

The Usefulness of a New Model for the Gully-Control Structures Effects Prediction

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Motto: Models are to be used, but not to be believed. (H. Theil)

ABSTRACT

Gully erosion has potential negative effects over the gully catchments, the gully channels and/or over the downstream confluent. The channel evolution together with the associated landslides can cause damages, which were detailed in the cause-effects matrix (Fig. 6).

One of the engineering solutions for the potential risks diminution consists of the gully equipping with check dams.

The paper deals, first of all, with the possibility of forecasting the stable slope of the deposition profile above gully- control structures. The prediction is based on a study of 43 cases. The research finished with a model, which is able to anticipate the equilibrium gradient magnitude. (Formula 16)

The author considers that the interest for the stable slope value accuracy is justified because this gradient serves for the "H"- height of dams- calculation. From an economic point of view, the structure costs and the upstream-trapped sediment volumes increase with H^3 .

The equilibrium slope is also important because it offers the possibility of assessing the size of sediment diameters, which continue to be transported and delivered in the emissary. This assessment is necessary in an environmental impact study and in the decision regarding the best gully trimming alternative choice.

INTRODUCTION

Romania is a European country lying on 237 thousand km^2 . Romania has natural conditions, which determine the intrinsic vulnerability at water erosion and landslides on 63.8 thousand km^2 . These degradations affect 43 percent of Romanian agricultural surface.

The gross sediment yield proceeded from various sources is 126 million tones per year. (Motoc, 1982). The delivery ratio of sediments is 44.6 million tones per year. It is supplied in a proportion of 36.2 percent by surface erosion and 36.9 percent by gully erosion. In Romania, the gully erosion is the most important component of the sediment amount discharged from the lateral small watersheds towards the permanent river network. Gullies can be intermediaries either between the hillslopes and the river, or sediment suppliers from own sources. There is gully erosion in the majority of watersheds with sloped agricultural lands. This process shapes quickly the depression relief producing damaging effects by degradations, aggradations and generating of associated processes. (e.g. landslides). The soil and water users of felt both inside the small watershed, and

the impact downstream. Externalities can exceed, most of times, the damages from inner watershed.

In a systematic approach, the natural streambed of a gully is an open, dynamic, probabilistic system of a process – response in cascade pattern. The aggressive inputs, which produce changes in the system, are organized both at the level of watershed and have natural streambed.

The present work is focused on the energetic aspects of this process for the natural system and for the anthropically altered system, too. As concerns the natural system, the powerful inputs during the out rush are: the velocity of the biphasic flow, the shear stress, the power of the flow and its loading and transport capacity. The inputs are able to induce changes in the system. The direction of the modifications depends on the ratio between the available energy of the flow and the strengths opposed by the stream support. The final tendency is to reach the state of dynamic equilibrium. The equilibrium is settled down between the energy entered the system and the energy used inside the system.

The ways for the energy consumption and dissipating are: a mechanical work effectuation on the stream support and the sediments transport on one hand and the changes from a kind of energy to another one on the other hand. The main means of intensification the energy dissipation are: ensuring conditions for an increased turbulence generation, the growth of fluid viscosity or the change of the flow conditions by inducing some disturbances with dissipative effect.

The last method application will be depicted. The engineering solution is to do some barriers and to plant streambeds. The check dam is a perturbation for the natural gully erosion process. It is able to produce significant effects in the phase of high flood propagation along the erosion streambed and in the gully erosion mechanism. The main goals had in view are that the dam should control the ravine dynamics and should partly protect the downstream objectives against silting. The check dam can fulfill these roles because it is permeable for water but it traps a part of sediments contained in the out rush. In the upper pond of the dam a sediments deposit is materialized. The deposit gradually reaches the quota of the weir inlet. The original streambed thawed raising up to the new local basis of erosion represented by the weir inlet, leads to important changes in the geometrical features of the wetted section and in the sediment delivery ratio.

I was interested in the final gradient of the deposition profile above gully – control structures. This slope value assures the stabilization of the banks and of the new created

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longitudinal profile.

RESEARCH GOALS

1. Uncertainty management in the value prediction for the stable gradient among the gully – control structures.
2. Usefulness of the barring effects prediction.

RESEARCH METHOD

For the first objective achievement the steps were: The informational system creation for the data base by: documentation and gathering of the materials existing at the designers; expeditionary prospecting of the site; field measurements; samplings; grading analysis. Then, the informatics system was settled up by data interpretation and processing.

