GIS APPLICATIONS IN THE LANDSCAPE PLANNING OF OUTDOOR PIGS BREEDING

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ABSTRACT

The present work concerns the study of a methodology of environmental analysis to identify suitable areas for outdoor pigs breeding. The purpose of the research is to promote the utilization of marginal territories through alternative livestock activities in order to provide typical products of high quality, regarding the animal welfare and the impact of breeding plants on the environment. The research was conducted in rural areas of south Italy, located in the hilly and mountain regions of the Appennine chain.

For these studies a raster data set, which includes aerial digital orthophotos and IGMI (Italian Geographic Military Institute) cartography with scale 1:25000 (paper and digital form), was used. In order to organize the procedure for the realization of thematic maps, specific geographical features were checked. Then, by video digitizing and air photo-interpretation, it was possible to deduce a few thematic maps of the land-use, the slopes and aspects, the road infrastructures, the hydraulic network, the urbanized areas. In accordance with these themes and other information, an environmental analysis was conducted, elaborating different informative layers to identify the suitable areas of the territory for the sustainable breeding. For these elaborations a GIS software (Arc View ESRI) was used.

The study allowed to identify a few areas characterized by different aptitude for the sows breeding and for pigs in fattening phase. The results of the experimental study were provided with tabular and cartographic data sets, that constitute the main tools for the management of the following phases of the territorial planning.

KEYWORDS: Outdoor pig production, G.I.S, suitable areas, sustainable breeding.

INTRODUCTION

The present work reports an environmental analysis of the method used to identify the most suitable territories for the extensive pig breeding. It refers particularly to the phase of sows kept outdoor and to the pigs in fattening phase, in agricultural and forest areas.

Nowadays the improvement of rural areas and the sustainable utilization of secondary forest resources (under-wood products, acorns, chestnuts, beech-masts) can be pursued through alternative breeding systems. The aim of these innovative systems is to promote the exploitation of typical products of high quality, respecting the animal welfare and reducing the impact on the environment. This may be possible thanks to a sustainable use of forest food resources.

The development of these livestock productions finds the most suitable locations in rural areas, characterized by a different use of the territory. In fact, this is also possible in connection with the aims of the regional programs for the improvement of rural districts (according to the agricultural-forest development plans).

For example the whole extensive pig breeding, or any phases of it, may be a new form of utilization of the marginal agricultural areas, in order to avoid abandoning them. In this way there is the opportunity of exploiting the abundant spontaneous food resources, like the fruits of the forest plants.

Since the aim is to identify a new utilization of these marginal areas up to now abandoned, we shall be able to foresee these breeding forms.

However we need to remember that there are some Italian and European laws which provide a series of regulations for the outdoor breeding (forest police rules, regional rules, urbanistic norms, hygienic-sanitary norms). In particular these restrictions concern the possible impacts on the environment, imposing rules that reduce the damages on the forest plants and on the soil, owing to grazing.

Now we can understand the needs of a careful analysis of the rural land in order to find the most suitable locations and their potentialities, in connection with the aims of the breeding planning above-mentioned.

The object of this research regards the study of a methodology for landscape planning to carry out appropriate environmental assessments. In fact the definition of correct operational procedures and the individuation of necessary tools could favour sustainable management of the territory.

MATERIALS AND METHODS

To identify an operational methodology, suitable for the different Italian regional districts, the territorial analysis was effected using a raster data sets, which are available for the whole Italian territory. This raster data set includes aerial digital orthophotos (AIMA 1997) and IGMI (Italian Geographic Military Institute) topographic maps with scale 1:25000. For the acquisition, storage, analysis and display of these geographic datas a G.I.S software Arcview 3.1© has been used.

A small town in Calabria region was chosen as the territory for the development of the present research.

The topographic maps were scanned in order to elaborate them by personal computer. The scansion in black and white colours allows an excellent elaboration of the maps on the screen (even with enlargements reaching the scale 1:100). Besides the chosen parameters allow the overlap of the several layers that the software employed does not manage.

