Ann. For. Res. 53(2): 161-174, 2010

ANNALS OF FOREST RESEARCH
www.e-afr.org

The typology, frequency and magnitude of some behaviour events in case of torrential hydrographical management works in the upper Tărlung watershed

I. Clinciu, I. C. Petrițan, M. D. Niță, N. C. Tudose

Clinciu I., Petrițan I. C., Niță M. D., Tudose N. C. 2010. The typology, frequency and magnitude of some behaviour events in case of torrential hydrographical management works in the upper Tărlung watershed. Ann. For. Res. 53(2): 161-174, 2010.

Abstract. During the 20-25 years from their startup, the torrential hydrographical management works carried out in the upper Tărlung Watershed (55 dams, 22 sills, 25 traverses and 4 outlet canals) have exposed a number of 24 behaviour event types: 13 out of them reduce the safety of exploitation and the sustainability of the works (hereinafter called damages), while the other 11 reduce the functionality of the works (hereinafter called disfunctionalities). The following behaviour events have the highest frequency: (i) damages caused by water and alluvia erosion (erosive damages), followed by breakages, in the category of damages, and (ii) unsupervised installation of forest vegetation on the managed torrential hydrographical network and apron siltation, in the category of disfunctionalities. For methodological reasons, only the erosive damage of works was successively analysed, according to two criteria: the average depth (cm) in the eroded area and the percentage of the erosive area out of the total surface. Further on, by combining the two criteria for analysis, five representation areas with the same damage intensity were defined (very low, low, medium, high and very high intensity). With the aid of the event frequency values recorded in these areas and of the coefficients attributed to each intensity class (from 1 for very low intensity to 5 for very high intensity), the author reached the conclusion that the level of the recorded intensity of the damage caused by water and alluvia erosion ranged from very low to low.
Keywords water, alluvia, erosion, damage, erosive damage, disfunctionality.

Author. Ioan Clinciu, Ion Cătălin Petrițan, Mihai Daniel Niță, Nicu Constantin Tudose - Transilvania University of Braşov, România.
Manuscript received January 05, 2010; revised November 15, 2010; accepted November 19, 2010; online first December 30, 2010.

Introduction

Upon the initiative of the late professor Stelian Munteanu – corresponding member of the Romanian Academy, former chairman of the FAO Working Party on Mountain Watershed Management within the European Forest Commission (1970 - 1982), with the contribution of the former Mixed Staff for Torrential Watershed Management (within the University of Braşov) and with financial resources mostly allotted by the former Forestry Department, starting with 1975, a series of torrential hydrographical management works in the upper Tărlung Watershed, upstream the Săcele water storage (Braşov county), were carried out. There were four aims at the time (Anonymous 1975-1985): (i) diminishing the alluvia flow towards the Săcele water storage lake, through torrential hydrographical management works in the forest area of the watershed; (ii) protecting other (forest and non-forest) objectives in the watershed (National Road 1A Braşov-Vălenii de Munte, forest roads, lands and forest constructions in the proximity of the hydrographical network etc.) against destructive torrential flow; (iii) monitoring the behaviour, under different torrential conditions, of the most economical types of torrential hydrographic network management works carried out in our country ("undersized" dams); (iv) setting up a "natural laboratory" to meet the didactical-experimental necessities of Torrents Control discipline at the Faculty of Sylviculture and Forestry Engineering.

After more than a quarter of a century from the beginning of the management works, the following question arises completely justifiably: to what extent were the initial targets reached?

For a scientifically grounded answer, a research project started in 2001 (Clinciu 2001) and carried out in the period 2002-2004 dealt, among others, with the behaviour of works on the torrential managed network of Tarlung Valley, regarding both their progress under natural circumstances, during exceptional torrential flow, and their reaction to slowly, but long term acting destructive factors. The research results (Clinciu et al. 2003, 2005, Clinciu 2005 a, b) were recently resumed, enhanced and interpreted, with reference to the statistical-mathematical side of the phenomenon (Clinciu 2008).

For the first stage, three research objectives were pursued, namely: (i) the type of the recorded behaviour events and their localization; (ii) the frequency of these recorded behaviour events; (iii) the intensity (magnitude) of some of the behaviour events which occurred and their causes.

The objectives were pursued separately for the class of works affected by different behaviour events, without their being stopped, separately for the class of works that were partially stopped and separately for the class of works that were stopped entirely.

In the space allotted to this paper – not being able to present all the research topics - we shall refer only to works pertaining to the first class mentioned (which is the main class), while laying emphasis on the analysis of aspects concerning the type (typology) and frequency of the recorded behaviour events, and also on presenting our (original) methodology for the quantification of the intensity of one of the most frequent recorded behaviour event: erosive damages by water and alluvia.

With this thematic approach, our research enters the actual European preoccupations of controlling flash-floods and inundations (Heinimann 2002, Anonymous 2003, 2004, 2005) and provides another answering solution to the tasks that arise to the national authorities aiming at the accomplishment of "The flood risk management national strategy" (Clinciu & Gaspar 2005, Gaspar & Clinciu 2006, 2007).

Material and methods

The research material comprised 106 hydrotechnical works carried out along 21 torrential valleys on Upper Tărlung Watershed, upstream the Săcele water storage (Braşov county)(Fig. 1).

