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COMPARATIVE ANALYSIS OF LAND EVALUATION SYSTEMS FOR DOUGLAS COUNTY

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ABSTRACT

The USDA Soil Conservation Service LESA system is evaluated and analyzed in two phases. First, using ten years of building permits in two targeted zones in Douglas County, Kansas, a variety of LESA structures are compared. Redundant factors and the impact of different weighting systems are examined. Phase Two follows with a systematic method to determine the Site Assessment factors and their interactions. Results indicate that certain evaluation structures are more reliably consistent and that the systematic approach in Phase Two improves LESA considerably. In addition, it is concluded that the final grading mechanism needs attention, to assure proper protection. Planners are cautioned to consider these issues when implementing LESA for their area.

INTRODUCTION

Resource planners have long been concerned about the preservation of prime agricultural land [1-4]. They have utilized preferential taxation, conservation easements, and focused zoning restrictions to prevent farmland conversion. These efforts have produced mixed results, and are not always readily recognized as successful [1, 5].

This lack of success prompted the U. S. Department of Agriculture's Soil Conservation Service (SCS) to develop another tool for farmland preservation, the Land Evaluation and Site Assessment System (LESA) [6]. The LESA structure is devised to enumerate and assess the appropriate physical, social, and economic factors to meet the planning objectives of a particular region. Its

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intent is to assist, not to replace, decision makers by providing an equitable and more rational basis for their decisions. It is designed to be implemented on a county-wide basis.

LESA is a two part system containing both a Land Evaluation subsystem (LE) and a Site Assessment subsystem (SA). The LE subsystem rates the physical capability of the soil to support viable agricultural production. The soils of a given county are rated and placed in groups ranging from best to worst for a specified agricultural use. From this, a relative score is assigned, the best soil being given a score of 100, while the remaining soil groups are assigned prorated lower scores. All of these scores are derived from the National Cooperative Soil Survey in consultation with the County SCS district conservationist. The LE subsystem is a value recommended not to exceed one-third of the entire model (100 points in a 300 point model) [7].

The SA subsystem incorporates factors of local or regional importance which are more closely related to social and economic planning factors. The SCS recommends that this subsystem be assigned to two-thirds or more of the model (200 points in a 300 point model). Each of the SA factors are assigned weights which reflect the relative importance of each factor to the decision makers. Then the factors receive values based on the degree of compliance with the condition of that factor. The subsystem score is a linear function, the sum of the products of all SA factor values and weights.

The LESA system was field tested in 1981 in a national pilot program involving twelve counties in six states (Florida, Maryland, Illinois, Pennsylvania, Washington, and Virginia) [7]. Program participants recommended to the SCS that LESA be introduced nationally via SCS technical assistance to state and local governments. LESA has been presented to SCS state staffs and various state officials and has been adopted in two counties as a result. Currently in Kansas the Douglas County Planning Staff has been considering adoption of LESA or a similar system to help curb the development of agricultural lands. In addition, Shawnee County, adjacent to Douglas County on the west, adopted a LESA structure in 1983 [8].

Despite its attractiveness there are some shortcomings inherent in LESA as outlined by the SCS and as it is usually implemented at the local level. The assignments of internal weights and values for each factor can have major impacts on the final scores calculated for a site. Further, there is no allowance for the interdependence of these Site Assessment factors in most of the adopted LESA systems.

The research described here examines several of these points. Phase One examines the impacts of alternative weight assignment structures on the same sites. Results of Phase One indicated a lack of factor separability, requiring further study. Phase Two thus explores a specific approach for logically and efficiently determining the Site Assessment factors as well as exploring the explicit (or implicit) interactions among these factors.

The main research issues being examined are thus:

1. What is the impact of weights on the final outcome of LESA scores?
2. What is the impact of varied internal weights on these outcomes?
3. How can the interdependence of evaluation factors be addressed?

STUDY AREA AND SAMPLE USED

Many of the countries in eastern Kansas are experiencing high growth rates, consequently the agricultural areas are being reduced in size due to development pressures. Douglas County is one of these. Its primary city, Lawrence, houses the University of Kansas and several industries. Located forty miles west of Kansas City, Lawrence has recently experienced one of the fastest rates of growth in the United States [9]. While the overall population of the county increased 13 percent between 1970 and 1980, the population in the unincorporated portions of the county increased 18.8 percent [9]. The total 1980 population for the rural townships is thus already greater than that predicted in the county's 1976 Plan, with rural residential construction up 32 percent [10]. With an average rural parcel size of thirty acres for this development, an increase of ten acres per parcel over the decade, considerably more agricultural land is being converted or developed. In the past fifteen years, Douglas County has lost over 40,000 acres of productive farmland (13% of its total area). This loss is in part due to the creation of Clinton Lake and Park, but at least one half of the loss is due to residential and industrial development pressure into the rural areas and expansion [10].

Within Douglas County, previous studies have produced two useful data bases. In the University of Kansas Geography Department, classes have studied the development of a Geographical Information System (GIS) based on LESA; this work is fully documented by Williams [11]. Their research developed data bases for two distinct areas, each five by six kilometers in size (Figures 1-3). Area (NE) is adjacent to Lawrence, the Kansas River and the Lawrence Airport, and includes a site once proposed for an industrial park. Area (SW) exhibits most of the different physiographic types found in Douglas County. These include the Wakarusa and Kansas river floodplains, wooded areas, the cuesta complexes, and glacial outwash plains. In addition, Area SW is bounded on the east by Iowa Street (U. S. Highway 59) and the Clinton Reservoir Dam to the southwest. This is an area which is experiencing much of the county's increasing development since the completion of Clinton Reservoir. The combined factors of mixed land uses, adjacency to the City of Lawrence, and the variety of development pressures make both of these areas ideal for the current study.

