Issue 8, 2024, e15644
ISSN: 2594-5033
Article: Thematic Dossier
Editor: Altemar A. Rocha
http://periodicos2.uesb.br/index.php/geo
https://doi.org/10.22481/rg.v8.e2024.e15644.en

The levadas and their implications for the dynamics of the slopes in the north of Portugal

Las levadas y sus implicaciones para la dinámica de las laderas en el norte de Portugal

As levadas e suas implicações nas dinâmicas das vertentes, no norte de Portugal

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Received on: 08/27/2024
Accepted for publication on: 30/10/2024

Abstract

Hydraulic works are commonly investigated in terms of efficiency and installation and operating costs. However, it is also important to assess their impact on environmental aspects, especially their repercussions on river and slope systems. The aim of this study is to present an example of works that have been responsible for hydraulic, sedimentary, erosive and depositional changes in a stretch of a river channel in northern Portugal. Documentary analysis and field activities were carried out to identify the main changes suffered in the Levada do Piscaredo area. The research revealed that the ancient occupation represented by the levada generated significant changes, especially in the slopes, which underwent alterations both in their shape and in the erosive and depositional processes.

Keywords: hydrogeomorphology; multifunctional channels; erosion; sedimentation.

Resumen

Las obras hidráulicas suelen investigarse en términos de eficiencia y costes de instalación y explotación. Sin embargo, también es importante evaluar su impacto en los aspectos medioambientales, especialmente sus repercusiones en los sistemas fluviales y de laderas. El objetivo de este estudio es presentar obras que han sido responsables de cambios hidráulicos, sedimentarios, erosivos y deposicionales en un tramo de canal fluvial del norte de Portugal. Se realizaron análisis documentales y actividades de campo para identificar los principales cambios sufridos en la zona de Levada do Piscaredo. La investigación reveló que la antigua ocupación representada por la levada generó cambios significativos, especialmente en las laderas, que sufrieron alteraciones tanto en su forma como en los procesos erosivos y deposicionales.

Palabras clave: hidrogeomorfología; canales multifuncionales; erosión; sedimentación.

Resumo

Obras hidráulicas são comumente investigadas ao nível da eficiência e dos custos de instalação e operações. Contudo, também é importante avaliar os seus impactos sobre aspetos ambientais, sobretudo nas repercussões que exercem sobre os sistemas fluviais e de vertentes. É objetivo deste estudo apresentar um exemplo de obras que foram responsáveis por mudanças hidráulicas, sedimentares, erosivas e deposicionais num trecho de um canal fluvial existente no Norte de Portugal. Para tanto foram realizadas análises documentais e atividades de campo para identificar as principais alterações sofridas na área da Levada do Piscaredo. A investigação revelou que a ocupação antiga representada pela levada gerou alterações contundentes, principalmente nas vertentes, que sofreram alterações tanto nas suas formas, quanto nos processos erosivos e deposicionais.

Palavras-chave: hidrogeomorfologia; canais multifuncionais; erosão; sedimentação.

Introduction

The tradition of intervening in river systems to transport water and slopes to promote different occupation profiles dates back to the origins of civilization (Silva, 2018). Over time, these complex movements have undergone technical evolution as they have spread throughout the world. As a result, it is understood that spaces are being dominated and altered, hijacking their natural dynamics, which, in turn, present resistance (Mossa; James, 2013; Macklin et al, 2014).

For Cooper et al. (2018), this type of appropriation attests to the so-called geotechnogenesis, in which the processes of aggradation and degradation along the surface are a hallmark of human dominance (Peloggia, 2019). These changes, as observed by Haff (2003), therefore have repercussions on the geological stratum, relief forms, soil, system responses to climate variations and biotic dynamics.

As an example, in northern Portugal there are numerous examples of human intervention, through the construction of reservoirs, mining operations, terraces and irrigation channels, among many other actions, which have led to changes in the landscape and which require specific investigations for each case. The area of the present study is precisely in this region where works that have altered the courses of rivers stand out, creating artificial channels, dams and cuts in the slopes to relativize the role of climate on agriculture. Aware that these changes have repercussions on hydrogeomorphological processes, the objective of this study is to present the works that were responsible for hydraulic, sedimentary, erosive and depositional changes in a section of a river channel in northern Portugal.