For research purposes, the managed torrential network was examined and for each work individually there were recorded data resulting both from the visual observation of the progress and the measurements that were carried out simultaneously or afterwards. Among the measured characteristics there are: the usable height, the non-silted height, the length of the siltation, the river bed width, the length of the spillway sill, the apron length and width, the depth of the alluvia layer on the apron, the surface and depth of the eroded or weathered areas in any of the works component areas, the downstream reach erosion depth etc., in the case of transverse hydrotechnical works, also the dimensions defining the cross section of the canal, the length of the canal and the dimensions of the canal joining constructions (confusor and evasor) or the constructions underlying the canal, in the case of discharge canals.

In order to identify and describe the type of the recorded behaviour events, we preserved the general classification scheme, which was proposed and used for previous research (Lazăr & Gaspar 1994), and also completed and adapted by the author of this paper (Clinciu et al. 2003), in terms of registering the localization of the aforementioned events. Thus, 20 component parts were defined and taken into account in the case of transverse hydrotechnical works, respectively 10, in the case of discharge canals.

It is worth noticing that, in both cases, the

Figure 1 Torrential hydrographical management works in the Tărlung Valley at 20 (25) years from their construction

Note: (a) The 1M0/2,0 traverse in the de sub Stânci Brook, (b) The 3B0,5 sill in the the Zimbrului Valley, (c) The 7M2,0 dam in the Adânc de Sus Brook, (d) The 4B4,0 dam in the Tare Brook (Photographs: Clinciu, 2003).

component parts include not only the physical parts of the construction, upon which its safe exploitation depends, but also parts related to the functionality of the construction (such as the spillway, weepers, openings) or parts where the construction interacts with the other works (such as the works in upstream and downstream areas, in the case of transverse works, or the confusor and evasor in the case of discharge canals) or with the environment (such as the embedding areas and the body-wall-underground wall area, in the case of transverse works, and the left-side and right-side bordering areas, in the case of discharge canals).

In order to facilitate the behaviour analysis of transverse hydrotechnical works (which are the most numerous), by using the data comprised in the primary cards, the works distributions were determined and represented graphically by torrential valleys and height classes, separately for sills and dams. Further on, we performed the data centralization with respect to the type and localization of the behaviour events identified during field visits, and afterwards we dealt with creating a hierarchy of the frequencies of these events according to three criteria: number of affected works (NLA), number of affected work parts (NPLA) and their ratio (NPLA/NLA). The frequencies obtained by each criterion were studied statistically, which allowed us to determine: the arithmetic mean, the standard deviation and the variation coefficient.

In order to reach the third research objective –quantification of the intensity of works damages by water and alluvia erosion - only transverse hydrotechnical works were taken into account, while the analysis was carried out only for one of the component parts: the body corresponding to the overflowed area.

Two criteria were considered for setting the damage intensity: the average depth in the eroded area (cm) and the percentage of the eroded surface (%) out of the total area.

Following the combination in the graphical representation of the two criteria through an original methodology, presented in this paper, five areas with the same damage intensity were determined (from very low to very high), the frequencies corresponding to each area were added separately and different coefficients were used (from 1 to 5) by levels of damage intensity.

Thus, this lead to setting a global coefficient for the intensity of the works erosion by water and alluvia; depending on this coefficient, the magnitude of the damage could be quantified on the scale including all the works in Tărlung Valley and their entire functioning period.

Results and discussion

Distribution and didactic-experimental valences of works

On the scale of the entire Upper Tărlung Watershed (upstream the Săcele water storage), along the 21 managed torrential valleys, more than 100 hydrotechnical management works were performed on the torrential hydrographical network (Fig. 2), out of which dams were the most numerous (55). With an almost equal number (25 and respectively 22), then come traverses and sills; discharge canals are much more poorly represented (only 4). The number of works in the same valley exceeds 10 only in three cases (Fig. 2).

In terms of height (Fig. 3 and Fig. 4), the distribution of works is quite different from the normal one, but only in the case of dams. As far as sills are concerned, most works are 0.5-1.0 m high, while in the case of dams, the best represented height class is 3.5-4.0 m.

The didactic and experimental value of the works is underlined by their belonging to a relatively high number of types, subtypes and constructive variants, as well as by the different structure of works, depending on the type of construction materials: approximately 80 works were built using concrete and more than 20 using stone masonry; some of the works

