum microplate as the subducting plate. The collision of these continental micro plates took place around 1600 Ma ago. The model considers Convergence and collision of the Singhbhum micro plate against a stationary Chhotonagpur micro plate in three cycles. The first cycle (2000–1550 mya) relates with the northward movement of the Singhbhum micro plate and its collision with the Chhotonagpur micro plate. In this event it is believed that Dalma volcanic was emplaced as ophiolite in a flysch environment. In the second cycle (1550–1000 mya) the Singhbhum plate is assumed to have rotated clockwise towards NE and generated folds, including the NW-SE trending fold of the Dhanjori rocks. The third cycle (1000–850 Ma) relates to the overriding of the Singhbhum plate onto the Chhotonagpur plate in a NNW-SSE direction, subduction of the continental lithosphere in the southern part of the Singhbhum fold belt, and also deformation and metamorphism. At the close of the orogenic cycle the Singhbhum fold belt was uplifted and subjected to erosion. Whereas some scientists have opposed this model and accounted for the presence of a rift valley between Chhotonagpur plate and Singhbhum plate. The analysis of climatic condition in the field of geomorphologic studies is an important aspect. Apart from the lithological features like structure, types of rocks etc. climatic condition play an important role in fashioning the land surface. The geomorphologic processes in a region vary with changes of climatic conditions. The main characteristic of climate of this region is the changes of climatic condition from arid to humid. The existing residual hills found at different parts of this region (for example Phooldungri) and some trees (like Cactus, which are found near Rajbari) are proved this type of climatic change.

Plate 1: evidence of climatic changes

The Middle Subarnarekha Basin area i.e. south eastern part of Chhotanagpur plateau is characterized by Monsoonal climate ,but according to Koppen's climatic classification it falls under the semi arid climate. This kind of Geo climatic consequences are the major drivers of land use variability.

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7. Analysis of land use changes

Analysis of land cover/use changes between 1976 and 2014 in Kankuram basin has shown that there have been significant changes in land cover/use. Such process has involved substantial conversion of vegetation cover from higher forms (closed forest and woodland) to lower forms (mixed cropland, cultivation with bush crops and open grassland). For example, it is noted that between 1976 Figure 5 and 2014, about 26% of the total catchment area was converted from natural vegetation to cropland. This has been more evident in the North eastern and central part of the basin.