For the second objective, the actions consisted of: the quantitative assessment of some effects; the matrix method utilization for the impacts inventorying; social-economic investigations accomplishment.

Romania has natural areas distinctly affected by the gully erosion. I have placed my research disposition in the Argesel watershed, which is representative because of the big density of the gullies, their strong activity and number of check dams executed on each gully.

River Argesel is 65 km long and has a watershed of 250 km². On the 50 km distance, traversing an agricultural area, the river has 80 tributaries, 69 being gullies. The total length of the gullies is 79.6 km and their density is great, namely 2-5 km/km². All the 69 gullies have check dams in various stages of sediment basins filling. Being concerned in the equilibrium gradient upstream the dams. I identified on 30 gullies 66 dams with the above channels reached at stability. (Fig. 1).

The those 30 gullies watersheds are of 0.25-6.74 km² (8 under 0.5 km² and 3 over 5.5 km²) the altitude is between 320 m-850 m height above the Black Sea level. Other specific features of the watersheds are: annual rainfall from 690 to 1000 mm increasing from South to North. The torrential core on 15 minutes is in the first or middle third part in the rain duration. The main land uses are: meadows, forests and orchards. They are not affected by surface erosion.

RESULTS

The solutions will be presented in the same order as the objectives were formulated.

Results in the management of uncertainty in the stable gradient value prediction

Uncertainty is an unavoidable component of all predictions. (De Jongh 1988). There are sources of errors at the level of input data, of prediction models and of probability that the effects are about to be settled down. The various types of uncertainty need to be handled in different ways in order to decrease the risk of getting some unrealistic values.

The process of prediction has six stages. There are specific ways of reduction the uncertainty in each of these stages. Thus, the management of uncertainty becomes possible and the risk in prediction is reduced to an acceptable level.

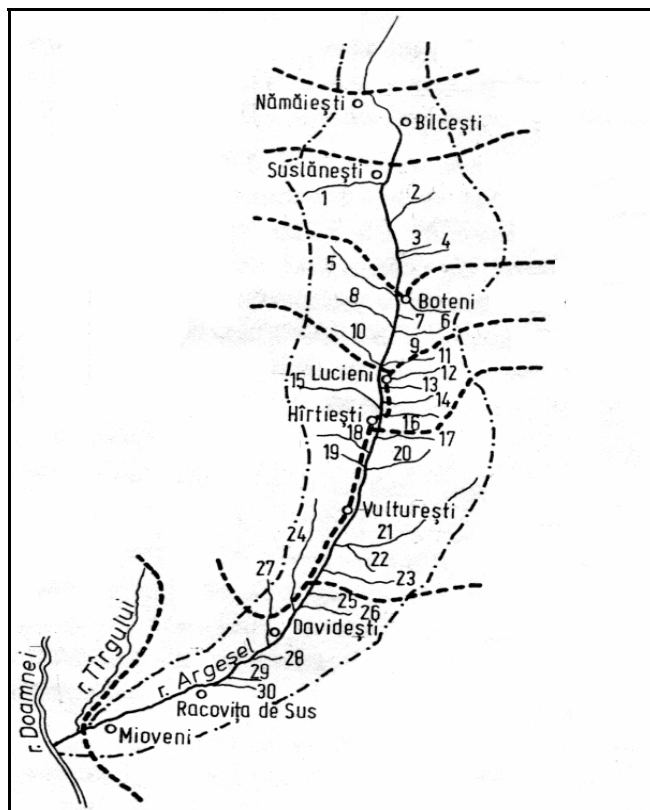


Figure 1. Argesel watershed with 30 investigated gullies.

The six stages mentioned above are:

1. Inventorying and selecting of the significant inputs;
2. Data gathering;
3. Choice or creation of a method for obtaining the prediction;
4. Preparation of the method for use;
5. Application of the method;
6. Presentation of the results.

I have applied all these six phases in my thesis for the doctoral degree (Otlacan, 1989). First, I selected those variables, which have a great participation in the stabilization of the gully longitudinal profile. These are: the geometrical specific features of the wetted section of the original streambed and after the deposition; the hydraulic conditions of the flow (peak discharge, strengths opposed by the streambed, average velocity, and bottom velocity); the specific features of the streambed material (granulometry, critical velocity for initiation of motion of sediments), as well as the height of the structure.

In the second phase, of data gathering, there are the following techniques for the uncertainty reduction: the measurement method selection for the magnitudes previously sorted and the sampling program design in order to achieve a required level of accuracy and significance.