Then, all digital maps selected were georeferenced with the aim to get an only informative layer which represented the cartography of the territory, defined by a well-known reference system. Rather than to convert paper maps into digital maps, in the future we shall be able to use directly the digital ones if they are already available for the interested areas.

By a GIS software and a video-digitizing process, the following vector data sets were organized in several map layers:

- elevation (obtained by video editing process of the contour lines);
- administrative boundaries;
- hydrographic network;
- road network.

Then, by the photointerpretation of the digital orthophotos, we mapped the following themes of land-use, necessary to meet the different needs of planning:

- wood;
- arboriculture;
- shrubs or grasses vegetation;
- pasture;

- tree covered pasture;
- sowable land;
- tree covered sowable land;
- urbanized areas.

Topographic information (elevation, road network, hydrographic network) is essential to find unsuitable breeding areas, which could also be forbidden by law or for environmental planning reasons. With reference to the legislation in force, there are several cautions to adopt when planning pig breeding, particularly about pollution topics (Ferrari, 2001). Generally the main problems concern water pollution and soil erosion. Besides there can be other unsuitable areas for extensive pig farms because of their closeness to urbanized areas or road networks; some European laws contemplate these cases.

To test this methodology for the environmental analysis, we considered some "*conditions of restriction*" connected with the road network, the hydrographic network and the slopes, in order to plan a few bounds of restriction (tab. 1).

The methodology developed during the present study considers only some parameters, but it is possible to increase it with other forms of restriction, as for example the forest restrictions for the regulation of wood grazing.

Tab. 1: Conditions of restriction to the location of outdoor pigs breeding.

CONDITIONS OF RESTRICTION	
RESTRICTIONS	SAFE DISTANCE
Road Network	50 m
Urbanized Areas	100 m
Hydrographic Network	30 m for the surfaces with slopes from 0 to 10 % 50 m for the surfaces with slopes from 10,1 to 25 %
All the surface analyzed with slope above 25% must be considered bound to restriction	

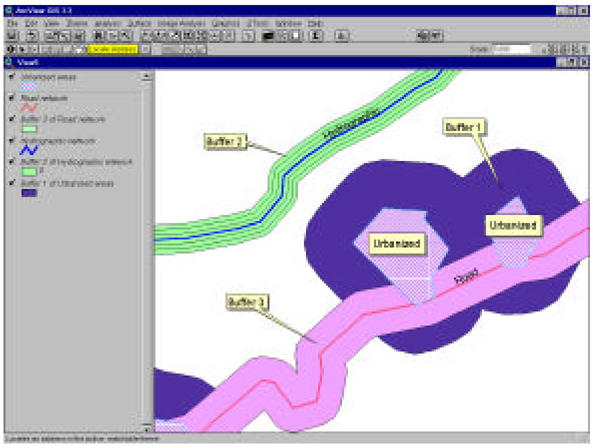


Fig. 1: Buffering to identify the safe distance from urbanized areas, roads network and hydrographic network.

With reference to table 1 we must observe that the bound areas, due to road networks and urbanized areas, were drawn using fixed parameters (50 m from road networks and 100 m from urbanized areas) whereas the bound areas concerning hydrographic networks are correlated to the slopes of the surrounding surface. This to simulate hypothetical and different risks of water pollution.

For the same purpose we could also consider other ecological parameters such as the local geologic and pedological characteristics. Besides we established that all grounds with slope above 25% must be forbidden to pig breeding to avoid problems of soil erosion.

After setting this kind of restrictions, it was possible to find the right position and extension of the bound areas by "buffering"(Fig. 1).

To study the influence of the slopes relating to the bound areas, it was realized a Digital Terrain Model (DTM). Starting from elevation spots, irregularly distributed and filed in a specific layer, it was realized a Triangulated Irregular Network (TIN) (Fig. 2) (P.K. Garg and A.R. Harrison 1990).