The current project sampled ten years of building permit applications for new single family homes from 1974 to 1983. This sample contained all the sites of newly constructed single family houses, as recorded through building permit applications, in each study area. In addition, within each study area the research

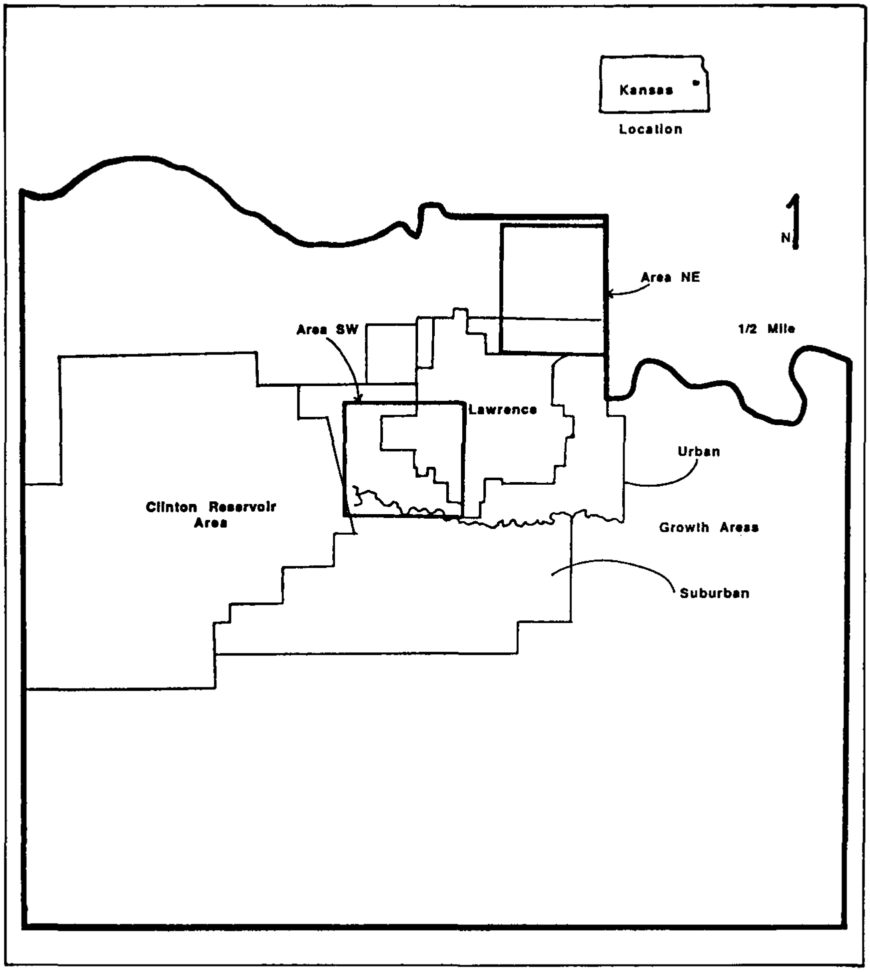


Figure 1. Location map of two study sites in Douglas County, Kansas.

in Phase One compared a set of hypothetical building sites with the existing permit sites. A hypothetical site consisted of any parcel of 160 acres or more and was evaluated in terms of its potential protection as or conversion from agricultural use.

PROCEDURE

Phase One

The procedure for Phase One reflects the original intent to compare both established and proposed LESA structures using the same data bases. It should be noted here that the data bases utilized had specified limitations which first