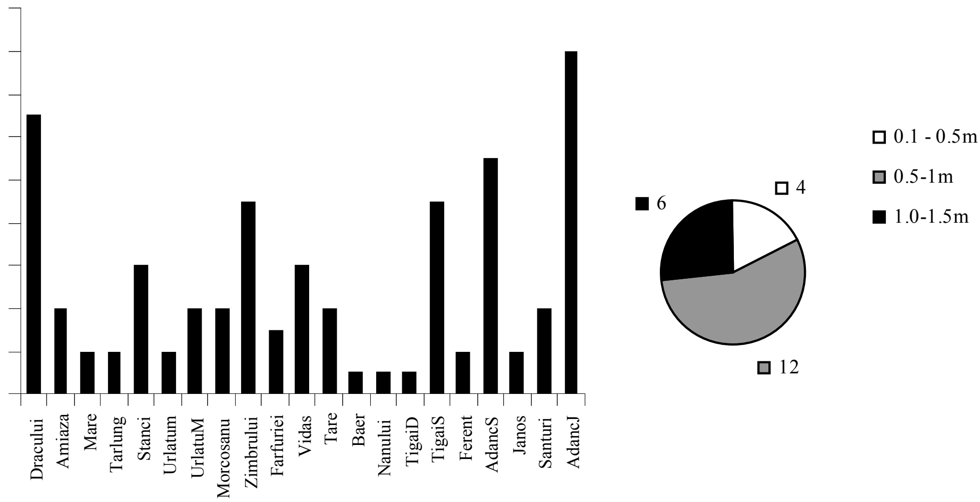


Figure 2-3 Distribution of number of works in torrential valleys (left) and of sils by height (right)

comprise elements of other construction materials as well (worn-out railways, worn-out tractor/truck tyres etc.). The different (plane and solid) geometry of experimental "undersized" dams (Clinciu et al. 1998) is extremely striking; these are the most numerous in the researched area (37 out of the aforementioned total number of 55).

The typology and frequency of recorded behaviour events

A number of 24 behaviour events were identified during field visits and recorded on the cards, out of them 11 belong to the class of damages affecting the safety of exploitation and the sustainability of the works (class I), while the other 13 belong to the class of disfunctionalities which occurred during the exploitation of the works (class II).

The events in the first class („damages") include: cracks (F), breakages (R), carrying away events (A), deformations (Df), damages by water and alluvia erosion (De), weathering (Dz), unfastening (Dc), infiltrations (I), undermining of the body (Sc) or of the apron (Sr) and suffusions (Sf).

Out of the events in the second class we mention: the obstruction of the spillway (Bdv), the obstruction of the energy dissipating teeth (Bdi), clogging of the apron siltation (Cr), unsupervised installation of forest vegetation (Ihv), the clearing of the siltation (Spat), the unaccomplishment of the siltation (Nat) and the covering of the works by the alluvia (În). This class (II) also includes some of the deficiencies recorded during the technological execution process, and which, subsequently, hindered the adequate functioning of the works and/or the systems they belong to (for example, unaccomplishment of some project solutions - Nsp, unaccomplishment of some work - Ne, unaccomplishment of the earth fills – Nu).

Given the great variability of the recorded damages and disfunctionalities (Clinciu 2005 a, b), in terms of both their nature and their localization, we firstly created a hierarchy of the events, separately for each class, taking into account the number of affected works (NLA), the number of affected work parts (NPLA) and their ratio (NPLA/NLA); then, for each of these three variables, we determined the same number of statistical indicators: the arithmetic

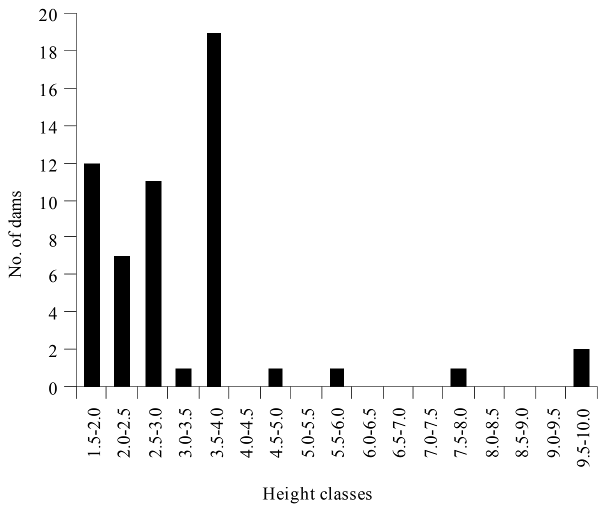


Figure 4 Distribution of dams by height classes

mean, the standard deviation and the variation coefficient.

In comparison with the number of affected works (NLA), the most frequent behaviour events recorded are the following (Tables 1-2): damages by water and alluvia erosion (52), followed by breakages (49) and carry away events (48), in the first class of events (damages), and the unsupervised installation of forest vegetation (59), followed by apron siltation (55), in the second class of events (disfunctionalities).

According to the number of affected works (NPLA), the hierarchy of the frequencies is the following: breakages (68), carry away events (66) and erosive damages (60), in the class of damages, and unsupervised installation of forest vegetation (78), covering of works by alluvia (60) and apron siltation (55), in the class of disfunctionalities.

From the point of view of the ratio between the number of affected work parts and that of affected works (NPLA/NLA), the hierarchy of the events changes as follows: (i) in the first class, the highest value of the NPLA/NLA ratio (1.64) is recorded in the case of weathering events, followed closely by infiltrations (1.60); (ii) in the second class, the most frequent are the events consisting in the covering of the works by the alluvia (with a value of the NPLA/NLA ratio of 2.72) followed, at a considerable distance, by the unaccomplishment of some work parts, which is not a disfunctionality proper but a construction deficiency.

It is interesting to notice that the values of the statistical average of the behaviour events frequencies are rather close from one class to the other, ranging from 22 to 24 in the case of NLA, from 27 to 30 for NPLA and from 1.20 to 1.30 in the case of the NPLA/NLA ratio. As far as the variation coefficients are concerned, the highest values (which, however, are not very different from one class to the other), were identified in the case of NLA (around 84%) and NPLA (84% and respectively 89%), while in the case of the NPLA/NLA ratio, the frequency variability was much more salient in the case of the events in the second class (41% as compared to 18% in the first class).