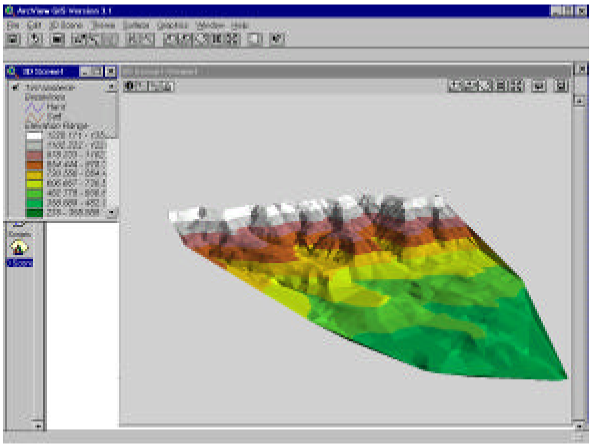


Fig. 2: Map representation of elevation range of the surface

By this model it was possible to realize a new map layer of slopes for the following analysis. In fact, on the basis of TIN (pitch 1 meter) it was possible to go up again to a fixed dimension of cell matrix. By interpolation between the elevation, it was attributed elevation "z" to each cells matrix. This level "z" was calculated connected with its centre (Fig. 2 and Fig. 3).

In this case, the present analysis was carried out with cells matrix small enough (1 m^2), because we effected these tests on geographically reduced areas (till 50 km^2).

From this, an informative matrix layer relating to the slopes ("*p*") was drawn, in order to divide them into fixed dimension (width) "*slopes classes* ". The matrix has been classified in 3 classes of slope (Fig. 3):

$$1^{st}\ \text{class}: 0 \le p \le 10\%$$
$$2^{nd}\ \text{class}: 10\% < p \le 25\%$$
$$3^{rd}\ \text{class}: p > 25\%$$

In the following elaboration phases, with the same principles, other information, such the aspects, was drawn (Fig. 4).

The informative map layer relating to the slope, drawn in matrix shape, was converted into a vector layer to make possible a following phase of analysis. Then, from forbidden zones and slope layer, we can identify all unsuitable areas by geoprocessing (*union* and *intersect*). The breeding farms will not be allowed to use these unsuitable areas because of the restrictions referred above.

The figure 5 points out the general result of the environmental analysis. It shows the bound areas to pig breeding for environmental restrictions (roads, hydrographic network, urbanized areas) and for steep slope (above 25%).

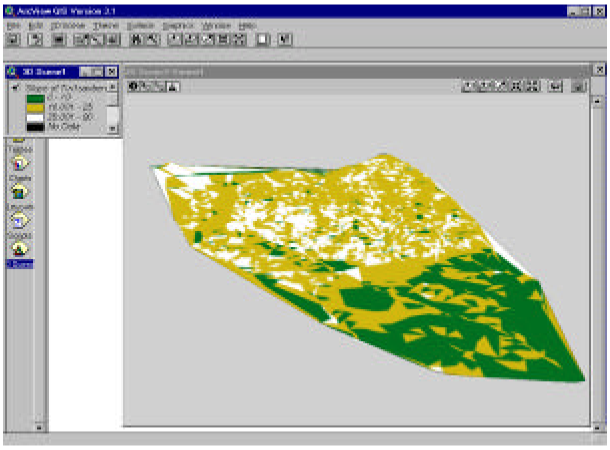


Fig. 3: Map representation of the classes of slope.