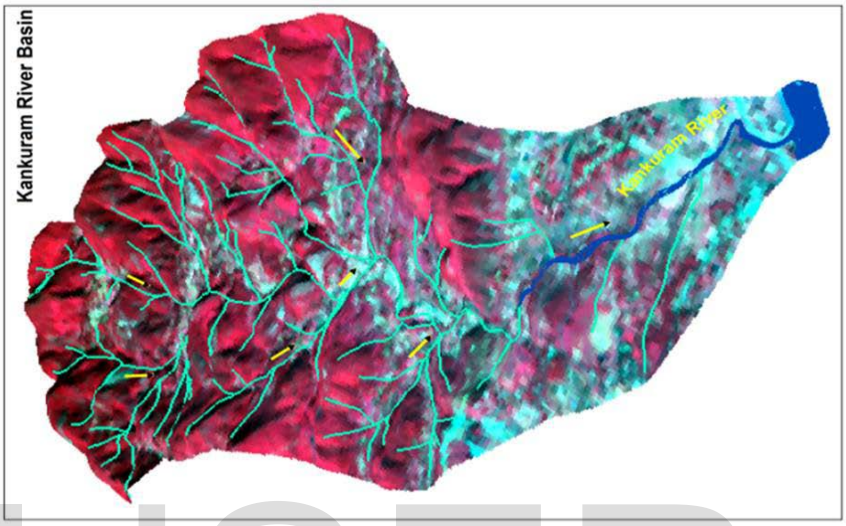

Figure 3: DEM of the study area

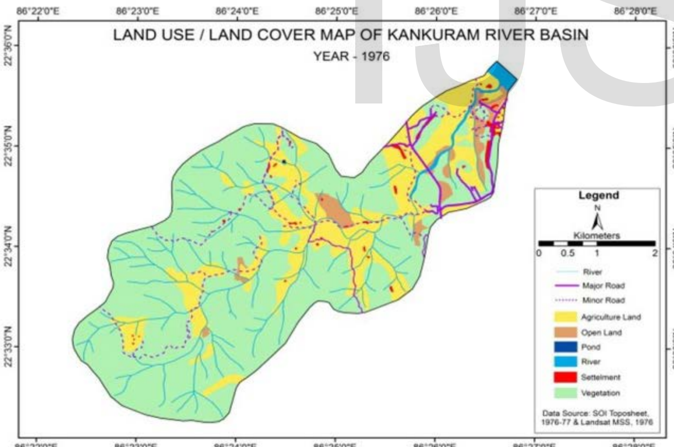

Figure 4: land use/land cover map 1976

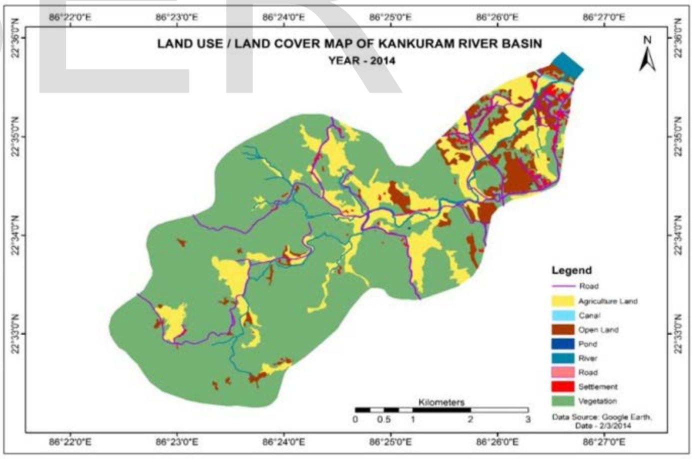

Figure 5: land use/land cover map 2014

However, there has been an increase in cultivation of bush crops and area with integration of trees and crops. Also there has been more fragmentation of the natural forests. For instance we can see that in figure no. 6.3, the total forest area was about 90% of the total basin area was under vegetal cover, 22.01929 sq km, in the year 1976 it decreased to 14.4557 sq km, which was 63% of the total basin area.

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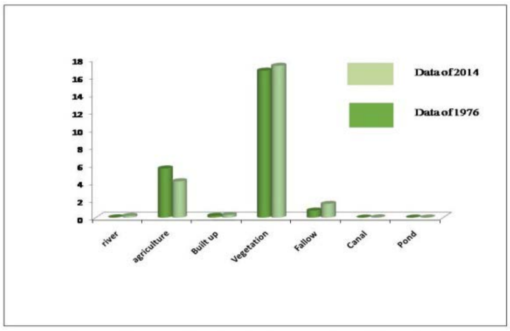

Figure 6: changing nature of land use between 1976 2014

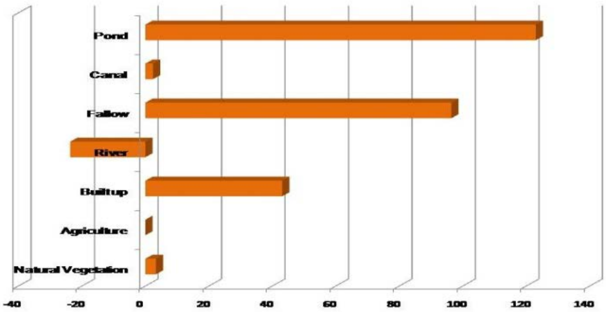

Figure 7: positive and negative changes of land use (1976 and 2014)

8. Application of CLUE model on land use changing

The CLUE modeling framework, which is validated in this study, is one of the few spatially explicit land use models that analyses land use change at multiple scales. CLUE was developed and tested at country level for Costa Rica (Veldkamp and Fresco, 1996a,b.Schoorl et al., 1997). Since, the model has been successfully run for various countries in Latin America and Asia: Java (Verburg et al., 1999a); China (Verburg et al., 1999b); Atlantic zone of Costa Rica (Kok and Veldkamp, 2000); Ecuador (De Koning et al., 1999). It uses a (statistical) description of land use patterns and their dependency on a set of socio-economic and biophysical variables at a number of spatial resolutions.The Conversion of LandUse and its Effects modelling framework CLUE) (Veldkampand Fresco,1996; Verburg et al., 1999) was developed to simulate land use change using empirically quantified relations between land use and its driving factors in combination with dynamic modelling of competition between land use types.