Some of the variables mentioned in the first phase were measured directly. Thus, by means of a topographic survey there were obtained the specific geometrical features of the streambed after the finish of sediment deposition. In order to increase the reliance on these data the measurements were

repeated 2-5 times in 6 years, for the slopes upstream the dams and for the width of the channel at the structure. The height of the structure spillway inlet above the original thawed was also measured.

From the initial 66 cases, 23 were eliminated because they presented distortions due to some local factors, like: bridges, alluvial cones of the tributaries superposed on the deposition, remainders of the construction materials, lateral inflow, etc.

As concerns the discharges, I had at my disposal the values calculated by the designer for the probability of 5 percent, in various original sections of streambed. I could reconstitute some discharges, directly after the rain by measuring the wetted section depth. The traces let by the out rush on the vegetation, on the channel slabs, or on the spillways were used.

In order to establish the three kind of velocities the vegetation presence or absence and the sort of vegetation were noticed. Besides, samples of sediments at the dams and at the 30 m, 50 m and 100 m distance upstream the dams were drawn. The sample weight was complying with Romanian standard, namely 0.1-2 kg for fine sand until gravel. After the grading analysis it resulted the diameters D_{20} , D_{50} , D_{90} .

Despite of the care for the inputs accuracy some sources of errors still persist. They are difficult to remove having in view the spatial-temporal variability of the magnitudes to be ascertained and the conditions that the studies should limit in some acceptable costs. The inputs real values deviation in comparison to those used in the models of calculation explains part of the miss of similitude between the calculated and measured slope of equilibrium.

In the prediction process, the third phase follows in which the uncertainty management is necessary. In this phase it is required to choose or to create a forecast model. I have used both ways: I made my option for some existing models but I created a new model, too.

There is a unanimous agreement that the digital models, which simulate the natural processes, are uncertain, first, because they can not exactly reproduce what happens in reality. Thus, some simplifications must be accepted. Secondly, the model limits may occur from the chosen relationship. This type of error arises from the insufficient knowledge of the process physics.

I selected 3 models among those existing in the specialty literature for the calculation of the longitudinal profile stable gradient. Common to the models which I dealt with is the fact that they refer to the ephemeral flows, strongly loaded and torrential. At the present level of knowledge the specific features of this flow regime are very poor studied. The differences among the models regard the start assumption and the used parameters. Each author accompanies the recommended formula by values for the factors entering in the model structure.

Supino Model (1965) is a black box type of model. It is in the shape of morphometrical relations empirically obtained. It is recommended for the Italian torrents.

The stable slope S_s can be calculated using the formula:

$$S_s = (vu_c)^{1/3} B^{4/3} n^2 / Q^{4/3} \quad (1)$$

where: v – ratio between the mean velocity of water and the corresponding velocity at the river bottom (nearly equal to 1.3-1.5); u_c – maximum permissible velocity, depending on the size of bed materials, at which the erosion of river bed starts (suggested by Fortier and Scobey) (m/s); B – wetted perimeter, which can be considered equal to the width of the river (m); n – coefficient of roughness of the river (values extracted from Ven Te Chow) ($m^{-1/3}/s$); Q – flood discharge according to which the torrent training is designed (m^3/s).

The method applied to those 43 cases lasted for analysis leads to the results represented in Fig. 2. The other 2 models used in this work are based on physical laws and hydraulic theory applied to the sediments movement mechanism.

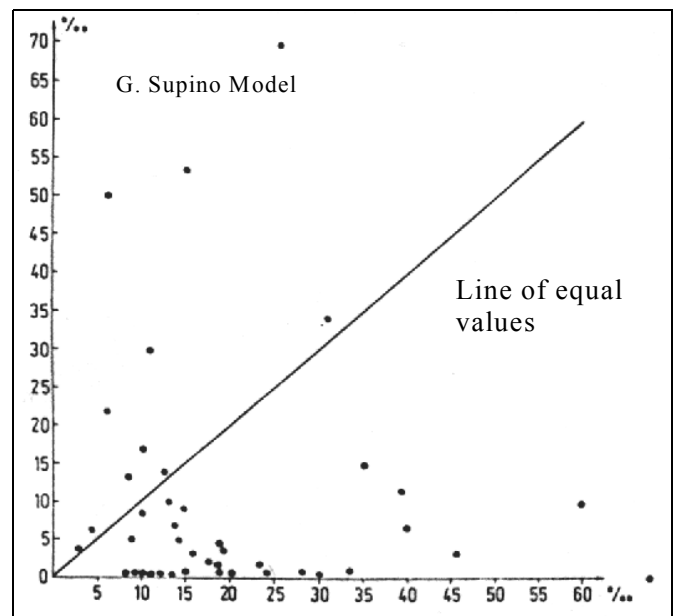


Figure 2. Comparison of measured (x_i) and computed (y_i) slopes. Regression coefficient $r_{yx} = 0.005$.