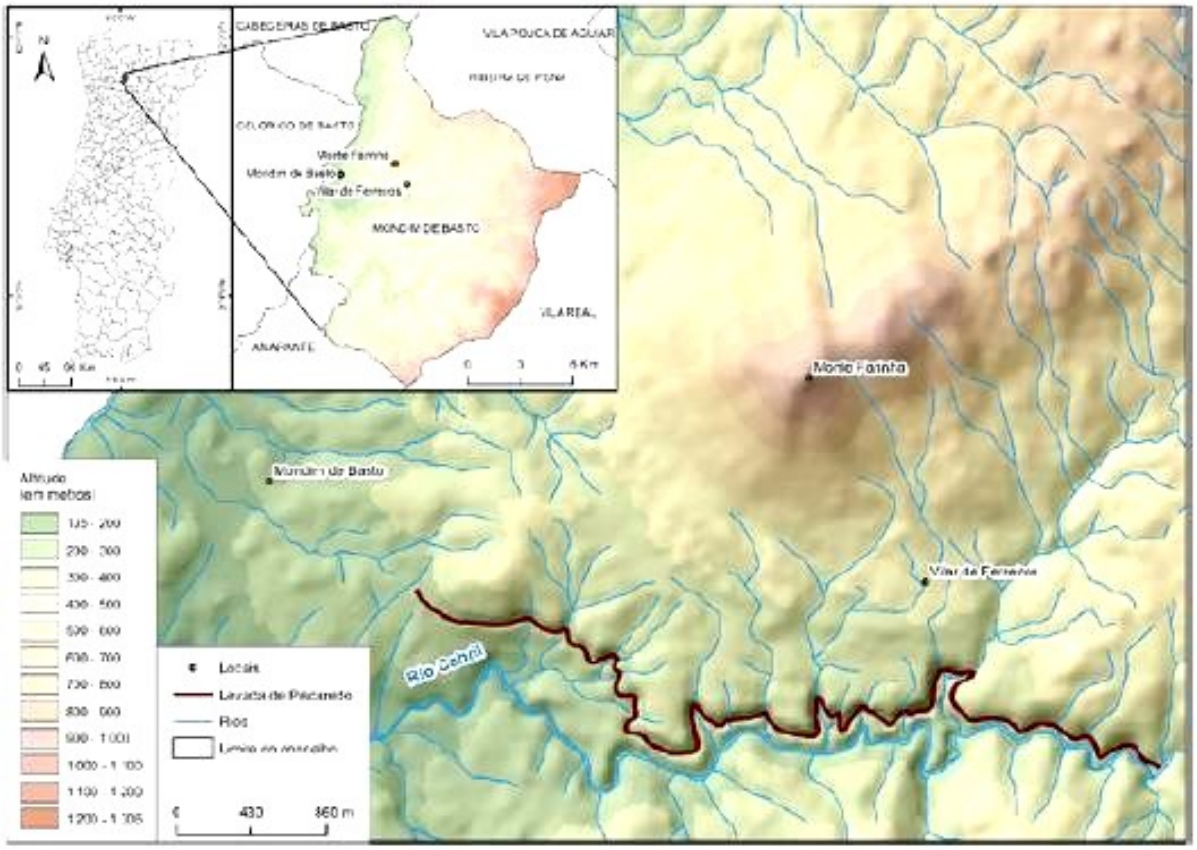
Materials and methods

The research integrated data obtained in the field, bibliographical and documentary research. Documents from the Portuguese Environment Agency (APA, 1970) helped to understand the management and maintenance of these structures, data necessary to assess the size of the works carried out and their impacts (Vieira et al., 2018). During the field activity, hydraulic structures, works to contain erosion forms, and retention or diversion of sedimentary materials in movement were observed. The field work also allowed, through the use of a drone and GPS receiver and other tools, measurements and photographic records necessary for a better understanding of how the slope/valley bottom system is altered by these works and how natural aspects are permeated by human agency.

Study area.