A comparative frequency analysis of the erosive damage of the works

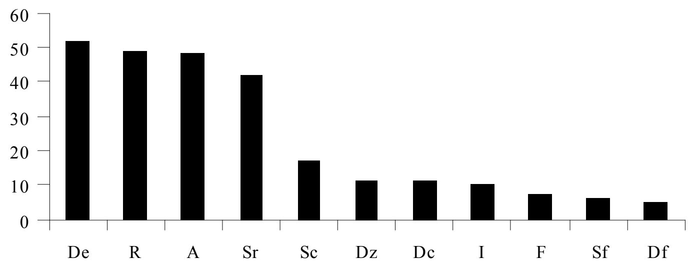
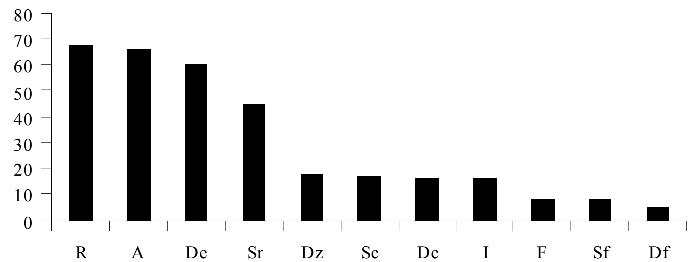
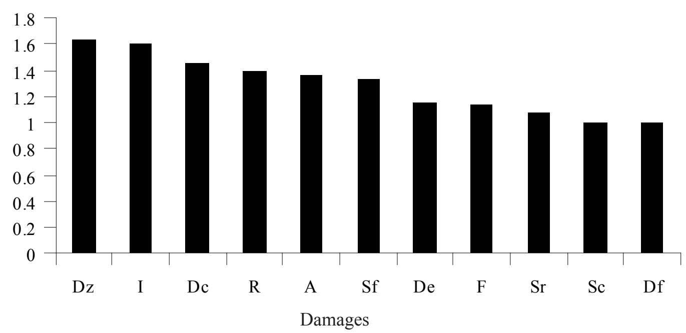
Taking into account the considerable diversity of the recorded situations, in terms of both the typology and the frequency of the identified behaviour events, a more thorough analysis is presented in what follows only for the damage by water and alluvia erosion, the damages which affect the safe exploitation and sustainability of the works which, for this class of events (damages), proved to be the most frequent.

We performed in advance a comparative analysis concerning the frequency of the event on torrential valleys, according to the types of torrential hydrographical management works and to the constituent parts of transverse hydrotechnical works. In order to facilitate this analysis, in figure 5 the typological frequency of works is presented in parallel with the frequency of the erosive damages of works, while figure 6 presents a hierarchy of the constituent parts of a traverse hydrotechnical work in the order of the occurrence frequency of the examined damage.

As far as the body of the overflowed area is concerned (the most affected component part - Fig.7), the frequency and the magnitude (intensity) of the damages were examined using two criteria: the average depth of the eroded (Fig. 8) area and the percentage of the eroded surface out of the total surface (Fig. 9).

The classification of the examined works according to these two criteria is presented in Table 3, in which we used for codification purposes two numbers (for example 1.7): the first represents the code of the torrential valley, and the second means the current position of the

Table 1 The hierarchy of recorded damages

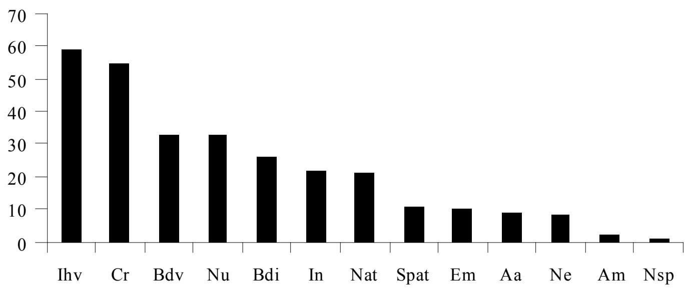
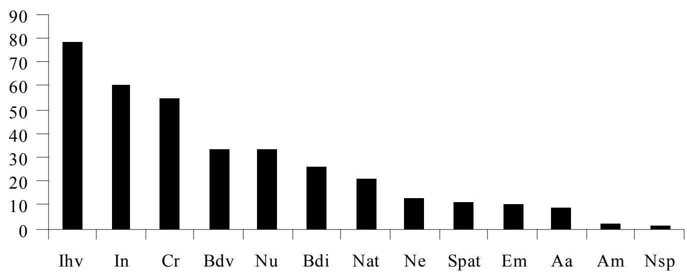
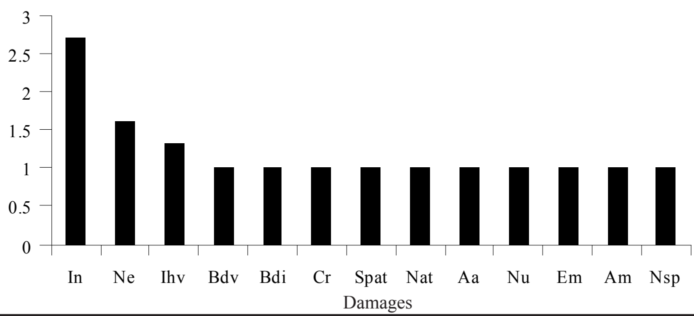
Hierarchy criterion	The hierarchy of damages according to their frequency of occurrence NLA – number of affected works NPLA – the number of affected work parts	Statistical indicators: Arithmetic mean	Standard deviation	Variation coefficient %
Events reducing the safety in exploitation and the durability of the works (class I)				
NLA		23.45	19.65	83.80
NPLA		29.73	24.82	83.50
NPLA/ NLA		1.29	0.23	17.75