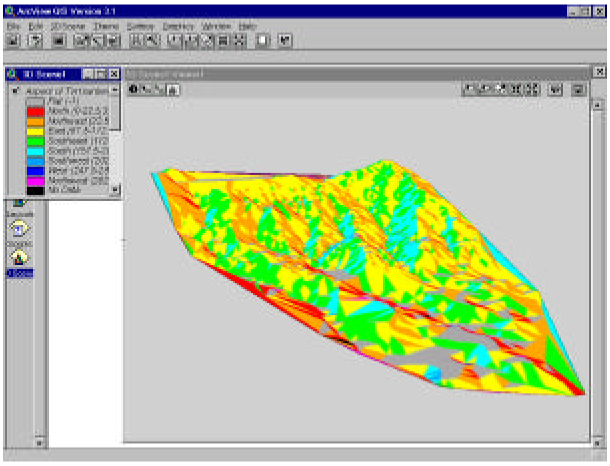


Fig. 4: Map representation of the classes of aspects

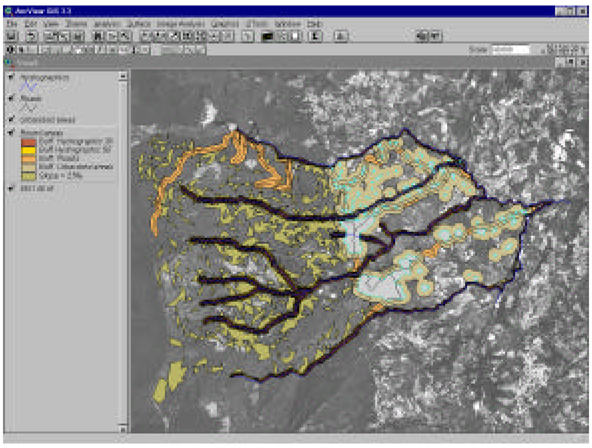


Fig. 5: Map representation of the bound areas.

After identifying the forbidden zones, the environmental analysis can point out the suitable areas for the extensive pig breeding. It needs to establish, for potentially suitable areas, a few principles of value attribution in order to define the classification of the *"suitable areas"* for this kind of breeding.

Therefore it is necessary to remember that the main purpose of this work is to promote the utilization of rural districts through alternative breeding forms. In fact the value attribution to different land-use classes must meet the objectives above mentioned.

The accuracy of the present analysis, concerning the suitable territories of the interested areas, depends on the applied methodology. The different values, set on several agro-forest ecosystems, explain their suitability for the alternative breeding form in synthetic way. These values come from considerations which concern the physical (elevation, aspect, etc) and biological features of the territory. The vegetational features are particularly interesting, in fact it is necessary to effect careful evaluations in order to have right values. Anyway, we need to adopt a specific methodology of study for every application.

In the present analysis, two different breeding phases were taken into consideration:

- outdoor sows breeding (especially in farrowing phase, in fencing areas);
- outdoor pigs breeding in fattening phase.

In order to estimate the suitability of the different land-use, in the interested area the following values were attributed (Tab. 2).

Tab. 2: Attribution of different values of land-use to calculate the vocational index .

Type of land-use	Sows in reproductive Phase	pigs in fattening phase
Shrubs or grasses vegetation with scattered woods	2	5
Sowable land	10	10
Arboriculture	2	2
Tree covered sowable land	10	10
Pasture	10	10
Wood	2	5
Tree covered pasture	10	10
Urbanized areas	0	0

Considering the agro-forest economic characteristics of rural area, we supposed alternative activities to promote the utilization of marginal territories. We considered the extensive breeding the right form to increase the productive value of these marginal areas. The highest values of the vocational index to plan breeding plant for sows were assigned to the sowable lands and grazing lands, because they are located on level grounds or with slight slope. Besides these kinds of grounds are characterized by draining soils and by their closeness to the business centre. These areas can be used for extensive cultivation, directly grazed by pigs.

On the contrary, the woods are considered suitable for extensive pig grazing in the fattening phase especially for the production of the secondary forest resources like acorns, chestnuts, beech-masts etc. These fruits of forest plants can increase the value of the pork's organoleptic characteristics through the grazing in the wild state.

The same considerations were made about other two parameters which characterize the territory: the slopes and the aspects. The more the slope increases, the bigger the problems of soil erosion become, also in consequence of animal grazing. Moreover in a steep slope it is very difficult to install the equipment for breeding especially in the farrowing phase. Table 3 classifies the used values concerning different classes of slope.