8.1 Model calibration and sensitivity analysis

In this paper, sensitivity analysis refers to parameters within the CLUE-S allocation procedure. Parameters in the demand module that regulate the total quantity of change, like GDP and food consumption per capita, are not included.. Because processes in Kankuram Basin were largely similar over the time period that was considered and rates of changes were in the same order of magnitude, calibration for small area with subsequent validation is justified. The validation for the area has to be evaluated carefully, since the basic grid level was used to calibrate the model. Within the CLUE allocation module, there are two key input parameters, which need to be calibrated: SCALE FACT and AUTODEV.

1. Scale parameter, SCALE FACT. Determines to what extent the elasticity changes as calculated at the coarse resolution will influence elasticity for changes at the fine resolution. This is its most important use:

RELCHANGEt=REL CHANGEt−1 SCALE FACT +1 − 1 SCALE FACT(1)

ELAS1=ELAS0×REL CHANGEt (2)

Where,

REL CHANGE is the cell specific relative change in area for each land use type (unit less),

ELAS1 the cell and land use specific elasticity to change fraction of total change),

ELAS0 the land use specific elasticity to changes K. Kok et al./Agriculture, Ecosystems and Environment 85 (2001) 223–238 227at coarse resolution (fraction of total change), t the year index. SCALE FACT changes the value of REL CHANGE, which in turn influences the elasticity to change at the fine resolution. The higher SCALE FACT, the closer REL CHANGE will be 1, the more elastic changes at the fine resolution will be, and less the influence of the coarse res- olution. At higher values of SCALE FACT than approximately 10, the influence of the coarse resolution on the final output at the fine resolution becomes negligible.

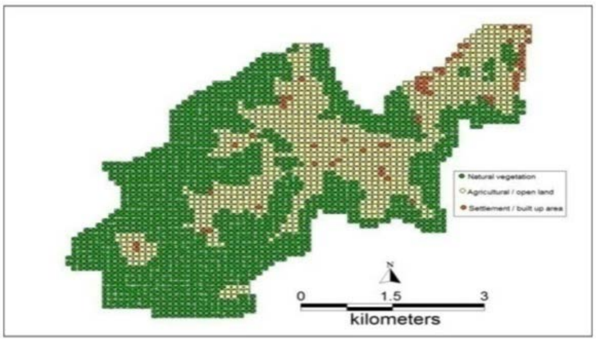

Figure 8: gridded land use map of 1976

2. Autonomous development parameter, AUTODEV.

Determines the relative importance of national quantity of change and changes at the finest resolution. This is one of the key uses:

ACTCOVt=ACTCOVt−1+(REGCOVt −ACTCOVt−1) ×AUTODEV

where ACTCOVt is the actual cell and land use specific area (ha/grid), REGCOVt the cell and land use specific area as calculated by statistical.(Fig no. 9)

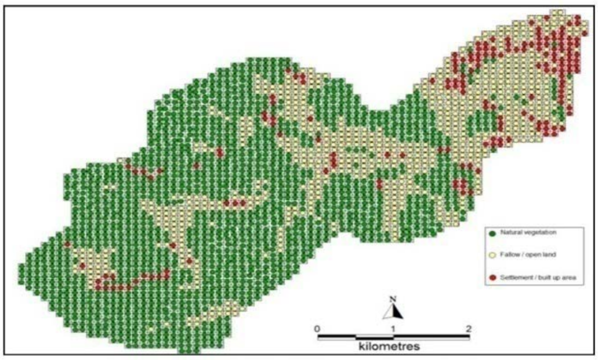

Figure 9: gridded land use map of 2014

Table 1: Calculation of land use changing parameters with total change and annual change

Variable	Annuals	Natural Vegetation	Agriculture	Built up	River	Fallow	Canal	Pond
Area(1976)	22.7842 sq.km	16.718583	5.587233	0.208837	0.262433	0.795044	0	0.003929
Area(2014)	23.4886 sq.km	17.276771	5.587233	0.298904	0.200276	1.561539	0.023969	0.008776
Total Change	0.7044	0.558188	0	0.090067	0.062157	0.766495	0.023969	0.004847
Total Change(%)	3.0916	3.33868	0	43.1279	-23.685	96.409	2.3969	123
Annual Change(%)	1.498	1.469	0	0.237	-0.1635	2.017	0.063	0.12755

Table 2: Calculated scale factor parameters for three main types of land use.