Brahms Model (1753) attributed by Lelliavsky (1955). In this case the condition for the longitudinal profile stability is theoretically expressed by the equilibrium of the forces acting on a grain in bed of sloping stream. (Formula 2).

$$P_x + (F - P_y) \sin \alpha \leq (F - P_y) f \cos \alpha \quad (2)$$

where: P_x – the drag force parallel to the bed; F – the submerged weight of the particle with diameter D ; P_y – the lift force; α – the original slope angle of the bed; f – the friction factor.

Assuming that

$$\sin \alpha \cong \tan \alpha \cong S; \cos \alpha = 1; \tan^2 \alpha = 0; f = 0,5; P_x = 2P_y$$

and after some simplifications, the final expression for the stable slope S_s is:

$$S_s = \frac{I}{4 + \left(\frac{I - 2S}{I - 0.4S} * \frac{1}{\sqrt{S}} \right)^2 \frac{B_o^2 D_o^2}{B_p^2 D_d^2}} \quad (3)$$

where: B_o , B_p – are the top width in the dam location (m), the index “o” represents the original situation and the present value (after the deposition) is marked by the index “p”; D_o – the sediment diameter most often arise in the original situation (before the gully trimming); D_d – the desirable diameter, adopted so that downstream damages should decrease. The basin is capable of trapping only the sediments with diameter D_d or bigger. I considered $D_o = D_{50}$ and $D_d = D_{20}$. The calculated values S_s are represented in the Fig. 3 in comparison with the measured values.

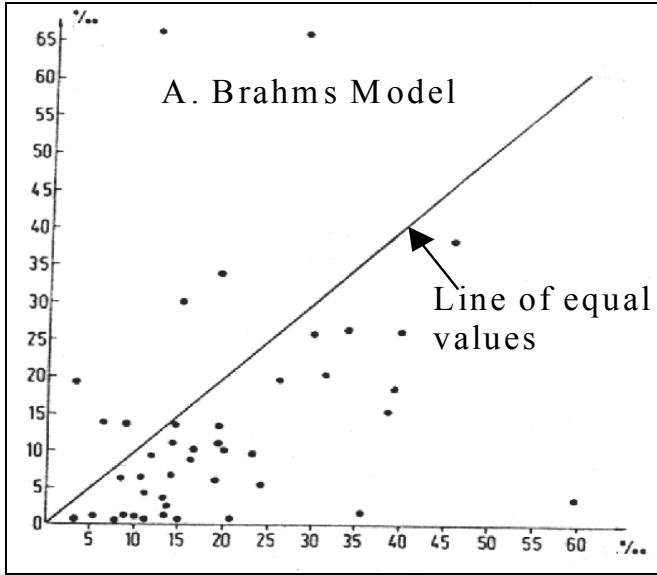


Figure 3. Comparison of measured (x_1) and computed (y_1) slopes. Regression coefficient $r_{yx} = 0.168$

Baloiu Model (1972) V. Baloiu is a Romanian professor. He starts from the theoretical hypothesis that the hydrodynamic equilibrium between the flow and the stream is provided with an out rush velocity equal to the critical velocity corresponding to the material from which the stream is consisting of. It results the formula (4) for the stable slope S_s :

$$S_s = \frac{v_c^2}{C^2 R} \quad (4)$$

where v_c is the critical velocity calculated in accordance to a Russian recommendation ($v_c = v_{0.1} h^{0.2}$), C is the resistance coefficient computed with the Bazin's formula:

$$C = 87 \sqrt{R} / \gamma + \sqrt{R}$$

where R is the hydraulic radius corresponding to the discharge having a return period of 2 years.

In the results represented in Fig. 4 the values for the stable slopes were calculated with the maximum permissible velocity for the diameter D_{50} .