Tab. 3: Attribution of different values of slope to calculate the vocational index.

SLOPE	SOWS IN REPRODUCTIVE PHASE	PIGS IN FATTENING PHASE
0 – 5%	10	10
5,1 – 10%	6	8
10,1 – 15%	3	6
15,1 – 20%	2	4
20,1 –25%	1	2
Above 25%	0	0

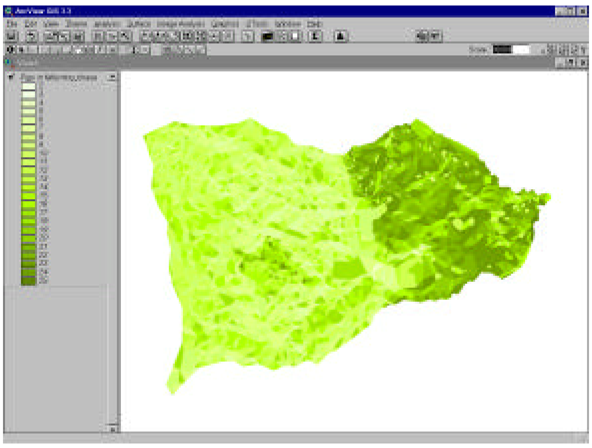
Even the aspect has great importance to define the vocational index, particularly when in specific environmental situations it is related to microclimate unfavourable conditions. Therefore it is necessary to assign different values to several aspects (Tab. 4).

Tab. 4: Attribution of different values of aspect to calculate the vocational index.

ASPECT	SOWS IN REPRODUCTIVE PHASE	PIGS IN FATTENING PHASE
N	1	2
NE	3	4
E	5	5
SE	3	4
S	1	2
SW	3	4
W	5	5
NW	3	4
Level ground	3	3

Comparing by a GIS software the parameters referred above, for the whole territory it was possible to assign synthetic values of suitability to the different breeding phases considered. The results of experimental study can be represented with cartographic data sets.

These map representations, obtained from the spatial analysis of the territory analyzed, constitute the thematic maps of the "*territory potentiality*".



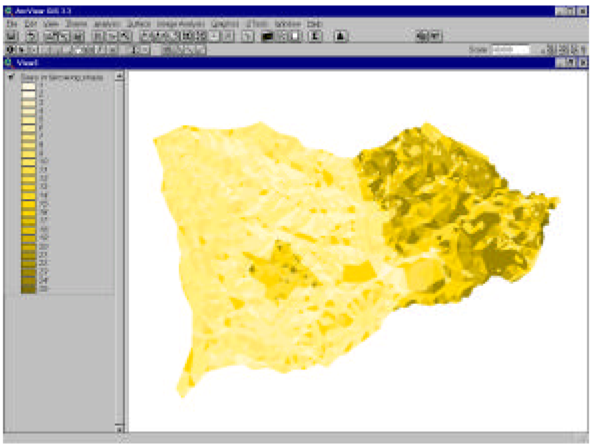


Fig. 6 -7: Thematic maps of potentiality of territory for pigs in the fattening phase and for sows in the farrowing-pregnancy phase.

The figures 6 and 7 represent the suitable areas for the sows breeding in the farrowing phase and for outdoor pigs grazing in the fattening phase. The whole territory is represented with cells of different colours which show all the "*classes of potentiality*". These classes represent the final result of the territorial analysis, which allows to give variable vocational index to basic units. The vocational index changes from a minimum of 1 (unsuitable areas) to a maximum of 25 (highly suitable areas).

Subsequently, by overlapping the *"territorial potentiality"* and *"conditions of restriction"* map layers, it was possible to display all the suitable areas for both breeding types, pointing out quickly the different levels of potentiality for each part (Fig. 8 and Fig. 9).