Scale Factor for Natural Vegetation	1.02
Scale Factor for Agriculture	1.00
Scale Factor for Built up	1.002

analysis (ha/grid), t the year index. The unit less AUTODEV (value between 0 and 1) determines to what extent cell specific changes will be governed by local preferences(REGCOV−ACTCOV) instead of by national changes. The higher the value of AUTODEV, the stronger the local effect. At val- ues above 0.50, the effect of further augmentation of AUTODEV becomes very small.At a value of 1, all changes are autonomous and the influence of national demand is negligible.Hence, the scale factor is ~ 1 which indicates that the AUTODEV parameter is 0 in this case. To analyze the change in land use, we take two levels. One is the basic grid level, that is (100m*100m) grids and the large grid, that is one 0.01km^2 grid.

Plate 4: cultivation of vegetables

9.Discussion

The sensitivity analysis includes two key parameters of the CLUE allocation procedure, that both regulate the influence of the coarse resolution on the fine resolution in the CLUE allocation module. The model Fig no. 11 proves to be especially sensitive to changes in AUTODEV, the parameter that controls the influence of autonomous development at grid cell level as compared to national demand changes. Model performance for Kankuram Basin is quite low as the unit of area is very small scale, leading to a minium influence of local dynamics. This finding is in accordance with the moderate to low dynamic local changes as they took place in the basin area 1976 and 2014. With a single model parameter, slow and steady changes governed by local demand fluctuations, as well as dynamic local changes are simulated. The overall model performance is slightly better for small scale areas, for which the model is calibrated.(Fig no. 9 and Fig no. 12).To determine the changes through the method of gridded land use each 0.01 km^2 grid drawn on the map is filled with the colour of its own dominating land-use character, having more than 50% of the each grid covered. Thus the two maps that are prepared with same method. By studying these maps we can identify the hot spots of change which have a keen relationship with slope terrain character and availability of water and other amenities. We see that the amount of natural vegetation as well as the settlements and road connectivity increased in the upper slope areas, and amount of fallow-land is decreased. But in the lower course and near the mouth, fallow land and built up areas increasing significantly(before o.32km^2 and after 100.00km^2).

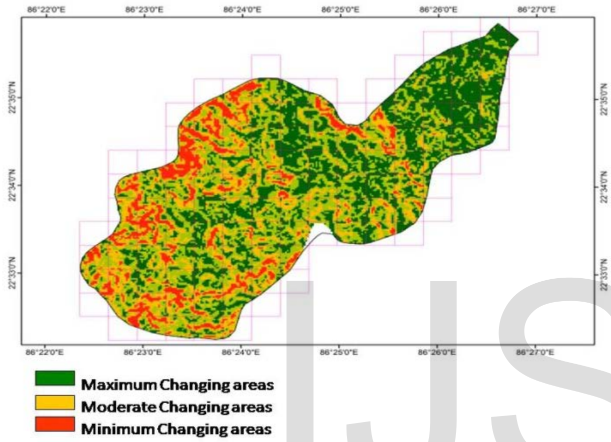

Figure 10: identification of changing areas

The increasing amount of natural vegetation is due to plantation to prevent soil erosion during monsoon and to encourage rural economy and social forestry. Fig no. 10 Plate no. 3 The lower course of river has a more rolling appearance than the upper hilly terrain so this part is feasible to make roads settlements and to cultivate. A easy availability of water through the newly built ditch encourages

10. Concluding remarks

Regarding the above discussion, it has been derived that this model is mostly applicable for sensitivity analysis of land use changing patterns and the parameter that controls the influence of autonomous development at the finest resolution, with improving results . It is successfully applicable for comparing through the time span. In India it may be adapted to as a land use model to handle very distinct land use change processes and we can also modify the model concerning the spatial variation. This model is applicable in both Meso to micro level study concerning any regional segments. But the major limitation is for better and accurate result we need high resolution satellite data.

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