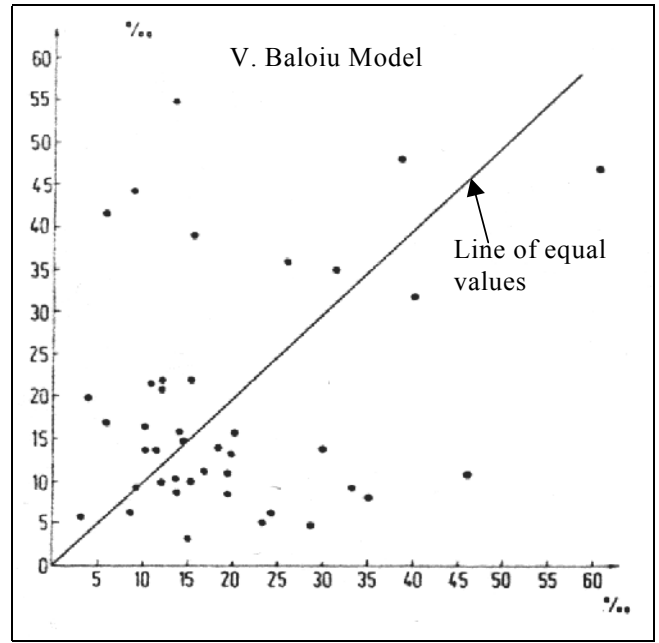


Figure 4. Comparison of measured (x_1) and computed (y_1) slopes. Regression coefficient $r_{yx} = 0.213$.

As concerns the model obtained as a result of my researches developed between 1982 ÷ 1988, it started with an American experiment performed by D.A. Woolhiser and A.T. Lenz (1965). The theoretic support is a deterministic model, based on fundamental physics law, namely the principle of continuity as applied to the sediment carried by a stream and the sediment forming the bed and banks.

$$\frac{d}{dt} [f(B)] = g(B) - g_s b \quad (5)$$

in which $f(B)$ is an arbitrary function describing the channel boundary; $g(B)$ is the sediment discharge capacity of the channel expressed as a function of the channel boundary configuration, and the product “ $g_s b$ ” is the rate of sediment supply to the channel section under consideration; b is the channel width.

$$\frac{d}{dt} [f(B)] = 0 \quad (6)$$

and

$$g_s b = g(B) \quad (7)$$

for channels in equilibrium.

The Du Boys formula was selected for the sediment discharge capacity. It is convenient for its simplicity.

$$g(B) = \psi b \delta_o (\delta_o - \delta_c) \quad (8)$$

in which: ψ is an experimentally determined coefficient; δ_o is the bed shear stress; δ_c – critical bed shear stress.

Utilizing the relationship

$$\delta_o = \gamma R S_e; R = \left(\frac{Qn}{bs_e^{1/2}} \right)^{3/5}$$

in the equation (8) and substituting the result into equation (7), it can be written:

$$g_s b = G_s = \psi b \left[\left(\frac{Qn}{b} \right)^{0.6} S_e^{0.7} - \delta_c \right] \left(\frac{Qn}{b} \right)^{0.6} S_e^{0.7} \quad (9)$$

Equation (9) is the theoretic support for the stable slope prediction model substantiation. The method for the equation solution consists of its simplification and in the pertinent variables identification. The values of these variables are going to be determined by field measurement. Assuming that $\delta_o - \delta_c \cong \delta_o$ and $S_e \cong S$ (S_e – energy slope; S – channel slope), the slopes ratio in terms of present and original values of the pertinent variables is:

$$\frac{S_p}{S_o} = \left(\frac{G_{sp}}{G_{so}} \right)^{5/7} \left(\frac{\psi_o}{\psi_p} \right)^{5/7} \left(\frac{Q_o}{Q_p} \right)^{6/7} \left(\frac{n_o}{n_p} \right)^{6/7} \left(\frac{b_p}{b_o} \right)^{1/7} \quad (10)$$

Two comments are necessary. The first one is that the product of the first four ratios on the right side may be considered fairly constant. The second observation refers to the fact that under equilibrium, the average original width b_o could well be correlated with the original slope S_o . As concerns the width b_p , it might be related to b_a (the width of the channel at the dam) and to H (the height of the inlet above the original channel quota). For example, considering a trapezoidal section,

$$b_p = b_a - \frac{H}{Z}$$

where Z is the side-slope. It results that:

$$b_p = f(b_a, H) \quad (11)$$

Incorporating the above observations in the Equation 10 we get the following expression:

$$S_p = C S_o^{b_1} [f(b_a, H)]^{b_2} \quad (12)$$

where C is a coefficient and b_1 and b_2 are arbitrary exponents.