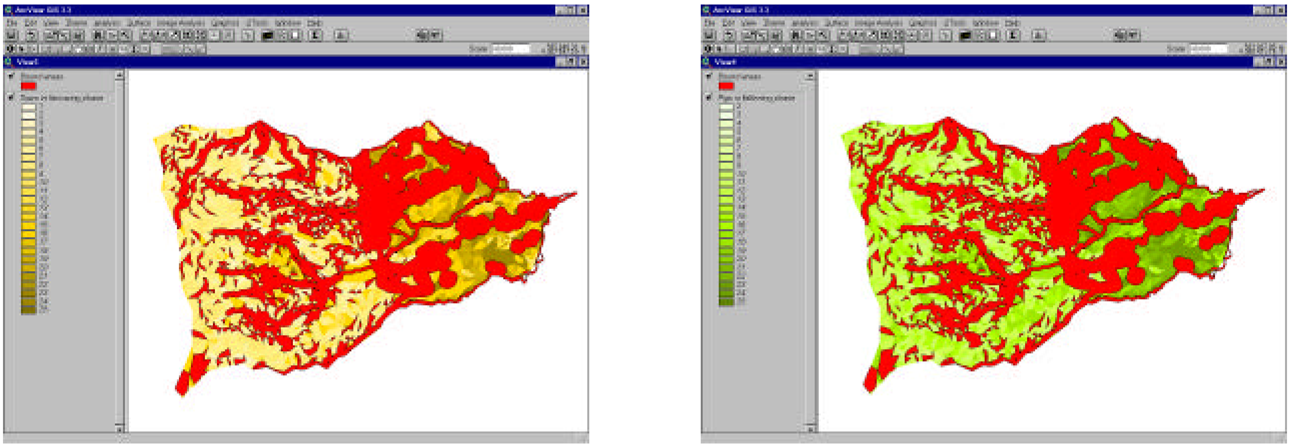


Fig. 8 – 9: Thematic maps of suitable areas for pigs in the fattening phase and for sows in the farrowing-pregnancy phase.

Results and Discussion

Tables 5 and 6 summarize the results of the analysis. Table 5 outlines the data concerning the areas that can be used in the fattening phase while table 6 refers to sows in the farrowing-pregnancy phase.

As we can notice, all the surface analyzed, about 19,2 square km wide, was classified in 25 suitable classes (col. 1) and for each of them the surface was calculated (col. 2). Then, for each class the part of surface that is *bound to restriction* was calculated (col. 3) and the one that refers to the areas that were united on the basis of their small extension.

In the example we assumed that areas less than 5.000 m^2 wide even if potentially suitable could not be easily used for swine breeding (col. 4). Columns 5 and 6 refer to the areas that can be really in use for the location of pig farms.

For both the breeding types the amount of the surface not bound by restriction is about 10,1 km^2 wide that is the 52% of the whole surface.

But this area is not suitable for breeding plants, in fact we can notice that almost all the classes of potentiality are present in the area, even the ones that have a very poor potentiality.

At an executive stage it could be convenient to make further studies, planning for instance to leave out those areas that have the poorest potentialities of development according to what the new model suggests.

In order to use the data for all practical purposes, it may be advisable to join some classes together to exclude the unsuitable areas from structural transformation.

So we assume to reclassify the area into new groups of range which correspond to 5 classes of potentiality, for the two kinds of breeding we considered: the following tables express the vocational classes for the breeding of sows in reproductive phase and swine fattening in wild grazing.

Tab. 5: Detailed analysis of the territory potentiality for pigs fattening in wild grazing.