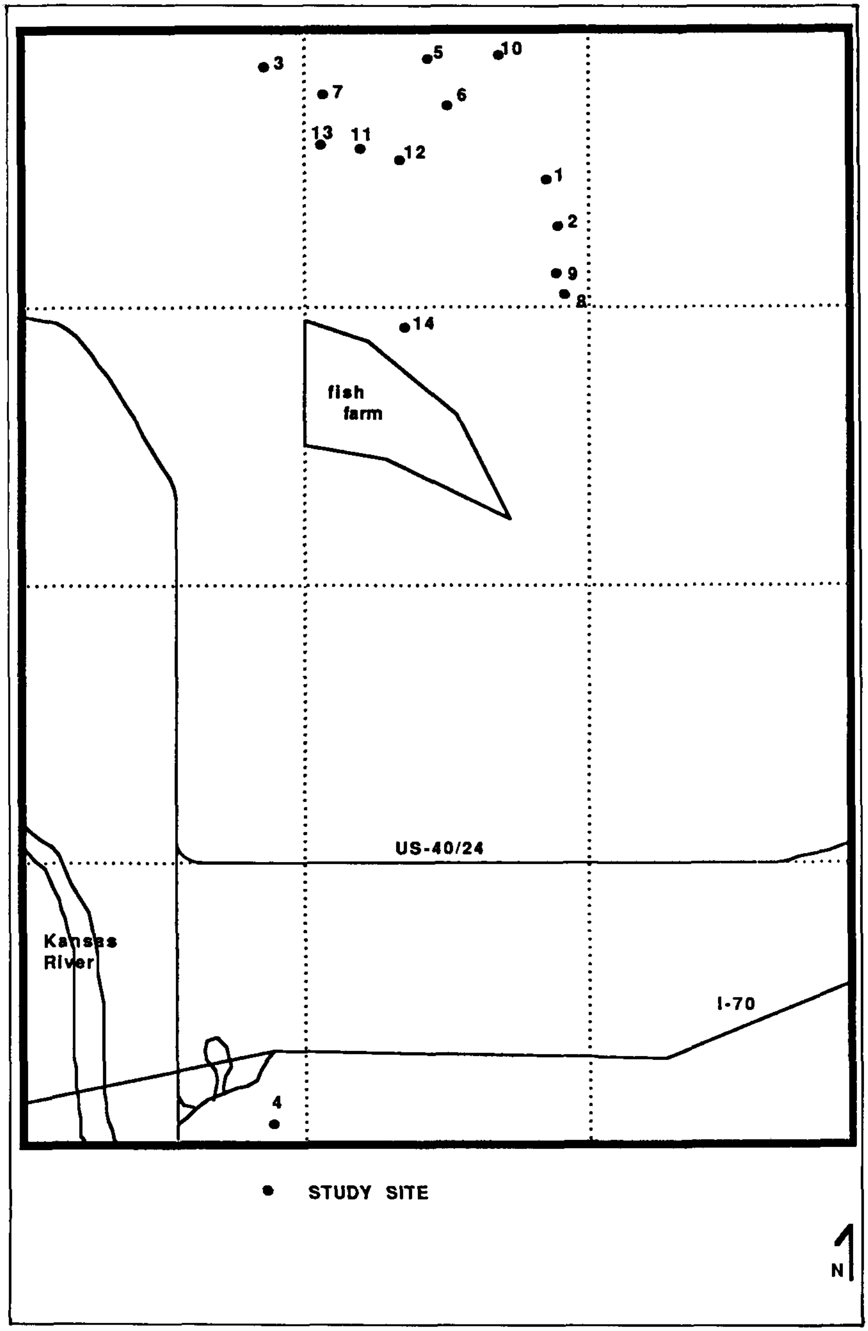


Figure 2. Area northeast – location of sites.

required attention. A few of the factors required for a particular LESA structure were not available in the data bases; others had to be adapted. For example, in the LESA structure adopted by Shawnee County, one factor of the SA subsystem is "percent of land in agriculture use within 1/2 mile of the site." However, the data available in the GIS used a radius of one and one-half miles, in keeping with the LESA structure discussed with Douglas County planning staff [12]. Since the final data included all the necessary adjustments to accommodate these variations, no significant inaccuracies resulted in the final scores. That is, any specific SA factor requiring revision or recalculation was checked for every site in the sample, thus assuring a consistent level of accuracy among all the sites. This research used the Map Analysis Package, a computerized geographic information system, to calculate or manipulate the map whenever possible [13].

The first step in this phase of the project entailed the calculations of the final LESA scores for each site. This part of the research utilized five different evaluation structures for purposes of comparison. These five LESA structures follow:

1. *GIS* – the numerical scores of the data base as available directly from the GIS project (these factors and weights were calculated by the Geography class according to recommendations from the original LESA report by the SCS [6]);
2. *GIS/DG* – the above data base, and its factors, using different weights for the factor calculations as suggested by Douglas County Planning Staff in 1983;
3. *DG* – the set of proposed SA factors for Douglas County (as per an internal staff memo of August 1982) and the same weights as in "GIS/DG" above;
4. *SHNEE* – the LESA factors and weights as adopted by Shawnee County; and finally
5. *TREE* – a "tree" structure of the proposed Douglas County factors, using weights adjusted from GIS/DG to reflect the hierarchical relationships of factors within the tree.

The tree structure, as illustrated in Figure 4, is useful for a variety of reasons. Initial examination of the LESA structure adopted by Shawnee County, as well as that proposed by Douglas County, uncovered some potential problems. When any evaluation system includes many different judgement factors, Rittel strongly argues that these factors must be mutually exclusive and independent elements, otherwise an overlap and "double weighting" effect occurs [15]. For example, there are four different factors in the examined LESA structures that address land use around each site. These are weighted and evaluated separately and include:

1. "Percent of land immediately adjacent to the site in agricultural use";
2. "Percent of land immediately adjacent to the site zoned for agricultural uses";

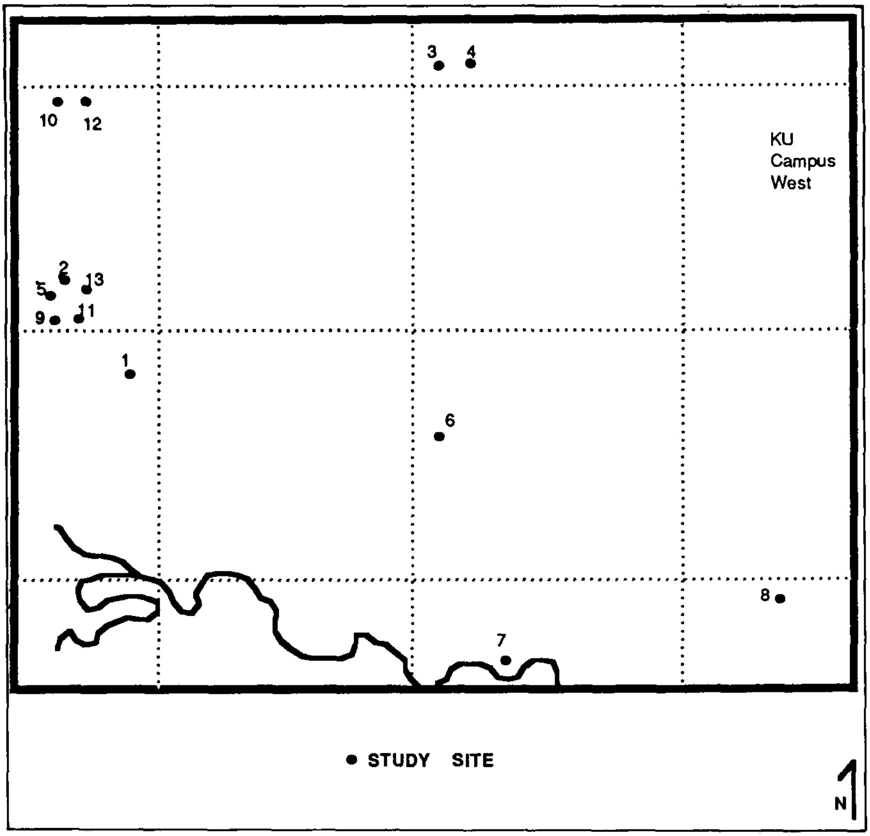


Figure 3. Area southwest – location of sites.