work in the torrential hydrographic management system, the numbering being performed starting from the downstream area towards the upstream one.

The data presented show that, in the case of transverse hydrotechnical works, 52 of the works in the torrential valleys (49% of the total) and 60 parts of constructions were affected by this type of damage, the NPLA/NLA ratio being of 1,15. It is worth noticing that, the above mentioned numbers also include the 4 works which, by the time of the visits on the field, displayed signs of degradation (for this reason, they were not highlighted in Table 3).

Out of the 21 managed torrential valleys, only in three cases we could not identify the damages

Table 2 The hierarchy of the recorded disfunctionalities

Hierarchy criterion	The hierarchy of disfunctionalities according to their frequency of occurrence NLA – number of affected works NPLA – the number of affected work parts	Statistical indicators: Arithmetic mean	Standard deviation	Variation coefficient (%)
Damages and deficiencies reducing the functionality of the works (class II)				
NLA		22.31	18.68	83.73
NPLA		27.08	24.06	88.87
NPLA/ NLA		1.20	0.49	40.82

(the Baer Brook, the Nanului Brook and the Sas Janos Brook). In the rest of the cases (18), the percentage of the affected works out of their total number (for the same valley) varies considerably: under 25% in 3 cases, between 25% and 50 % in other 3 cases, between 50% and 75% in 8 cases and over 75% in 4 cases.

The valleys where the percentage of the works affected by erosion is the highest are: the Ferenț Brook and the Right Branch of the Tigăile Valley, both with 100%, and the Dracului Valley with 92%. The least affected were the works in the De sub Stânci Brook, the Vidaş Brook and the Valea Adâncă de Jos Valley (with only 17%).

According to the type of transverse hydrotechnical works, the situation is as follows (Fig. 5): out of the 52 affected works, a number of 29 (56%) are dams, a number of 13 (25%) represent sills and a number of 10 (19%) represent traverses. Correlating this situation with the examined types of works (where the dams represent 55%, sills 22% and traverses 25%), we can infer that the degradation was more frequent among sills and dams and less frequent among traverses. This result is understandable if we take into account that traverses have fewer component parts in direct contact with the water and the alluvia in movement, which cause the erosive damage to the masonry or concrete.

In the case of discharge canals, the damage was identified in three out of the 4 canals (so in 75% of the cases).

Concentrating on the parts where the examined damages were discovered (and respectively identified), we can notice (Fig. 6-7) that the highest degradation frequency in the case of transverse hydrotechnical works, is displayed by the body corresponding to the overflowed area, eroded in 43 out of the 52 examined cases; with equal frequencies (6 each), follow the apron and the energy dissipating teeth; only two cases of erosive damages were identified for the right wing and one for the body of the un-overflowed area – the right side, the body corresponding to the un-overflowed area (left side) and the left wing.

Quantifying the intensity of the erosive damages of the works

As previously mentioned, in order to achieve the third objective of our research – quantifying the intensity of the erosive damage to the works caused by the combined action of water

Table 3 Encoded position of the works affected by erosive damage in the body overflowed area, on the assessement scale of two analysis criteria

Percentage of eroded area (%)	Depth of eroded area (cm) 0-5	5-10	10-15	15-20	Over 20	Total
0-10	1.7; 1.10; 12.3; 16.4	9.2; 15.1; 18.2; 21.3	21.1			9
10-20	1.11; 1.12; 9.1; 12.2; 17.2; 18.3	1.2; 1.4; 1,6; 7.1; 18.1; 21.6	7.1	16.1	21.5	15
20-30	1.5; 8.1; 12.1	1.3; 1.9; 9.4; 9.5				7
30-40		1.7		11.1		2
40-50	1.5; 1.11; 1.12; 9.3; 16.5; 18.2	20.1			9.2	8
50-60	2.2	1.8				2
60-70	1.6; 1.8					2
70-80						0
80-90						0
90-100	21.2				1.1; 1.1	3
Total	23	17	2	2	4	48

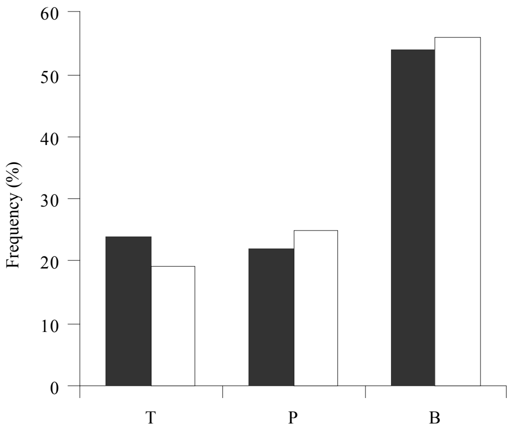


Figure 5 Comparison between the frequency of the erosive damage and the typological frequency of the works, in the case of transverse hydrotechnical works
T – traverses; P – sills; B – dams; In black: the typological frequency (%); In white: the extent of the erosive damage (%)