As for the location of the study area, the town of Mondim de Basto is located in the North of Portugal, on the border between the provinces of Minho and Tras-os-Montes. In this community, the importance of agricultural tradition is still important, a fact visible through the maintenance and continued use of infrastructures such as levadas, such as the Levada do Piscaredo/Pisqueiredo, which transport waters along the slope of the Cabril River and its tributaries, especially the Cabrão, to the irrigated area (map 1).

Map 1 - Location of the municipality of Mondim de Basto and Levada do Piscaredo.



Source: Vieira (2024).

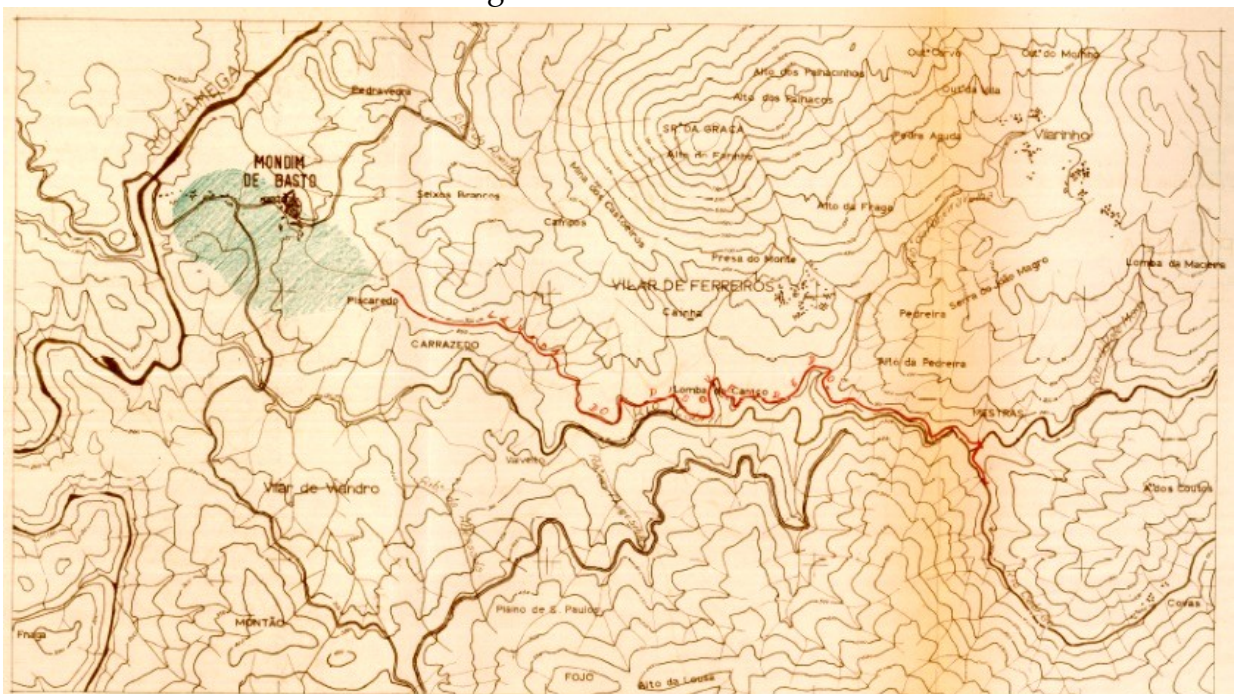
The transposition area is located in a mountainous relief environment, formed mainly by granite rocks, with some schist occurrences. The valleys are deep, the slopes are steep and subject to erosion, the soils are sandy loam in the granite areas and clayey on the schist areas. The climate regime is influenced by the proximity of the Atlantic Ocean, with precipitation rates concentrated in the winter. These

characteristics revealed in the field potential for both erosion and depositional processes that need to be better understood.

Results and discussion

The Levada do Piscaredo, as a human topographic signature (Taroli; Sofia, 2016), highlights the impacts generated on the slopes and valley floor, since its implementation in the 17th century, until the daily maintenance and the major renovation of 1970 (map 2). Originally, the canal was 5,600 meters long, from the dam/dam on the old river to the irrigated areas, receiving an additional 1,500 meters to connect the levada to an increase in flow at the confluence of the Cabril and Cabrão rivers.