3. "Percent of land within one and one-half miles of the site in agriculture use"; and
4. "Percent of land within one and one-half miles of the site zoned for agricultural uses."

A quick view of Figure 4 confirms the obvious redundancy implied in these identified SA factors. As Wright indicates, the original SCS proposal included categories of evaluation factors, which would reinforce the use of the tree structure [16]. This structure can greatly simplify the LESA evaluation model. Weights are assigned only within each level, or branching, of the tree, which in turn contains a smaller and therefore more understandable set of judgements factors. This approach assures discrete sets of factors established within an overall hierarchy. The adjusted weights given in Figure 4 reflect those provided in conversations with members of the planning staff [16].

For each site, it was necessary to make several calculations. First the LE

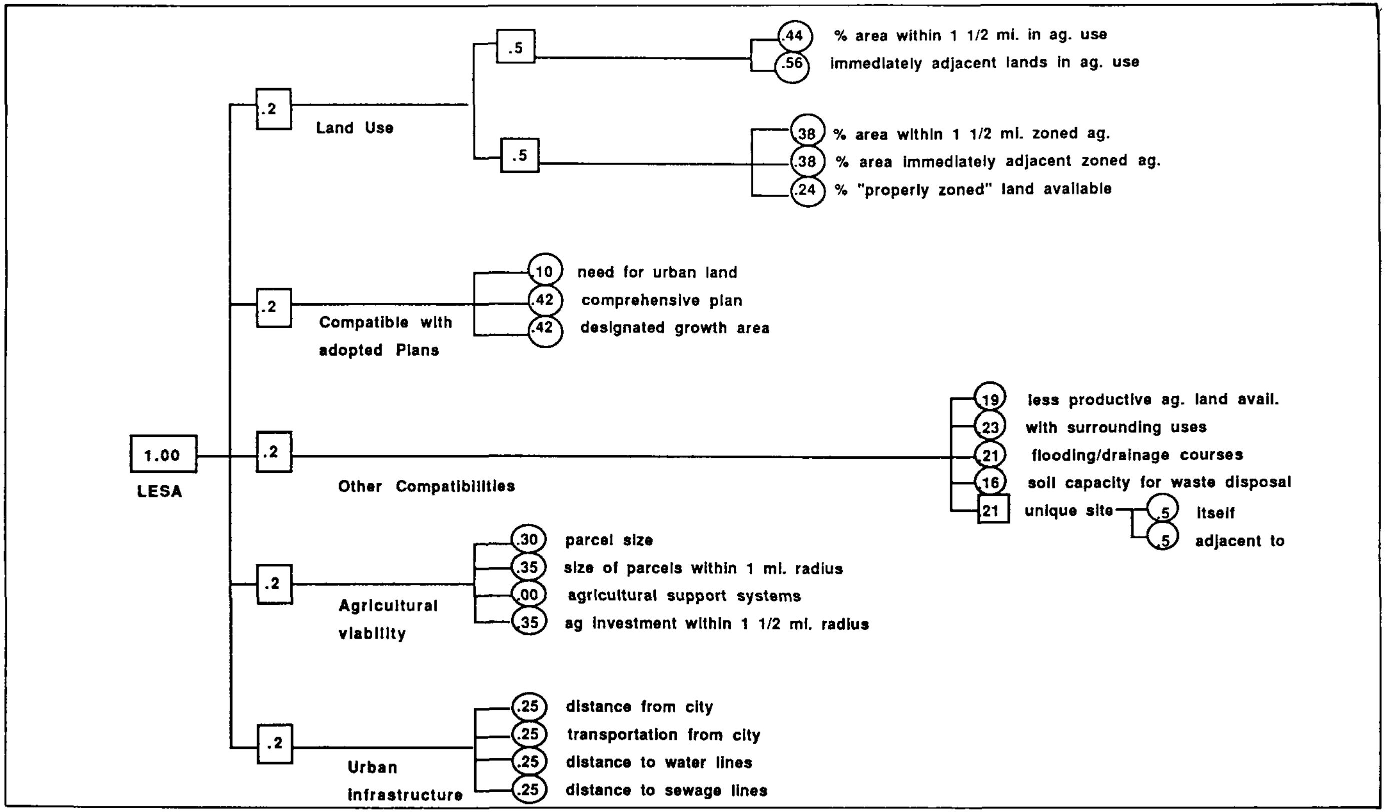


Figure 4. Tree of aspects for Douglas County LESA (system labelled "TREE" in Table 1).

score was determined; this remained constant under all five LESA structures. These scores were available directly from the GIS data base, calculated according to the recommended procedure using "indicator crops" [11]. Then the various SA scores were calculated according to the five described LESA structures. When added to the LE scores each site received a final LESA evaluation score. For purposes of comparison, a set of calculations for Douglas County with equal weights assigned to each factor became the "control" scores. The averaging of LESA scores for each site across all five systems allowed an analysis of deviations from mean scores. This was done only for Area NE, to check these potential deviations and to determine if any of the five systems produced inherently skewed results.