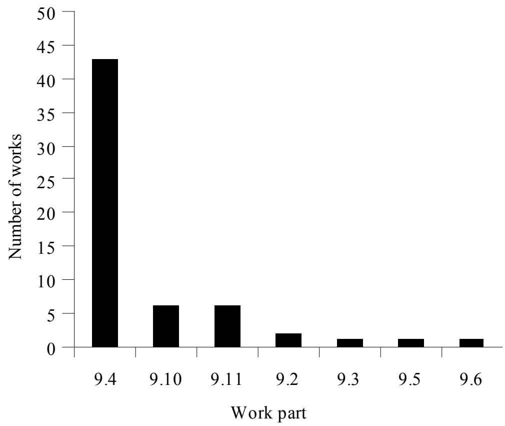


Figure 6 The hierarchy of parts of the works according to their erosive damage frequency
(9.4 - body of the overflowed area; 9.10 - apron; 9.11 - energy dissipating teeth; 9.2 - right wing; 9.3 - body of right undischarged area; 9.5 - body of left undischarged area; 9.6 - left wing)

Figure 7 The dam 8B3,0 in Zimbrului Valley degraded by water and alluvia erosion in the area of the overflowed body (Photo: Clinciu 2003).

and alluvia - only the transverse hydrotechnical works were considered, and the analysis was performed on just one of their component parts: the body corresponding to the overflowed area. Two criteria were taken into account in expressing the intensity of the damage: the average depth in the eroded area (expressed in centimeters) and the percentage that the eroded area occupies out of the total surface.

From the point of view of the depth, the erosive damage identified during the research is distributed as follows: (i) on the assessment scale proposed and used by Nicolae Lazăr and Radu Gaspar in their research carried out in the period 1992-1994 (up to 10 cm = superficial erosion; over 10 cm = deep erosion), our data are distributed as follows: superficial erosion: 39 cases (that is 83%), deep erosion: 8 cases (17%); (ii) on a more detailed scale, proposed by us and used as part of the present research, the erosive damage is distributed as follows**:** very superficial (up to 5 cm): 23 cases (48%); superficial (5-10 cm): 17 cases (35%); medium deep (10-15 cm): 2 cases (4%); deep (15-20 cm): 2 cases (4%); very deep (over 20 cm): 4 cases (9%).

From the point of view of the percentage of the eroded surface (that is, the percentage of the work which was affected, in this case, the body of the overflowed area), the same global analysis reveals the same distribution of erosive damage: very little extensive (up to 20% of the surface): 24 cases (51%); little extensive (20 – 40%): 8 cases (17%); medium extensive (40 – 60%): 10 cases (21%); very extensive (60-80%): 2 cases (4%); highly extensive (80 – 100%): 3 cases (6%).

Represented graphically (Fig. 8 and Fig. 9), the above mentioned data offer a first image of the magnitude of the damages; indeed, judging by the two criteria, we can notice that only 13% of the cases of erosive damage in the overflowed area are deep or very deep and only 10% of these cases display very extensive or highly extensive damaged surfaces.

In order to combine the two criteria and, thus, decide on the global intensity of the damage, the table containing the encoded data for the works affected by erosive damage (Table 3) was replaced by a network of cells (5 x 10 = 50 cells), containing the number of cases (event frequency). The next step was to decompose the network thus obtained (Fig. 10) in 5 distinct areas, each containing 10 cells; each area has a certain damage intensity, ranging from very low (for the left upper area of the network) to very high (for the right lower area of the network). Obviously, on the diagonal we can find the cells with medium damage intensity.

Because the numbers entered in the cells represent the number of cases (frequencies), by adding them, separately for each area, the following frequencies were obtained according to the degrees of damage intensity (Fig.11): very low intensity: 35 cases (72.34%); low intensity: 7 (14.90%); medium intensity: 3 (6.38%); high intensity: 1 (2.13%); very high intensity: 2 (4.25%).

If we attribute different coefficients to the five intensity degrees, from 1 for very low intensity to 5 for very high intensity, and if we calculate the weighted average, we obtain:

$$K_{De} = \frac{35 \cdot 1 + 7 \cdot 2 + 3 \cdot 3 + 4 \cdot 1 + 5 \cdot 2}{48} = \frac{72}{47} = 1.53 \approx 1.5$$

This result prompts us to claim that the erosive damage caused by water and alluvia on the torrential hydrographic management works in the Tărlung Valley has displayed, so far, a relatively low intensity (between very low and low), the damage in question being distributed in approximately equal percentages (26 and respectively 21) in the downstream area of the works and respectively in their crown area.

Conclusion

On the whole of the Upper Tărlung Watershed (upstream the Sacele water storage), along the 21 torrential valleys which were managed, over 100 torrential hydrographical management works were performed, out of which dams are the most numerous. The traverses and sills are almost equally represented, while the canals are very poorly represented.