Map 2 - Levada do Piscaredo, according to documentary records, and the irrigation area served near the village of Mondin de Basto

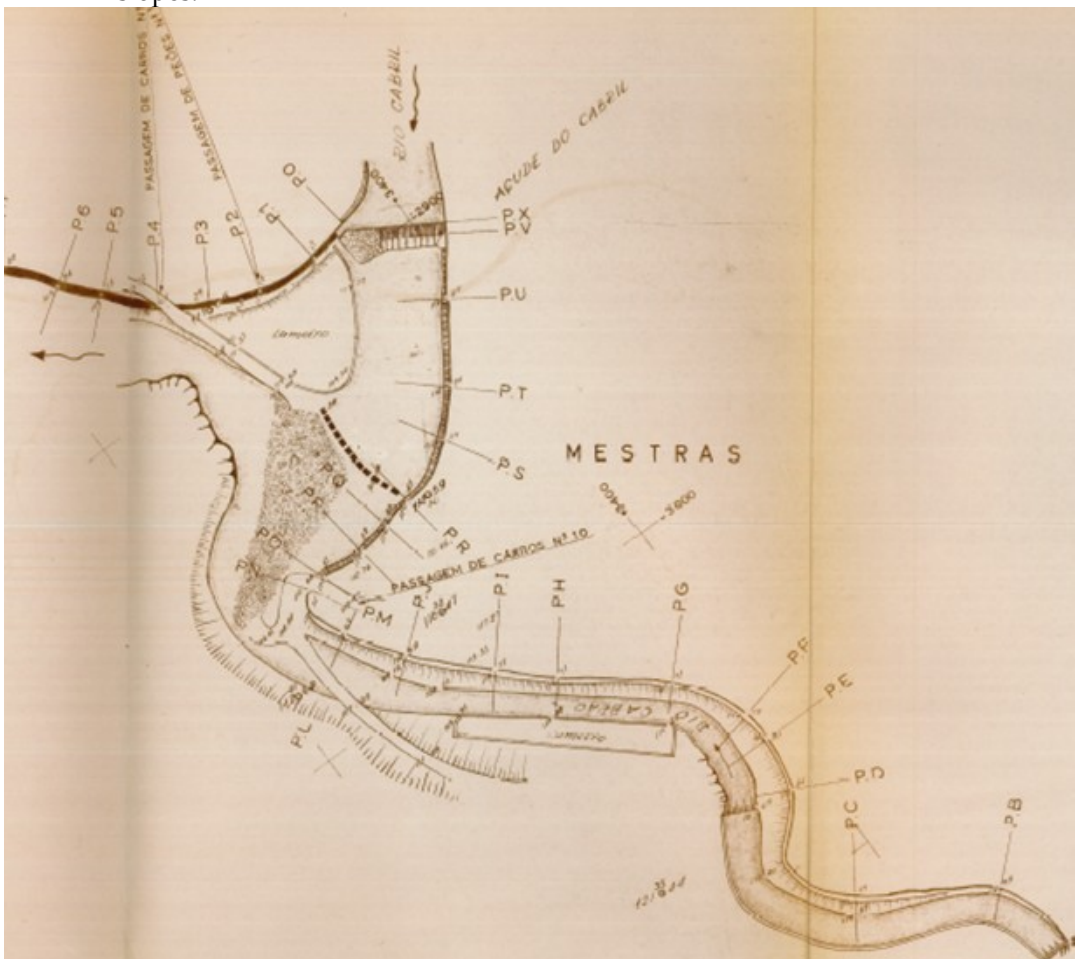


Source: APA (1970)

The main hydrogeomorphological repercussions observed in the field along the diversion system are discussed below. Initially, as the main water collection system, the weirs and diversion dams (map 3) modify the speed and level of the water upstream of their

structures, creating lentic environments with sediment retention. Downstream, the structures contribute to the reduction of the flow and sedimentary material, since these are partly transferred towards the slope by the artificial channel.

Map 3 - Plan diagram of the transposition system between the Cabril and Cabrão rivers with the slopes.