Once all the sites had final LESA scores, interpretations of these scores were done relative to a final evaluation, or decision, structure. This is another point which reflects judgements by decision makers and may vary considerably. Shawnee County adopted the SCS recommended structure which allocated 100 points maximum to the LE subsystem and 200 maximum for the SA subsystem. Using the 300 point total from this system, four specific grade levels evolved:

	If LESA Score Is:	*Then Planning Action Should Be:*
A	$\geqslant$ 250 Points	Extremely high protection efforts
B	225-249	High protection efforts
C	200–224	Moderate protection efforts
D	$<$ 200	Low protection efforts

One hypothesis was that variations on this scoring structure would lead to different permit responses, so two final evaluation structures were examined for Area NE. Since none of the sites scored greater than 225 in Phase One, the first alternative rescaled the decision categories to have a maximum possible score of 225 rather than 300. Since questions exist regarding the initial 1:2 ratio of LE:SA scores, another approach involved recalculating the scores to see if this ratio was significant. Establishing a 1:1 ratio for the LE:SA factors produced a second alternative set of scores.

Phase Two

This phase of the project tested a specific approach for establishing the SA factors in a logical and efficient manner. The approach to enumeration of factor weights and incorporation of factor interactions involved an iterative learning model, allowing several opportunities for planners to change their minds in the face of new information (see Figure 5). It provided a formal procedure for selecting factor weights as mutually exclusive entities via the Delphi technique [17]. Following the determination of factor weights the relationships of the factors were structured using a *cross-impact* matrix.

Further model operation occurred through the application of the Kane

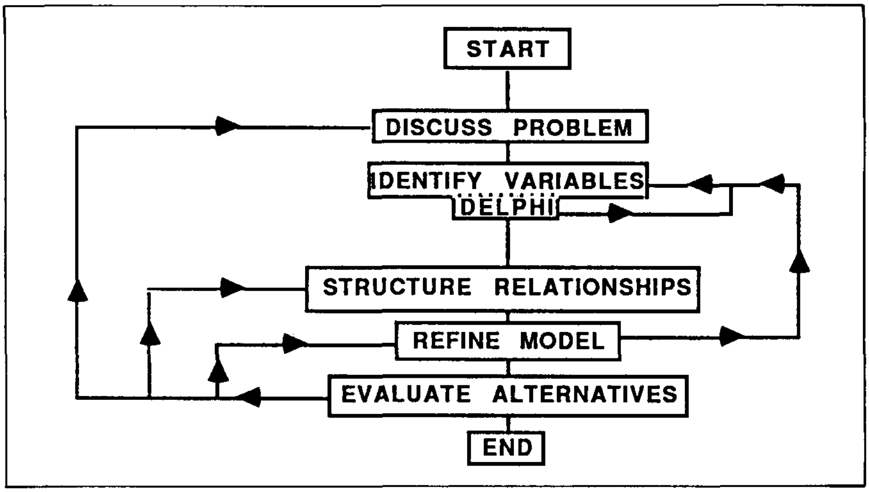
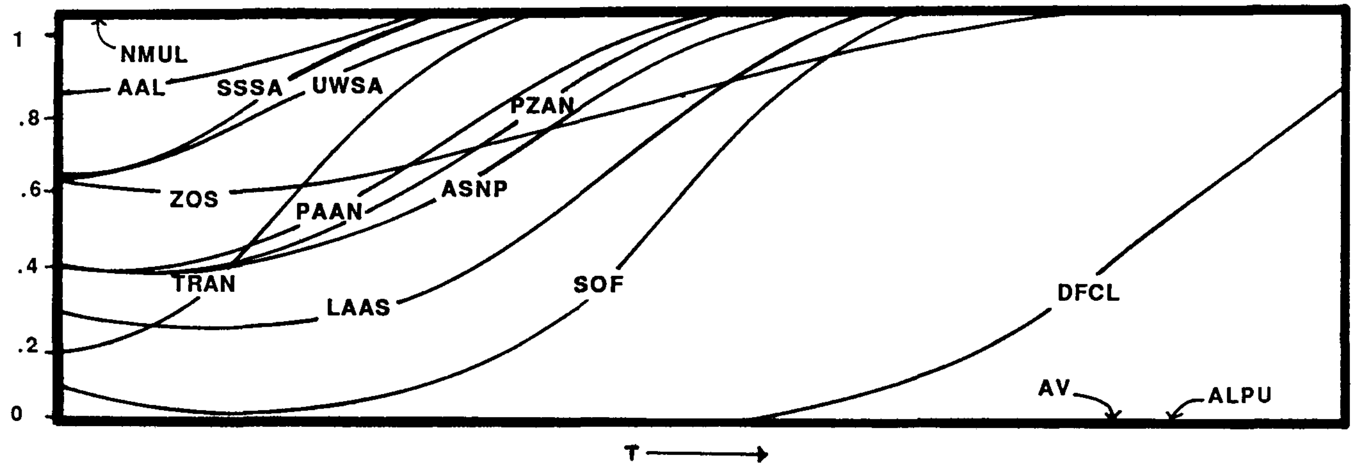


Figure 5. Iterative learning model.

Simulation Model (KSIM), which indicated the effect of factor interaction over a period of time [18]. Incorporation of these established interactions to the final factor weights determined the final LESA model for Phase Two.

Initial discussion with participants from the Douglas County Planning and Zoning Administration Officers began with the LESA system as originally developed by the SCS. This group decided that the 100 point value for Land Evaluation was arbitrary, and not useful for the area under consideration. Discussion continued with the presupposition that Land Evaluation would be weighted along with the Site Assessment factors, and that it be given a weight appropriate to planning in Douglas County. The planners then compiled a list of factors which were of use in their decision-making processes, and each participant privately ranked and weighed each factor as an independent agent in the planning process. They also indicated their reasoning behind this ranking for later discussion. Subsequent meetings led to arbitration among the participants until a concensus was reached.

Once the factors were defined and their weights established, the cross-impact matrix of the factors was compiled. This is one technique available which addresses the problem of interdependent factors as raised in Phase One. The matrix was designed to conform to the KSIM utilization of policy factors. A sum of the policy factors became a single value, then these values were tabulated. With a completed matrix, a study site was selected, with the various factors receiving appropriate weights. At this point a run of KSIM indicated the long term impacts of these factors on this chosen site (see Figure 6). The planning staff then discussed the results at length to decide if the model was performing as expected.



