The use of check dams for soil restoration at watershed level: A century of history and perspectives

M.E. Lucas-Borja, G. Piton, M. Nichols, C. Castillo, Y. Yang, D.A. Zema

PII: S0048-9697(19)33362-5
DOI: https://doi.org/10.1016/j.scitotenv.2019.07.248
Reference: STOTEN 33442

To appear in: *Science of the Total Environment*

Please cite this article as: M.E. Lucas-Borja, G. Piton, M. Nichols, et al., The use of check dams for soil restoration at watershed level: A century of history and perspectives, Science of the Total Environment, https://doi.org/10.1016/j.scitotenv.2019.07.248

Editorial

The use of check dams for soil restoration at watershed level: a century of history and perspectives.

Lucas-Borja, M.E.[1,*]; Piton, G.[2], Nichols, M.[3], Castillo, C.[4], Yang, Y.[5], Zema, D.A.[6]

[1]Castilla La Mancha University, School of Advanced Agricultural and Forestry Engineering

Department of Agroforestry Technology and Science and Genetics. Campus Universitario s/n

C.P. 02071, Albacete (Spain). * ManuelEsteban.Lucas@uclm.es

[2]Univ. Grenoble Alpes, Irstea, Grenoble center, UR ETNA, Grenoble, France.

3 United States Department of Agriculture - Agricultural Research Service – Southwest Watershed Research Center, Tucson, Arizona, 85719, USA

[4] University of Cordoba, Dept. of Rural Engineering, Campus Rabanales, Leonardo Da Vinci Building, 14071 Cordoba, Spain

[5] Department of Sediment Research, China Institute of Water Resources and Hydropower Research, Beijing, 100038, China

[6] Mediterranean University of Reggio Calabria, Department AGRARIA, Reggio Calabria, Italy

Keywords: Check dams; soil erosion; runoff; gully erosion; soil hydrology; watershed restoration.

Check dams are transverse structures built across stream-beds and gullies for controlling water flow and sediment transfer. Typically, check dams are made of stones, gabions, earth, masonry, concrete or wood logs. Throughout the world, national, regional and local authorities have spent, and still spend, large amounts of funds for erosion-control schemes at the basin scale. These projects focus on runoff detention and the control of sediment supply to rivers by constructing

check dams along with other soil conservation and vegetation restoration tools in watershed uplands. The stabilization role of these structures is well known, i.e. they durably constrain the stream-bed through the creation of vertical and planar fixed points. These structures and their side effects serve the purpose of better controlling solid transport. Several papers in this Special Issue, demonstrate expected key side effects of check dam construction for example, improving vegetation cover (Ricci et al. 2019) or bringing targeted changes in sediment connectivity (Marchi et al. 2019). Abbasi et al. (2019) provide many different well established examples from around the world regarding the use of check dams in watershed management projects that aim to control soil erosion and runoff. However, although the number of constructed check dams continues to increase in response to soil erosion prevention purposes, flood control needs and sediment transport regulation, their expected impact - to reduce the upstream slope of the regulated reaches or to stabilize torrent beds - is sometimes not achieved due to local circumstances such as the poor construction quality, inadequate check dam location and lack of rational design procedures. Observations of channel cross sections and bed materials made in several studies indicate that check dams may increase erosion downstream of the structures. In addition, other studies have pointed out that dams represent one of the most dominant forms of human impact upon fluvial systems (Wohl 2006), as they disrupt the downstream transfer of water and sediments. However, a number of works have focused on preventing such problems and failures in projects and structures. For example, Rossi and Armanini (2019) provide a new approach for impact force estimation on open check dams to help prevent structural failures. Gregoretti et al (2019) presented a new model-based approach for design and performance evaluation of works controlling stony debris flow with an application to a case study at Rovina di Cancia (Venetian Dolomites, Northeast Italy).

Check dam installation is often carried out with general expectations of controlling water flow and sediment supply, but the actual responses frequently remain untested. Research papers presented in this special issue aim to achieve a comprehensive synthesis of check dam effects at the watershed level in soil restoration schemes including conceptual thinking, field observations, and feedback from applied tests and trials. This Special Issue brings together scientific and technical experiences from all around the world and provides an evidence of the legacy effects of check dams. Shared insights highlight the role of complex interactions between ecological elements,

geomorphic processes and engineering activities to improve the use of check dams for conserving soil and water resources. More in detail, this Special Issue gathers twenty contributions to a better knowledge of check dam functioning and effects on erosion and hydraulic processes. These papers demonstrate that studies using remote sensing data or aerial photographs (Alfonso-Torreño et al., 2019; Ricci et al. 2019), field survey (Robichaud et al., 2019; Li et al, 2019; Nichols et al., 2019; Mongil et al., 2019; Shi et al., 2019; Navarro-Hevia et al., 2019), numerical modelling (Gregoretti et al., 2019) and laboratory experiments (Rossi et al., 2019) are important for understanding the numerous interactions between water and sediment, as well as the geomorphology and ecology of hillslopes and channels. This information will help researchers to better understand the key geomorphic impacts that transversal structures may have at the watershed level and will provide managers with some new methods and criteria to prioritize maintenance operations and plan new construction. Future research should aim to demonstrate the effectiveness and feedbacks based on long term monitoring of existing systems or from extreme events experienced by structures. New monitoring and modelling techniques need to be investigated to improve check dams design and adaptations. Finally, innovative design criteria that advances both traditional and open check dams should be encouraged to optimize future installations within various geomorphological, climatic and ecological settings.