In comparison with the number of affected

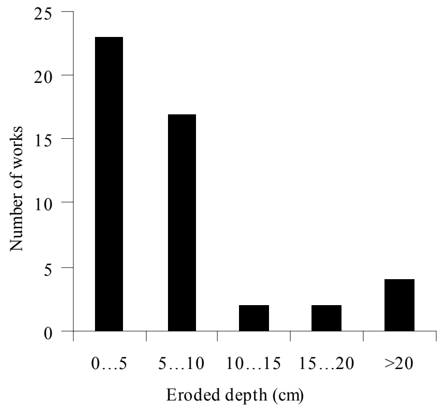


Figure 8 The erosive damage frequency according to the depth of eroded area

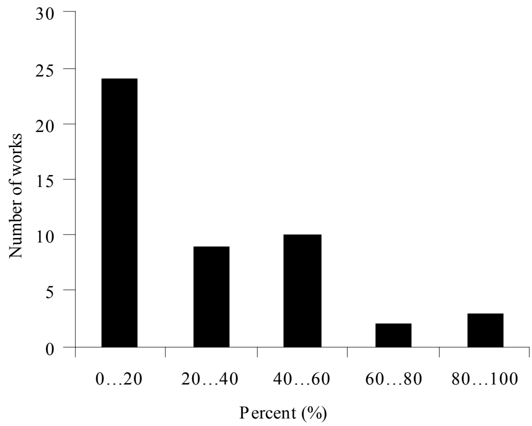


Figure 9 The erosive damage frequency according to the percentage of the degraded area

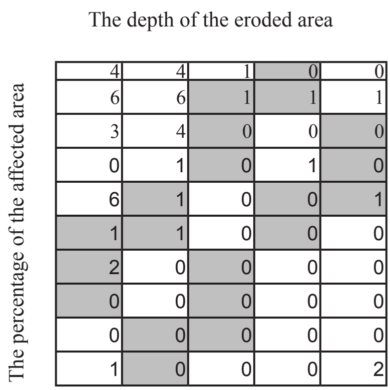


Figure 10 The combination of the two analysis criteria and the delimitation of the five graphical areas which are characterized by the same damage magnitude

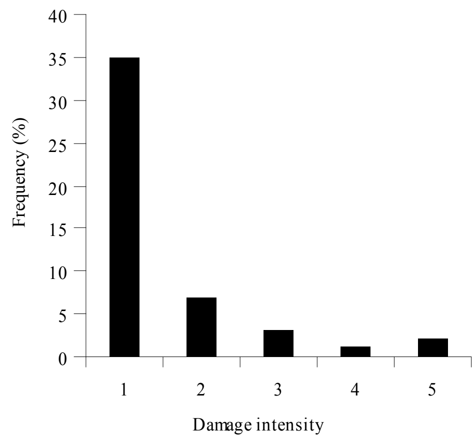


Figure 11 The frequency of works degraded by the erosion of water and alluvia according to the intensity classes of these damages

works (NLA), the most frequent behaviour events recorded were the following: damages by water and alluvia erosion, followed by breakages and carry away events, in the first class of events (damages), and the unsupervised installation of forest vegetation, followed by the apron siltation, in the second class of events (disfunctionalities).

Considering the number of affected work parts (NPLA), the hierarchy of the frequencies is as follows: breakages, carry away events and erosive damages, in the class of damages, and the unsupervised installation of forest vegetation, the covering of the works by alluvia and the apron siltation, in the class of disfunctionalities.

The statistical averages of the frequencies of the damages are similar for the two classes. As far as the variation coefficients are concerned, the lowest values were identified for NLA and NPLA, while for the NPLA/NLA ratio, the frequency variability was higher in the case of the events in the second class.

The erosive damage was more frequent among sills and dams and less so among traverses, which have fewer component parts in direct contact with the water and the alluvia in movement.

According to the parts where the damage was discovered (and respectively identified), in the case of transverse hydrotechnical works, the highest degradation frequency is displayed by the body corresponding to the overflowed area.

Only in 13% of the cases, the erosive damage in the overflowed area is deep or very deep, and only in 10% of these cases, the damaged surface is very extensive or highly extensive.

For methodological reasons, the erosive damage of works was successively analysed, according to two criteria: the average depth (cm) in the eroded area, and the percentage of the erosive area out of the total surface.
Further on, by combining the two criteria for analysis, five representation areas with the same damage intensity were defined. With the aid of the event frequency values recorded in these areas and of the coefficients attributed to each intensity class the author reached the conclusion that, in the case of the torrential hydrographical management works in the upper Tarlung Watershed, the level of the recorded intensity of the damage caused by water and alluvia erosion ranged from very low to low.

In conclusion, although the present paper presents only a partial image of the issues approached during the research period, we believe that the results obtained are conclusive enough to claim that the torrential hydrographical management system on the Tărlung Valley was well conceived, that the objectives set for the management projects were achieved to a great extent (including the didactical and experimental purposes) and that the premises / hypotheses taken into account at the planning stage of the management works were fully confirmed, including the risk which has to be considered, from the very beginning, in the case of the exploitation of the most economical experimental works.