FACTOR ABBREVIATIONS:

AAL----Availability of alternative land
ALPU--Availability of land zoned for use
ASNP--Average size of nearby parcels
AV-----Agrivestment within two miles
DFCL--Distance from city limits
LAAS--Land in agriculture adjacent to site
NMUL--Need for more urban land

PAAN--Percent area in agriculture nearby
PZAN--Percent land zoned in agriculture nearby
SOF ---Size of farm
SSA----Sanitary sewerage system available
TRAN--Transportation accessibility
UWA---Urban water system available
ZOS ---Zoning of Site

Figure 6. Kane Simulation Model showing rates over time.

The planners seemed satisfied with the outcome of a single run of the model. which simplified the process overall. It is important to note that upon evaluation of alternatives, the cross-impact matrix and KSIM can be run as often as necessary to obtain the desired model outcome, as Figure 5 indicates. Also, it is important to understand that the simulation model will often indicate a lack of certain LESA variables necessary for proper land use planning. Should this occur, it is possible to return to the Delphi Technique to reestablish additional factors and their weights.

Since the participants found the model results satisfactory, the LESA weights were adjusted using the values in the cross-impact matrix. This was done by adding all the positive and negative impacts on each factor and adjusting these to a percentage change. The percentage change was then multiplied by the original factor weight to determine the change in the factor weight. Since positive impact percentages indicate that factors affecting any individual factor are acting together to increase the value of that factor, and since this research attempts to accommodate these interactions in a linear mode, changing the sign of the total percentages prior to multiplication assures this. The values were then zeroed. These ranked multipliers were then multiplied by the factor weights themselves. The final LESA values for Phase Two were obtained by adding the initial weights to the calculated weights.

A validity check of the results of this new LESA model development method utilized the building permit data bases already established to reflect the planner's wishes for development in this county. LESA scores from the system originally proposed by County staff ("DG" in Phase One) were compared to those scores derived from this model. Estimates of conditions existing during the year of building permit issuance led to both sets of scores. Original (DG) and new (Phase Two) scores were averaged and the results analyzed. It must be remembered that the very existence of building permits does not indicate that the planners would approve issuance of such permits. Political pressure and legal loopholes will often allow issuance of permits against the wishes of the planners. Also, some of the permits are for farm homes which will encourage the continuance of agriculture in these areas, rather than discourage it.

RESULTS

The clearest indication from Phase One is as expected: the different factors will yield different recommendations on a given site; further, the same set of factors weighed differently will produce different protection areas. The examples given in Table 1 show these cases. However, other comparisons were less straightforward. Area NE was examined for deviations, using the full set of scores relative to another full set to determine positive or negative deviation. That is, standard deviation calculations within each system's scores were not used, as this is inappropriate here. The test for deviation thus occurred as

Table 1. Various System LESA Scores, Phase One

PHASE ONE: LESA SCORES LE:SA = 1:2; Max = 300								
	LE	LE + SA TOTAL						MEAN
ID #	Only	GIS	GIS/DG	DG	SHNEE	TREE	CONTROL	SCORES
				Area Northeast				
NE 1	10	124	116.6	107.0	159.2	98.2	111.4	121.00
NE 2	10	124	113.6	104.0	136.1	98.2	108.6	115.18
NE 3	77	199	185.8	178.9	215.6	173.4	133.8	190.54
NE 4	100	182.3	181.3	178.8	182.9	164.7	170.9	177.99
NE 5	5	126	117.8	108.6	118.1	110.8	115.0	116.16
NE 6	10	130.5	119.2	112.9	143.2	106.8	117.2	122.52
NE 7	84	208.5	194.5	187.6	213.2	182.4	191.7	197.24
NE 8	75	191	180.8	171.8	210.4	162.8	175.1	183.36
NE 9	75	188	179.2	170.2	220.0	160.6	173.3	183.48
NE 10	5	126	117.8	108.6	118.1	110.3	115.0	116.16
NE 11	77	213.5	194.2	174.2	208.0	164.6	190.2	190.90
NE 12	75	205	189.4	181.3	202.3	158.8	190.5	187.36
NE 13	84	202	191.6	185.3	218.4	178.6	193.5	195.18
NE 14	63	202.5	184.6	176.5	198.2	172.8	183.4	186.92
MEAN:	54	173.0	161.9	153.3	181.7	135.4	155.0	163.14
				Area Northeast				
SW 1	5	105	96.8	94.5	116.2	97.7	101.4	102.04
SW 2	77	175	159.8	157.6	160.5	177.5	169.7	166.08
SW 3	10	51	65.4	67.7	72.4	68.7	73.6	65.04
SW 4	10	49	46.9	51.4	72.4	54.4	57.3	54.82
SW 5	5	94	83.2	86.1	78.2	102.7	94.1	88.84
SW 6	75	165	147.8	144.1	163.7	149.0	152.3	153.92
SW 7	100	194	168.6	170.8	183.2	183.9	173.6	180.10
SW 8	84	129	123.2	128.6	152.7	138.5	133.1	134.39
SW 9	10	50	79.7	82.4	83.5	101.0	90.0	79.32
SW 10	10	123	98.0	97.7	101.2	104.5	104.5	104.98
SW 11	5	94	83.7	84.4	91.0	97.3	94.1	90.08
SW 12	75	190	163.4	165.6	178.3	170.9	169.5	173.64
SW 13	77	168	163.2	164.7	163.0	172.3	169.7	166.24
MEAN:	42	122	113.8	115.1	129.3	126.8	121.8	120.00

described. None of the tested systems had a consistent bias; however, one system had only a single deviant site, while two others had only two deviant sites. It is significant to note that no single site or set of sites is consistently deviant across different evaluation structures, indicating that the system deviations cannot be attributed to the unique qualities of any particular site.