In a first approximation, a linear regression model may be used for the function $f(b_a, H)$ explicitness:

$$\frac{S_p}{S_o} = a_1 + b_2 b_a + b_3 H \quad (13)$$

where b_a and H are the independent variables.

Then, a new multiple not linear regression model may be used if some deviations between the computed and measured slopes are found.

$$S_p = a_1 S_o^{b_4} (a_1 + b_2 b_a + b_3 H)^{b_5} \quad (14)$$

In the preparation phase for the model utilization, the software for the statistical techniques was applied to the same 43 input data used in the other models. The results are:

$$\frac{S_s}{S_o} = 0.497 + 0.0017 b_a - 0.113 H \quad (15)$$

and

$$S_s = 0.663 S_o^{0.89} (0.497 + 0.0017 b_a - 0.113 H) \quad (16)$$

In the last phase of the uncertainty management I answered to the exigency of presenting the results and of deciding which model should be recommended. In order to have some objective arguments, the 4 models for the stable

slope simulation were statistically compared. The statistical analysis allows the comparison between the observed set of values x_i and the homologous computed set of values y_i . This analysis leads to the conclusion that the fourth method adjusts the best value of the equilibrium slope. Having a correlation coefficient r_{yx} closer to 1.0, this model reflects a stronger relation between the two sets of variables.

In order to recommend the 4th method for the design activity the statistical test was continued. The result was that r_{yx} is significant even at the 0.999 confidence level. The plotting of the confidence interval bounds for the regression line proved that all the couples of values (y_i, x_i) are included in the interval for the 0.99 assurances. (Fig. 5).

The recommendation of using the 4th model relies, also, on the conclusion of other trial. The method was applied to 25 data of South Western Wisconsin (N.E. Minshall, 1953), which did not participate in the model calibration. The correlation coefficient is $r_{yx}=0.915$, though.

The explanation for the multiple regression method ability to anticipate a more correct value can be found, first, in the fact that it operates with directly measurable sizes. Thus, the accuracy of the input data may be guaranteed. Secondly, having in view that the studied events are aleatory, it is suitable to promote a theoretical substantiation, which should lead to the pertinent variables selection. A statistical processing must be applied to these variables.

The validity field of the model is: the original thawed slope up to 15 percent; dams from concrete or rubble masonry with a height less than 3.5 m; non-cohesive streambed material of $D_{90}=0.2 \div 20.0$ mm; values of the ratio stable slope/original slope $S_s/S_o=0.05 \div 0.6$. Besides, the model is applicable in watersheds comparable to Argesel watershed with respect to climate, topography, soils and vegetal cover.

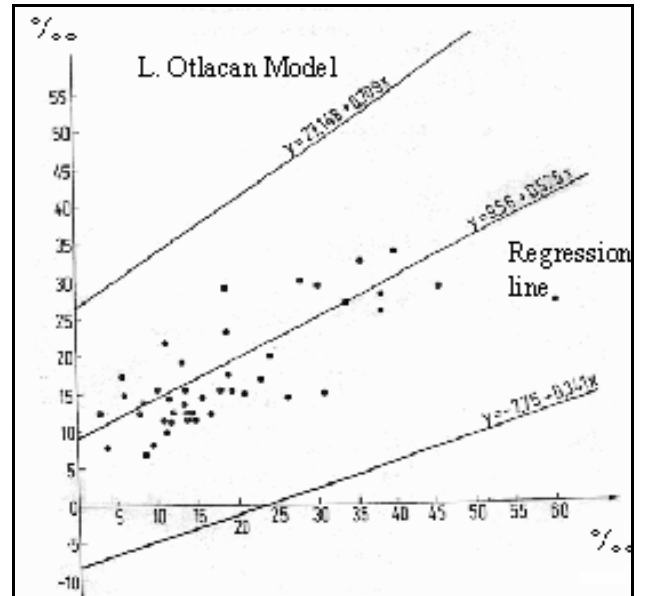


Figure 5. Comparison of measured (x_i) and computed (y_i) slopes. Regression coefficient $r_{yx} = 0.770$.

Results in the assessment of the usefulness of the barring effects prediction

The equilibrium slope value is a resultant, which integrates the consequences of the gully erosion process anthropically modified. This final gradient of the sediments deposit serves to the gully control structures dimensioning. Thus, the structure height H depends on the stable slope S_s computed value:

$$H = L(S_o - S_s) \quad (17)$$

where: L – equipped sector length (m); S_o – original slope (m/m).