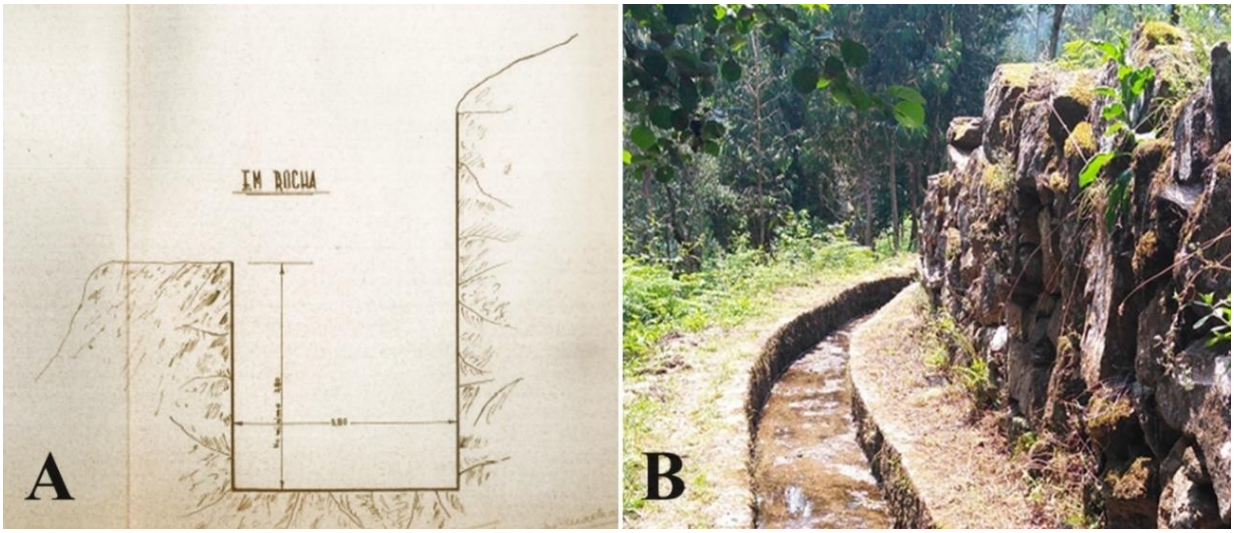
Source: APA (1970).

The levada was opened in rocky slopes, directing water and sediments from the valley bottoms to the slopes. Interventions were carried out in these channels to capture, contain or redirect surface flows from the slopes. These structures combine changes in the dynamics of the slopes by both catalyzing and mitigating erosion and deposition processes (Panel 1).

In some sections, erosion processes or the rocky material of the slope conditioned narrow passages to the artificial channel (Panel 2), requiring the

construction of support barriers to ensure that the structure would not be lost due to erosion processes. These barriers are rustic, generally made of cut and fitted stones or masonry bricks.

Panel 1- A: Cut in the rocky slope for installation of the levada. In the diagram it is possible to notice that the cut was made in order to accommodate the flow and avoid spills. B: Cut in granite rock and accommodation of the channel cover.



Source: A) APA (1970) and B) Vieira (2017)..

Panel 2 - Canal passage in a narrow section with erosion threatening the structure. And gutter to isolate flows from the slopes of the artificial canal

Source: Vieira (2017).

Direct connections between the slope and the artificial channel were also observed, such as ravines and watercourses, and in these cases the flows reached the artificial channel or were diverted by means of gutters. As the artificial channel has sectors with leaks or ruptures, there is an increase in erosion rates, instability in the

slopes and even landslides. As a result, in several sections since the beginning of the diversion, walls have been built to contain the erosion processes originating from the natural course itself.

In one of the sections, there are approximately 1,200 meters of support walls from the channel to the lower portion of the slope. Also in the upper portion of the slope, long walled sections were built to reduce the risk of landslides, which are more susceptible to surface cutting and the passage of water (panel 3).

Panel 3 - Stone wall installed in the upper part of the slope stabilizes the structure of the artificial channel, while reducing the risk of collapse due to the river activity of the Cabril River in the lower part.

Source: Vieira (2017).

Regarding the processes that develop within artificial channels, sedimentation is the most prominent, although the structure based on impermeable plates facilitates flow and reduces deposition. However, seasonal cleaning is necessary, as sediment deposition advances in some sections with less slope and consequent reduction in flow speed (photo 1). From the removal of material within the channel, small marginal deposits are formed that, when consolidated on the channel banks, form the so-called anthropogenic marginal dikes (Silva, 2018).