No single site of the actual building permit samples consistently scored high among all evaluation scales. However, from the hypothetical sites utilized in Phase One, H7 of Area SW, and less consistently H1, H3, and H10, of Area NE, received high scores according to the final evaluation scale. With the alternative final scoring scale which lowers the maximum possible score to 225, these high scoring sites become more readily apparent (see Table 2).

Further, when adjusting the LE:SA ratio, the results are as expected. More sites score higher, thus falling into the "protection" category indicated in Table 2. Examining the Shawnee County System (SHNEE) shows that there are only

Table 2. Recommended Protection Levels

2A: Using Original LESA Grading Ranks

	Phase One (DG)	*Phase Two Adjusted to 1:2 = LE:SA (DMERS)*	
LESA Score	*NE/SW*	*NE*	*SW*
250	None[a] of the sites fell within these ranges	0	0
225-249		3, 7, 11, 12, 13	0
200-224		8, 9, 14	0
200	All	1, 2, 4, 5, 6, 10	All

2B: Adjusting the Grading Ranks (to account for Douglas County Scores)

	Phase One (DG)		*Phase Two Adjusted to 1:2 = LE:SA (DMERS)*	
LESA Score	*NE*	*SW*	*NE*	*SW*
208	0	0	3, 7-9, 11-14	0
187-207	7	0	0	7
167-186	3, 4, 8, 9, 11-14	7	1, 2, 4-6, 10	0
166	1, 2, 5, 6, 10	All the rest	0	All the rest

[a] Hypothetical sites NE H1, H3, and H10 were in the 200-225 range; SW H7 was also.

two sites which deviate from the overall trend of this structure to have higher scores than either the average or the set of equally weighed scores ("control"). The range of deviations is also highest for the SHNEE system; one of the two deviant sites helps account for this. By comparison, the tree structure, which eliminates or at least reduces redundancy among factors, had consistently lower scores overall; the few positive deviations are within 3 points of the average. This finding supports reexamining the final grading or decision points in terms of actual protection levels, especially if a tree structure is adopted.

The results of Phase One were sufficient to confirm the basic research issues: that a given site may have very different planning recommendations presented depending upon the LESA system chosen for use. Additionally, the LE:SA ratio will play a major role in the final score results. However, the LE scores alone are insufficient to use as predictors in the final LESA score. That is, regardless of the weight ascribed to LE, whether 100 of 300 points (33%), 100 of 200 points (50%), or as only one in the total set of factors (8.63%, as in Phase Two), the variation of scores for sites with 0 and with 100 (lowest and highest possible LE score) is too great to conclude that LE scores could be considered a predictor. Planners and permit decision makers should recognize the implications and potential limitations of any scoring structure they use.

The planners found the model developed in Phase Two to be an improved model over the Douglas County original (Table 3). Their desires to protect the land in Area NE from further expansion is not reflected in the DG LESA scores which average 153.3, corresponding to low protection efforts. The new LESA values averaged 230.6 points, which would allow higher protection efforts.

The planners' desire to provide low protection efforts for Area SW are well supported by both sets of scores. The average value in this area using the Phase Two system is 106.1. As originally proposed, the LESA average of 115.1 for system DG would also tend to discourage protection efforts.

Although the planners found the Phase Two LESA system to be improved, there was much difficulty in the establishment of the cross-impact matrix. The shear number of factors which had to be compared in a 23 x 23 matrix would likely preclude its use in a non-academic setting. Further, this same multitude of variables produced difficulty when attempting to explain the final KSIM model. A reduction of factors through a tree structure prior to cross-impact and KSIM applications would greatly improve the utility of this methodology to determine factor weights and to incorporate factor interactions.

DISCUSSION

There are several aspects of this study which merit further discussion. One immediate concern is the recognition of an inherent contradiction in each of the LESA structures examined. In several of the factors, the distance to an urban or developed area strongly influences the scores. The presence of urban

Table 3. Comparing Phase One and Phase Two Results for Both Areas in Douglas County

			With LE:SA = 1:2		*With LE = 8.63%*
ID #	*LE*	*SA*	*DG LESA*	*DMRS LESA*	*Of Total Set of Factors*
			Area Northeast		
NE 1	10	97.0	107.0	169.33	239.0
NE 2	10	94.0	104.0	174.87	247.3
NE 3	77	101.9	178.2	237.57	247.8
NE 4	100	78.8	178.8	171.96	116.6
NE 5	5	103.6	108.6	169.87	247.3
NE 6	10	102.9	112.9	173.67	245.5
NE 7	84	103.6	187.6	226.33	220.4
NE 8	75	96.8	171.8	222.66	228.4
NE 9	75	95.2	170.2	218.13	221.6
NE 10	5	103.6	108.6	168.80	245.7
NE 11	77	97.2	174.2	235.57	244.8
NE 12	75	106.3	181.3	232.97	243.9
NE 13	84	101.3	185.3	242.57	244.8
NE 14	63	113.5	176.5	215.77	235.2
MEAN	54	99.7	153.3	206.22	230.6
			Area Southwest		
SW 1	5	89.5	94.5	179.26	115.9
SW 2	77	80.6	157.6	160.77	132.6
SW 3	10	57.7	67.7	47.67	56.5
SW 4	10	41.4	51.4	42.93	49.4
SW 5	5	81.1	86.1	72.71	101.6
SW 6	75	69.1	144.1	159.65	133.9
SW 7	100	70.8	170.8	188.29	141.1
SW 8	84	44.6	128.6	149.64	105.4
SW 9	10	72.4	82.4	67.71	101.6
SW 10	10	87.7	97.7	90.20	120.3
SW 11	5	79.4	84.4	72.71	101.6
SW 12	75	90.6	165.6	149.25	118.3
SW 13	77	87.7	164.7	140.10	101.6
MEAN	42	73.3	115.1	117.00	106.1

infrastructure, the distance to town or to transportation systems, as well as the compatibility with the comprehensive plan "designated growth area" are all a function of proximity to the developed area. Those sites close to town will have SA factor scores which reflect this relationship. They will most likely have lower overall LESA scores as a result.