	TOTAL SURFACE	BOUND AREAS	AREAS LESS THAN 5000 m²	AVAILABLE SURFACE	
1	2	3	4	5	6
Class of potentiality	Surface m²	Surface m²	Surface m²	Surface m²	%
1	0	0	0	0	0,00%
2	749	749	0	0	0,00%
3	0	0	0	0	0,00%
4	30.042	30.042	0	0	0,00%
5	2.255	2.255	0	0	0,00%
6	18.769	18.383	386	0	0,00%
7	764.381	753.913	37	10.431	0,10%
8	84.855	79.534	707	4.614	0,05%
9	2.231.721	1.689.045	21.720	520.956	5,14%
10	1.017.661	1.013.584	27	4.050	0,04%
11	2.085.838	467.460	32.975	1.585.403	15,65%
12	1.251.956	351.640	16.963	883.353	8,72%
13	1.949.319	463.703	13.641	1.471.975	14,53%
14	1.270.728	366.007	10.558	894.163	8,82%
15	1.027.175	318.870	1.536	706.769	6,98%
16	899.879	217.730	7.077	675.072	6,66%
17	316.881	150.846	1.905	164.130	1,62%
18	1.615.391	465.795	17.498	1.132.098	11,17%
19	196.936	97.890	226	98.820	0,98%
20	1.100.637	568.022	630	531.985	5,25%
21	380.933	194.061	21	186.851	1,84%
22	1.124.393	594.243	4.017	526.133	5,19%
23	1.738.036	1.045.919	10.171	681.946	6,73%
24	107.727	65.374	992	41.361	0,41%
25	35.886	23.454	121	12.311	0,12%
Total	**19.252.148**	**89.78.519**	**141.208**	**10.132.421**	**100,00%**

By analyzing the figures 10 and 11 and the tables 7 and 8, we can point out that, as the values given to the different kind of land-use vary, the potential utilization of the areas changes.

From this study we can remark that the breeding of sows in the farrowing-pregnancy phase needs less availability of large extensions. In fact, we can notice by examining figure 10 that the less mentioned classes 1 and 2 are represented with very high percentages (61%).

Considering that the construction of a plant for the breeding of sows in the farrowing phase needs a smaller space than the one for swine fattening in wild grazing, the values we pointed out might show a good potentiality of the territory referred above for this kind of breeding.

The presence of woods in the area shows a strong vocation for swine fattening in wild state. Only the 5% of the territory is occupied by classes of lower vocation while the 55% has medium vocation and the 40% a high vocation.

Tab. 6: Detailed analysis of the territory potentiality for breeding sows in reproductive phase

	TOTAL SURFACE	BOUND AREAS	AREAS LESS THAN OF 5000 m^2	AVAILABLE SURFACE	
1	2	3	4	5	6
Class of potentiality	Surface m^2	Surface m^2	Surface m^2	Surface m^2	%
1	749	749	0	0	0,00%
2	27.246	27.246	0	0	0,00%
3	773.122	765.254	423	7.445	0,07%
4	744.459	216.294	21.538	506.627	5,00%
5	2.026.865	1.640.645	4.360	381.860	3,77%
6	1.862.457	400.289	33.955	1.428.213	14,09%
7	2.414.994	1.152.149	9.217	1.253.628	12,37%
8	2.027.803	456.737	17.698	1.553.368	15,33%
9	1.144.438	254.931	10.743	878.764	8,67%
10	659.680	120.835	1.037	537.808	5,31%
11	414.934	270.114		144.820	1,43%
12	43.633	15.339	558	27.736	0,27%
13	700.332	470.978	281	229.073	2,26%
14	381.079	146.775	5.917	228.387	2,25%
15	1.351.573	473.000	17.633	860.940	8,5%
16	865.005	414.804	2.141	448.060	4,42%
17	426.804	229.329	385	197.090	1,94%
18	380.933	194.061	21	186.851	1,84%
19	1.106.341	579.708	3.899	522.734	5,16%
20	0	0	0	0	0,00%
21	577.161	380.861	525	195.775	1,93%
22	0	0	0	0	0,00%
23	1.286.654	744.967	10.756	530.931	5,24%
24	0	0	0	0	0,00%
25	35.886	23.454	121	12311	0,12%
TOTAL	**19.252.148**	**8.978.519**	**141.208**	**10.132.421**	**100,00%**

Tab. 7: Vocational classes of territory for breeding plant of sows in reproductive phase.