From an economic point of view, the structure costs and the upstream-trapped sediments volumes increase with H^3 . Therefore the stable slope prediction is a useful tool needed in the economic analysis for choosing the best gully-trimming variant.

The works reliability is a technical aspect influenced by the concordance between the computed slopes and those produced in fact. In the case of the structure location according to their mutual supporting principle, the final slope underestimation leads to the partial silting of the upstream work. Thus, the investments become unjustified great. On the contrary, if the anticipated grade is steeper than the actual one, a part of the stream remains unprotected and erosions are developing. The upstream dam undermining increases the expenditures for the maintenance works.

From a power efficiency point of view, the gully control structures create a new stream with a bigger hydraulic radius than in natural conditions. The longitudinal profile gradient reduction counter balances (compensates) this increase and the final velocity v_f is smaller than the initial velocity v_i .

There is a significant reduction of the kinetic component of flow energy. The values of the ratios v_i^2/v_f^2 is of $1.8 \div 9$.

In 56.8 percent of cases the decrease is of $2 \div 3.5$ times. This effect may be quantified by a correct prediction of the equilibrium slope. The assessment of the size of diameters, which continue to be transported and delivered in the emissary, becomes possible in this way.

The gully trimming opportunity must be judged from more points of view than those already mentioned. In the decision taking it is important to establish what damages are avoided by intervention with works in comparison with the no-intervention alternative. I tried to complete the inventory of the potential harms generated by the gully erosion in the case of no intervention. The first step was to highlight the gully specific features. Some of them are as follows:

1. Often, gullies have neither major streambed nor meanders, so they dispose of a greater specific energy than the rivers in the same zone.
2. The watershed is smaller than 10 km^2 , therefore in the discharge value calculation the rain intensity may be considered uniform and the factors, which individualize the catchments area, must be taken into account.
3. In majority of cases the runoff is ephemeral or intermittent. This makes suitable the formative discharge calculation with the 50 percent insurance. Thus, it complies with the concept of effectiveness of a

modeling force.

4. The out rushes are torrential, having a sudden variation of the discharge in time and a heavy load of solid material.
5. The streambed dynamics happens either during the out rushes or between them. The active factor of the flood is the liquid and solid discharge variation.

Based on the enumerated specific elements I drew up the cause-effects matrix. (Fig. 6). It is obviously that the gully erosion induces numerous negative effects on the biotope, biocoenosis, human settlements, people welfare and on the landscape. Thus, this natural process introduces restrictions in the soil and water resources utilization.

The recently appeared ecological economics is interested in some additional indicators in comparison with the traditional economics. They are: the damages produced by the externalities; the total economic value of the environmental goods and services; specific valuation techniques of the projects for the environment protection. The works effects prediction is very useful in the damages assessment.

In a case study damages values produced downstream the watershed were 2.45 times bigger than those suffered inside the watershed. In order to obtain the total economic value of soil and water in a watershed I started from this value definition:

$$\begin{aligned} \text{Total economic value} = & \quad (18) \\ \text{Actual use value} + \text{Existence value} \end{aligned}$$

The first term may be computed by cost-benefit method. The technique used for the other 2 terms was the contingent valuation. This method uses as tool the socioeconomic investigation. A team of professors and students performed such a study in 3 rural settlements in Argesel watershed. We had in view to test the opportunities of maintaining the population in these places and of encouraging new landowners to come from their residential towns to the localities where they have just received a plot of land. From the point of view of eroded soils management, it was a practical work for facilitating the communication among the groups involved in this field. (L. Nedelcu, R. Sofronie, 1998).

The questionnaire contained questions by which we checked: the level of awareness about the quantitative and qualitative deterioration of the resources in the watershed; the degree of the community knowledge about the watershed working like a system. In this system, any change is felt by all the categories of public. Also, we wanted to find out the farmers opinions about the ways for their benefits and yields increasing and about their willingness to pay in order to improve the soil and water quality.

The sample included about 10 percent of husbandries. It resulted a relative low perception about the damages generated by the erosion. Thus, only 20-33.3 percent of those interviewed think that the anti-erosion works are necessary for the yields and benefits increasing. On the other hand, they would consent in 85-95 percent to contribute by means of work and money in order to improving the soil and water quality.