For the future monitoring and rehabilitation activities in the case of work affected by torrential flows, due attention will be paid, in the first place, to the two cases identified as a result of the research, where the intensity of the erosive damages is very high (the downstream face and the crown area of the 1B4,0 dam on the Dracului Valley), or high (the crown area of the 4B2,5 dam on the Zimbrului Valley).

Acknowledgements

The research results presented in this paper have been obtained within the framework of two research projects, both financed by The National University Research Council (CNCSIS). The titles of these projects are presente d in the bibliography section at position: Clinciu 2001 & Clinciu 2008.

References

Anonymous, 1975-1985. The execution projects drafted for the torrential hydrographical management works in Upper Tărlung Watershed. Mixed Staff for torrential watershed management. University of Brasov.

Anonymous, 2003. Lessons from the Past–Lessons for the Future, Twenty-third Session of the Working Party on Mountain Watershed Management. Swiss Agency for the Environment, Forests and Landscape. Berne, 202 p.

Anonymous, 2004. Twenty–fourth session of the working party on the management of mountain watersheds. Final report. European Forestry Commission - FAO, Rome, 15 p.

Anonymous, 2005. Preparing for the next generation of watershed management programmes and projects. Proceedings of the European Regional Workshop, Megève-France. FAO & EOMF. FAO, 136 p.

Clinciu I., Lazăr N., Păcurar V., 1998. Contributions to the "Undersized" dams stability and functionality study. A Case Analysis of a Catastrophic Storm Flow. Lito – FAO. The 21st Session of the Working Party on Mountain Watershed Management. Marienbad, Czech Republic, 14 p.

Clinciu I., 2001. Didactic and experimental valences, behavior in exploitation and the effects of management works of the torrential hydrographical system in Tărlung higher watershed (upstream Săcele water-storage). Scientific project, CNCSIS - Type A, Transilvania University of Braşov, 27 p.

Clinciu I., Chiţea Gh., Păcurar V., Petriţan C., Lupaşcu F., Vasilescu M., Coman D., 2003. Comportarea lucrărilor de amenajare a reţelei hidrografice torenţiale din bazinul superior al Tărlungului (amonte de acumularea Săcele). [Behaviour of management works of the torrential hydrographical network in Upper Tarlung Watershed]. Scientific Report 33, Transilvania University of Braşov, 42 p.

Clinciu I., 2005a. Magnitude of erosive damages in case of torrential hydrographical management works in Upper Tărlung watershed. Bulletin of Transilvania University of Braşov 12(47): 451-454.

Clinciu I., 2005b. Unele rezultate ale cercetărilor privind natura şi frecvenţa avariilor la lucrările de amenajare a reţelei hidrografice torenţiale din bazinul superior al Tărlungului (amonte de Acumularea Săcele) [Some results of the research regarding the nature and frequency of damages occured to the torrential management works in the Upper Tarlung Watershed] In: "Pădurea şi dezvoltarea durabilă", Transilvania University of Braşov, pp. 503-507.

Clinciu I., Gaşpar R., 2005. Comportarea lucrărilor hidrotehnice de amenajare a torentilor, o problemă de actualitate a cercetării ştiinţifice [Behaviour of the hydrotechnical torrent control structures – an actual problem of the research]. Revista Pădurilor 5: 36-43.

Clinciu I., Chiţea Ghe., Păcurar V., 2005. Valenţele didactico-experimentale, comportarea în exploatare şi efectele lucrărilor de amenajare a reţelei hidrografice torenţiale din bazinul superior al Tărlungului (amonte de Acumularea Săcele). [Didactic and experimental valences, behaviour in exploitation and the effects of management works of the torrential hydrographical system in Tarlung higher watershed (upstream Sacele water-storage)] Revista de Politica Ştiinţei şi Scientometrie.

Clinciu I., 2008. New researches regarding the behaviour of the torrential hydrographical management works in Upper Tarlung watershed (upstream the Săcele water storage – Braşov County). Scientific Report PN-II-ID-PCE-2008-2, code ID_740, Transilvania University of Braşov, 20 p.

Gaspar R., Clinciu I., 2006. Cercetări privind stabilitatea si rezistenta lucrărilor hidrotehnice de amenajare a torenţilor. [Research about the stability and resistance of hydrotechnical torrent control structures]. Revista Pădurilor 3: 27-38.

Gaspar R., Clinciu I., 2007. Cercetări privind gradul de torenţialitate al unor bazine hidrografice mici, predominant forestiere, parţial amenajate cu lucrări de corectarea torenţilor. [Research regarding the torrentiality degree from small, predominantly forested watersheds, partially fitted out with torrential correction works]. Revista Pădurilor 4: 12-19.

Heinimann H.R., 2002. Risk management – a Framework to improve Effectiveness and Efficiency of Resource Management Decisions. Twenty-third session of the working party on mountain watershed management. Published by the Swiss Agency for the Environment, Forests and Landscape. Berne, pp. 59-68.

Lazăr N., Gaşpar R. et.al., 1994. Cercetări privind stabilitatea, rezistenţa şi funcţionalitatea lucrărilor hidrotehnice de amenajare a torenţilor [Reserach about the stability, resistance and functionality of the hydrotechnical torrent control structures]. Technical Report 12RA, ICAS, 120 p.