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The Challenge of Soil Erosion: Where Do We Now Stand?

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Abstract

Issues around soil erosion continue to be widely debated in major journals and books. In the last 30 years there have been considerable advances in the understanding of off-site impacts of muddy flooding and fresh water pollution, and in flood protection. However, progress in erosion prediction has been disappointing especially in the continued reliance on out-dated and unreliable models. Alternative approaches using field-scale assessments are available and need to be more widely used.

Keywords: Soil Erosion: Off-Site Impacts; Erosion Models; Field-Scale Assessment; Soil Conservation

Opinion

This short review addresses some of the main issues to emerge in the sphere of soil erosion studies in the last c.30 years. During this time, the global output of papers and reports on soil erosion is impressive. Major journals devote considerable space to the topic: Catena, Earth-Science Reviews, Earth Surface Processes and Landforms, Geomorphology, Journal of Soil Conservation, Journal of Soils and Sediments, Land Degradation and Development, Soil and Tillage Research, Soil Use and Management. Various important reviews have appeared e.g [1] on rill and interrill contributions; [2] on gullies; [3] on rill data from plots and [4] on climate change and erosion. Edited books have attempted to pull together disparate studies e.g. [5-10] and Morgan's text book continues to be widely used [11]. Trimble's review of erosion in the Upper Mississippi hill country is an outstanding historical survey of periods of excessive erosion and latterly the success of conservation tillage [12]. Soil erosion is not a self-contained, easily-bounded subject. Thus, highly relevant studies appear in sub-disciplinary areas such as hydrology (sediment yields), lacustrine, arid and grazing studies, agronomic and agricultural areas. Erosion is not simply driven by physical factors [13], and therefore cognate disciplines of rural sociology, land use studies and rural economics play an important part: this is especially the case when considering the role of farmers in soil conservation. The recent exhibition of the photographs of Dorothea Lange in London and Paris, reminds us of the human costs of erosion [14].

Successes and Failures

In this time period there have been significant successes, areas where the science or practice has advanced. On the other hand, particularly in the area of erosion prediction, progress has been disappointing. The distinction between on-farm and off-farm impacts of erosion is clear. In western Europe, the on-farm threat of thinning soils impacting on crop yields, is now seen as a medium term, non-urgent threat [15] whereas, off-site damage to properties by muddy flooding is reported in many countries and associated costs are high [16,17]. The latter threat spans the boundary between soil conservation and flood protection and often requires specific protection measures to address off-farm, down-valley impacts.

A successful scheme in Flanders, Belgium, addresses these issues including the need to properly finance local flood-protection measures in towns and on adjacent farm land [18]. Growing awareness of the damage to freshwater systems by excess fine sediment, phosphorus, nitrates and metaldehyde, often from farmers' fields, has been driven by the European Union's Water Framework Directive [19]. This awareness drives the England-based Demonstration Test Catchment approach to tackling freshwater pollution e.g [20]. However, the global-scale threat to soils on the farm is far less clear because of the unreliability of the data. For the last thirty years, assessments of the scale and extent of global land degradation (including erosion) have tended to rely on GLASOD data [21]. This is qualitative and subjective and provides only a very generalised assessment.

In the last thirty years little progress has been made in erosion prediction using models. The choice is still between USLE-based empirical models and process-based models such as WEPP and EUROSEM. A panoply of other models falls into these two categories. The USLE and its derivatives are widely used because of their simplicity but extrapolation from databases developed on experimental plots (22x2m), to the field scale, patently does not work. It therefore remains unvalidated and promulgates misleading results [22,23,3]. On the other hand, process-based models have proved to be too data-hungry for widespread use. The EU has chosen to invest resources in a USLE approach. The sophisticated use of GIS and remote sensing does not disguise the fact that the resultant maps are unvalidated and in many cases plainly wrong [24,25]. The USLE over emphasises gradient and rainfall and under emphasises vegetative cover. Bandwagons in science are difficult to derail as evidenced by the 'success' of ^{137}Cs as an erosion assessment tool despite the evidence for caution [26]. In the UK, a relatively simple approach to erosion assessment has proved valuable. Field mapping of selected representative areas provides data on soils, the extent, frequency and risk of each crop to erosion [27,28]. Around this basic knowledge, detailed studies of particular risks such as those of extreme events [29], low-magnitude, high-frequency events [30], and pollution risks associated with runoff [31], have been assembled.

Models have also been used to support the idea of very high rates of erosion. Observed spatial and temporal variabilities of erosion across farmed landscapes suggest that average rates of >20 t ha^{-1} yr^{-1} are likely to be extremely rare. USLE predictions of >40 t ha^{-1} yr^{-1} are unlikely [32], and at the very least require supporting empirical evidence. Extreme rates such as 202m^3 ha^{-1} yr^{-1} on a UK field, when seen in the context of the spatial variability of erosion across the landscape [29], and long-term temporal variability, can be seen as what they are: extreme, non-typical events – but often with considerable off-site impacts [33].

While results from models have been generally disappointing, field-scale monitoring of erosion based on the first national survey, has produced data that compares well with other assessments, is cheap and for which the errors are known [34]. Finally, real progress has been made in understanding the connectivity or dis-connectivity of erosional processes [35], This is important as it addresses the management issue at the catchment scale rather than that of the individual field or watercourse. Progress is also evident in the adoption of conservation tillage especially in north and south America. This is not without its problems such as lower yields and polluted runoff but is likely good news for erosion control. In this, and other approaches, we still seek solutions to the dilemma of producing more food and limiting erosion and pollution, or what has recently been characterised as the need for 'smart intensification' [36].

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