Acknowledgments

The Guest editors are thankful to the editor in Chief, Prof. Damia Barcelo, the special issue editor Prof. Elena Paoletti for the support and encouragement to organize this special issue. The editorial team also acknowledge the industrial work of the reviewers and their valuable comments and suggestions crucial for improving the quality of the published papers in the Special Issue. We would like to thank Das Pallavi and Jia Yang for professionalism and provide handling technical issues. This work was also benefited of all the presentations during the consecutive 3 years check dam session in the European Geosciences Union (EGU 2017 to EGU 2019). Yang Yu received young elite scientist sponsorship program by China Association for Science and Technology (2017 to 2019).

Abbasi, NA., Xu, X., Lucas-Borja, ME., Dang, W., Liu, B., 2019 The use of check dams in watershed management projects: Examples from around the world. Sci. Total Environ. 676, 683-691. https://doi.org/10.1016/j.scitotenv.2019.04.249.

Alfonso-Torreno, A., Gomez-Gutierrez, A., Schnabel, S., Lavado, CJF., de Sanjose, Blasco, JJ., Sanchez, FM. 2019. sUAS, SfM-MVS photogrammetry and a topographic algorithm method to quantify the volume of sediments retained in check-dams. Sci. Total Environ. 678, 369-382. https://doi.org/10.1016/j.scitotenv.2019.04.332

Galicia, S., Navarro-Hevia, J., Martinez-Rodriguez, A., Mongil-Manso, J., Santibanez, J. 2019. 'Green', rammed earth check dams: A proposal to restore gullies under low rainfall erosivity and runoff conditions. Sci. Total Environ. 676, 584-594. https://doi.org/10.1016/j.scitotenv.2019.04.189.

Li, P., Xu, G., Lu, K., Zhang, X., Shi, P., Bai, L., Ren, Z., Pang, G., Xiao, L., Gao, H., Pan, M. 2019. Runoff change and sediment source during rainstorms in an ecologically constructed watershed on the Loess Plateau, China. Sci. Total Environ. 664, 968-974. https://doi.org/10.1016/j.scitotenv.2019.01.378.

Marchi, L., Comiti, F., Crema, S., Cavalli, M. 2019. Channel control works and sediment connectivity in the European Alps. Sci. Total Environ. 668, 389-399. https://doi.org/10.1016/j.scitotenv.2019.02.416.

Martino, B., Mauro, B., Massimo, D., Carlo, G. 2019. Model-based approach for design and performance evaluation of works controlling stony debris flow with an application to a case study at Rovina di Cancia (Venetian Dolomites, Northeast Italy). In Press. https://doi.org/10.1016/j.scitotenv.2019.05.468.

Mongil-Manso, J., Diaz-Gutierrez, V., Navarro-Hevia, J., Espina, M., San Segundo, L. 2019. The role of check dams in retaining organic carbon and nutrients. A study case in the Sierra de Avila mountain range (Central Spain). Sci. Total Environ. 657, 1030-1040. https://doi.org/10.1016/j.scitotenv.2018.12.087.

Nichols, MH, Polyakov, VO. 2019. The impacts of porous rock check dams on a semiarid alluvial fan. Sci. Total Environ. 664, 576-582. https://doi.org/10.1016/j.scitotenv.2019.01.429.

Wohl, E. 2006. “Human impacts to mountain streams”, Geomorphology. 79, 217-248

Ricci, GF., Romano, G., Leronni, V., Gentile, F. 2019. Effect of check dams on riparian vegetation cover: A multiscale approach based on field measurements and satellite images for Leaf Area Index assessment. Sci. Total Environ. 657, 827-838. https://doi.org/10.1016/j.scitotenv.2018.12.081.

Robichaud, PR., Storrar, KA, Wagenbrenner, JW. 2019. Effectiveness of straw bale check dams at reducing post-fire sediment yields from steep ephemeral channels. Sci. Total Environ. 676, 721-731. https://doi.org/10.1016/j.scitotenv.2019.04.246.

Rossi, G., Armanini A. 2019. Impact force of a surge of water and sediments mixtures against slit check dams. Sci. Total Environ. 683, 351-359. https://doi.org/10.1016/j.scitotenv.2019.05.124.

Shi, P., Zhang, Y., Ren, Z., Yu, Y., Li, P., Gong, J. 2019. Land-use changes and check dams reducing runoff and sediment yield on the Loess Plateau of China. 664, 984-994. https://doi.org/10.1016/j.scitotenv.2019.01.430.