In our opinion, there are potential conflicts between

Figure 6. Cause – effect matrix.

			Stocking on slopes and downstream	Stocking in and downstream gullies	Detachment by slides	Detachment by gully erosion	
A	1	Physical changes of soil characteristics	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		
	2	Increase of slope dryness				<input type="checkbox"/>	
	3	Soil settling on slopes	<input type="checkbox"/>				
	4	Marshes formation on slopes (swamps)	<input type="checkbox"/>				N
	5	Groundwater hydrological regime modification	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
	6	Torrentiality increase	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	E
	7	River bed morphometrical dynamics	<input type="checkbox"/>	<input type="checkbox"/>			
	8	Lakes and bottom lands silting	<input type="checkbox"/>	<input type="checkbox"/>			G
	9	River turbidity increase	<input type="checkbox"/>	<input type="checkbox"/>			
	10	Earth masses redistribution on slopes	<input type="checkbox"/>		<input type="checkbox"/>		A
	11	Definitive ground loss	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
	12	Increase of dust particles concentration	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	T
	13	Land slides starting	<input type="checkbox"/>		<input type="checkbox"/>	<input type="checkbox"/>	
	14	Slope breaking up				<input type="checkbox"/>	I
	15	Soil fertility decrease	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		
	16	Oxygen concentration decrease in river water	<input type="checkbox"/>	<input type="checkbox"/>			V
	77	Increase of CO concentration in air	<input type="checkbox"/>		<input type="checkbox"/>		
	18	Increase of ground water mineralization	<input type="checkbox"/>		<input type="checkbox"/>		E
	19	Soil pollution	<input type="checkbox"/>				
	20	Water pollution	<input type="checkbox"/>	<input type="checkbox"/>			
	21	Mobilization of the previous alluvial stocks	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	E
B	22	Habitat modification	<input type="checkbox"/>		<input type="checkbox"/>		
	23	Embarrassing of the flora and fauna development	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	F
	24	Human population distress	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
C	25	Pedogenesis inhibition	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		F
	26	Trophic chains unbalancing			<input type="checkbox"/>		
	27	Biocoenoses modification	<input type="checkbox"/>		<input type="checkbox"/>		E
	28	Starting of water anaerobiosis and deterioration	<input type="checkbox"/>	<input type="checkbox"/>			
D	29	Water inlets and land reclamation works silting	<input type="checkbox"/>	<input type="checkbox"/>			C
	30	Flood risk amplification	<input type="checkbox"/>	<input type="checkbox"/>			
	31	Decrease of the soil and water resources productivity	<input type="checkbox"/>	<input type="checkbox"/>			T
	32	Landscape degradation	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
	33	Lines of communication depreciation	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	S
	34	Damages in settlements	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
	35	Hindering of the tillages mechanized execution	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
	36	Water storage dams damaging	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		
	1	Increase of groundwater storing capacity	●				POSITIVE
	2	Soil fertilizers spreading	●				EFFECTS
	3	Enlivening of the supply with construction materials	●	●		●	
LEGEND							
Impact on:							
A	Physical-chemical specific features						
B	Biological conditions						
C	Ecological reactions						
D	Living standard						

farmers located in the same watershed or between farmers and other economic activities; between sustainable development and short-term interests. We are sure that we must do a lobby for the anti-erosion works.

CONCLUSIONS

The research work presented in the paper had in view two main objectives:

1. Uncertainty management in the value prediction for the stable gradient among the gully – control structures.
2. Usefulness of the barring effects prediction.

In order to answer to the first goal, the author applied six steps of a forecast process recommended by P.E. De Jongh (1988). A model that allows the calculation of the final gradient above the gully- control structures has been obtained. In order to have some objective arguments for this model use, it was statistically compared with 3 other models known in the scientific literature.

As concerns the second objective of the research, the usefulness of a tool for the final gradient of the sediment deposits was highlighted.

It has already been known that this slope serves to the calculation of the check dams height (Formula 17). Besides, the author considers that once the final slope of the new thawed being calculated, the level of the gully erosion damages reduction can be anticipated. In this way, it is possible to decide on the gully trimming opportunity and the chance the project is accepted by beneficiaries might increase.

Using investigation methods specific to the ecological economics, the author tested the level of the awareness about the gully erosion damages and the farmers' opinions about the gully trimming project opportunity. It resulted in a relative low perception about the relation between the farmers' benefits and the rate of the gully erosion process.

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