Photo 1 - Sedimentary material deposited in the channel that has its transport capacity reduced during periods of low flow.

Source: Vieira (2017).

Final Considerations

As an anthropic manifesto, it is understood that these channels are a valid example of topographic signatures and that, once addressed in this way, they help to better understand how slopes, valley bottoms and other elements are modified by them, while they need to be managed to reduce impacts and allow for correct functioning. Among the main impacts observed, we highlight:

- Fluvial alteration in the valley bottom due to the construction of dams, with an increase in the water level and retention of sediments upstream of the structure;

- Reduction in flow and sediments downstream of the dam/dam that still acts as an obstacle to biotic elements;

- Diversion of water and sediments from the valley bottoms towards the slopes, configuring an inversion of the drainage pattern;

- The cuts made to open the channels drive erosive forms. Observing the relationship between the impacts caused by these structures on the natural processes they alter and their constant dependence on interventions for their functioning, it is possible to consider that the levadas always operate towards their own interruption, whether due to erosion, sedimentation or other issues. Thus, the efficiency in the functioning of these structures is important for reducing operating costs, increasing the intervals between major maintenance, reducing water loss and increasing the capture of natural watercourses. There is also concern about the risk of landslides and collapses adjacent to these structures, issues that can only be understood from the association between issues of human occupation and altered hydrogeomorphological processes.

References

AGÊNCIA PORTUGUESA do AMBIENTE - APA, Relatório Técnico de reforma daLevada do Piscaredo, 1970

COOPER, A.H.; BROWN, T.J.; PRICE, S.J.; FORD, J.R.; WATERS, C.N. Humans are the most significant global geomorphological driving force of the 21st century. **TheAnthropocene Review**, 5(3): 222-229. 2018. https://doi.org/10.1177%2F2053019618800234

HAFF, P.K. Neogeomorphology, prediction and the Anthropic landscape. In: WILCOCK, P.R., IVERSON, R.M. Prediction in Geomorphology. **Geophysical Monograph**, Washington: American Geophysical Union, 2003. https://doi.org/10.1029/135GM02

MACKLIN, M.G., LEWIN, J., JONES, A.F. Anthropogenic alluvium: An evidence-based metaanalysis for the UK Holocene. **Anthropocene** 6, 26–38, 2014. https://doi.org/10.1016/j.ancene.2014.03.003

MOSSA, J., JAMES, L.A. 13.6 Impacts of Mining on Geomorphic Systems, in: Treatise on **Geomorphology.** Elsevier, pp. 74–95, 2013. https://doi.org/10.1016/B978-0-12-374739-6.00344-4

PELOGGIA, A. U. G., Conceitos fundamentais da análise de terrenos antropogênicos: o estudo da agência geológico-geomorfológica humana e de seus registros, **Revista do Instituto Geológico,** São Paulo, 40 (1), 1-17, 2019.

SILVA, R. E. Assinaturas Topográficas Humanas (ATH's) No contexto dos canais derivados multifuncionais e suas repercussões hidrogeomorfológicas. UniversidadeFederal de Uberlândia – UFU (**Tese de Doutorado**), 2018.

SILVA, R.E; Rodrigues, S.C ; Vieira, A.A.B . Role of vegetation inducing sedimentation in an artificial earth channel. **mercator** (Fortaleza. Online), v. 22,p. 1-21, 2023.

TAROLLI, P., SOFIA, G. Human topographic signatures and derived geomorphic processes across landscapes. Geomorphology, 255, 15 February 2016, Pages 140-161

VIEIRA, A. A. B. ; SILVA, R. E; RODRIGUES, S. C. O percurso pedestre da levada de Piscaredo (Noroeste de Portugal): Potencialidades Geopatrimoniais em espaços multifuncionais. **Terr@ Plural** (UEPG. online), v. 12, p. 307-319, 2018.

Acknowledgements

Financed by national funds from Portugal through FCT – Fundação para a Ciência e a Tecnologia, I.P., within the scope of the project UIDB/00736/2020 (base financing) and UIDP/00736/2020 (programmatic financing). Minas Gerais Research Support Foundation, FAPEMIG PCE00225/24

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