Yet as has often been documented, prime agricultural land closest to urban areas may be in need of the most protection USDA [5, 20]. This is certainly the case along the California Coast, and is likely to continue to be true within fertile flood plains adjacent to urban areas [19]. The present trend in the LESA systems examined, and the final grading structures adopted within them, do not account for this contradiction; instead they reinforce it. Unfortunately, this could result in LESA's unintended use to support continued suburban sprawl.

The intent of the tree system utilized in Phase One was to simplify the set of factors for judgment as well as eliminate a multiplier effect of the factor weights. The simplification afforded by the tree structure also has the effect of assuring that the assigned weights retain their original values, thus preserving the relative relationships of values among them. Overall, as noted earlier, the final scores using the tree structure were lower; the explorations of different final grading structures were doubly necessary given this result. The choice of cut-off points for different levels of protection in the final grading system thus becomes an even more critical planning decision. This, along with the ratio established between the LE and SA scores, has been given too little emphasis in reviews of LESA applications in view of their relative importance.

The use of the tree system has other implications. There may be only a few key factors which have any significant effect on the final SA score. Within the simplified tree system, the potential for this becomes more evident. For example, in a rural county like Douglas, practically the entire area outside of the city limits is zoned agriculture; thus the zoning of the site or of adjacent land is of questionable use in determining a LESA score. Further, any land in agricultural use is probably already zoned for agriculture use; however, it may not be zoned exclusively for agriculture. Thus certain factors, often given high weights by decision-makers, may actually have no direct effect in differentiating two sties. This is confirmed by the results of KSIM, in which the transportation factor emerged as a pivotal variable. In addition, the LE score is obviously a significant one; the elimination of its overwhelming weight in Phase Two of the research attests to that.

The severe reduction of the LE subsystem to less than three percent of the entire LESA model gave more control to the planning staff, and therefore for their purposes this reduction achieved a more useful system. This indicates the problem of conflicting scales of operation. That is, the LE subsystem is designed for operation at the national scale, with national goals, and the SA subsystem is designed to operate at the local level with local goals. The Douglas County planners essentially reduced the importance of the national goals to apparent insignificance compared to their own local goals. Subtracting the low-weight LE factor from the scores in the Phase Two system produced nearly identical values (see Table 3). Conversely, the LE scores cannot stand alone for the planning decisions. The planning goals of the local government must indeed find a useful balance with the national goals of agricultural land protection.

Another issue arises when looking at the agricultural use or potential of any given site. How agriculture is defined may change the resultant score achieved. If the LE scores are based on potential production of an "indicator crop," then those sites which are ranches or grazing lands are excluded [6]. Certainly, the choice of indicator crop is an important one made by any planners using the LESA system. As noted by Dent and Young, when quantitative evaluation factors are used for the basis of further studies, there is a need to make the qualitative assumptions and results clear, in case adjustments must later be made [21]. The concern raised here is that whatever choice is made can potentially discriminate against otherwise viable agricultural sites (such as pasture land). This question of defining "agricultural use" also affects the factor which examines an area with a radius of one and one-half miles from the site for agricultural use. The lenghy debate in the California Coastal Zone over the inclusion of grazing lands in the definitions of "Prime Agricultural Land" indicates that this is not an easy matter to resolve [3, 4, 19]. Again, individual planning agencies must address these potential limitations of LESA according to a balance of local and national goals.

Further, when analyzing the possible conversion of a large agricultural parcel to residential use, how much of the site should be scored with LESA? There may be a wide range of uses within one-half mile of the site on one side of a 160 acre parcel compared to the uses within the same distance of the opposite side. The hypothetical sites used in Phase One exemplify this dilemma. The location of the building within each 160 acre parcel was determined by topography, roads, and utility access—a "logical" location for a house on each parcel. There were alternative hypothetical locations for some of these sites, and they would have generated different values for certain aspect scores. Williams suggests an average LESA score may be required, using the GIS digitized structure for the entire site, even when not developing the entire parcel [11]. Taken a step further, why would LESA even be applied when a residential unit is proposed for a site which still remains agricultural?

CONCLUSIONS

Certain aspects of LESA need to be looked at very carefully before implementation occurs in any region. The choice of weights as well as the selection of aspects employed in any given LESA structure will have an effect on the final site scores. In turn, the final grading, or planning decisions based on these scores, will be affected. Even more important are the LE:SA ratio and the grading cut off points. When the LE score is minimized, as was done by the planners in Phase Two, the variability is unaccountable. Therefore the ratio recommended originally by the SCS should remain intact, as the two sets of calculations varying this ratio were too inconsistent to adopt as alternatives.

The use of a LESA structure requires a strong commitment to integrate it with planning policy decisions, especially when protection of agricultural lands near urban areas is needed. LESA does have a powerful potential for planning applications. Once the structure is determined, the different sites in the planning jurisdiction will have equal treatment in terms of the analysis of relative values. The simplification of the system is suggested, with a recommendation to adopt a tree structure within the systematic learning framework. In this way the aspects are better assumed to be mutually exclusive, and the key decision factors can be more readily identified. Further, the weights assigned in both the tree structure and the KSIM approaches remain closer to the intended weight values once assigned, improving the understanding of the structure's consequences through time.

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