SOWS IN REPRODUCTIVE PHASE				
Vocational classes		Surface m^2	% on total	
1	Low vocation	3572441	19%	61%
2		8109372	42%	
3	Medium vocation	2891551	15%	15%
4	High vocation	2779083	14%	24%
5		1899701	10%	

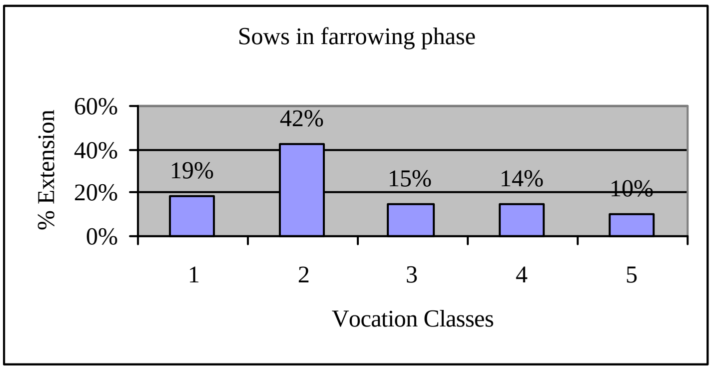


Fig. 10: Suitable territory for breeding plants in reproductive phase.

Tab. 8: Vocational classes of territory for pigs fattening in wild grazing.

PIGS IN FATTENING PHASE				
Vocational classes		Surface m^2	% on total	
1	Low	0	0%	5%
2	Vocation	540051	5%	
3	Medium Vocation	5541663	55%	55%
4	High	2602105	26%	40%
5	Vocation	1448602	14%	

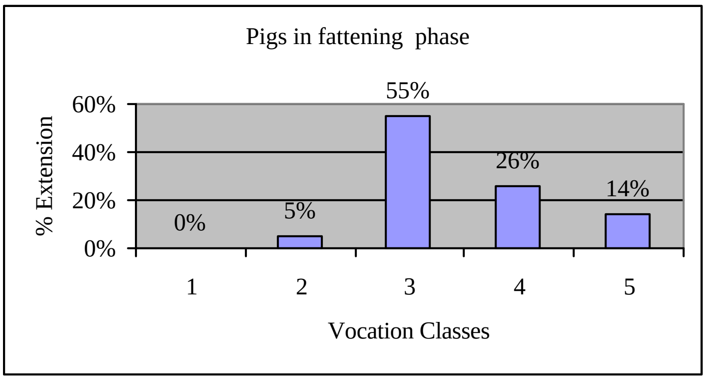


Fig. 11: Suitable territory for breeding plants in fattening phase.

A further analysis of the geographical setting of the areas and of their distribution, will allow us to express a more detailed qualification.

The vocational study of a territory cannot only concern the calculation of the areas characterized by their different destinations, but should also consider the physical peculiarities of the territory and its social and economic peculiarities.

The detailed analysis of the former information will allow us to identify the suitable parts of the territory which will be constitute the basic units for a good planning.

CONCLUSIONS

The analysis of the potentialities in the exploitation of the territory made up through GIS enables the realization of information files essential for an exact territory planning. A deep knowledge of the potentiality in exploiting the rural areas is needed on account of the continuous changes of agricultural strategies on a planning level. This strategy could also promote fast development programs which satisfy the market demand.

Through these kinds of information the farmer will be able to make the right choices to exploit the natural resources in a sustainable and rational way, to make good use of typical products, to respect the animal welfare, to reduce the negative impact on the environment.

The method we used during the analysis of the territory can be a good operative example suitable for strategies referred above.

In order to obtain an useful and efficacious result, it would be right to examine the methodology of analysis also with a more complete and detailed system of databases.

The bounds of restriction as well as the distance from road and hydrographic network or from urbanized areas, can be modified or increased according to the laws in force concerning the territory analyzed or specific requirements.

Special care is required in attributing values to different vocational indexes: in fact, even slight differences in attributing values to the same parameters could give very different results.

In the next months the methodology of environmental analysis shown in this study will be employed and improved in other different areas of Centre Italy.

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