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Original Research Article

Designing terraces for the rainfed farming region in Iraq using the RUSLE and hydraulic principles

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ABSTRACT

The rainfed region in Iraq comprises an area of more than 5 million ha of forest, grazing and farmland areas. Except the plains, the region suffers from moderate to severe water erosion due mainly to overgrazing and land mismanagement. Due to population growth and the shortage in water resources, an expansion in land used for agriculture in the region is expected. Terracing is an option when utilizing sloping land for agricultural production. A terrace design criterion was developed for the region in which terrace spacing was determined using the Revised Universal Soil Loss Equation (RUSLE); terrace channel specifications were determined using conventional hydraulic computations. Analyses showed that terracing is feasible on rolling and hilly sloping land in the high rainfall zone (seasonal rainfall >600 mm) where economic crops are grown to offset the high cost of terrace construction and maintenance. In the medium and low rainfall zones (seasonal rainfall 400–600 mm and 300–400 mm), terracing for water erosion control is generally not needed on cultivated land less than 10% in slope where wheat and barley crops are normally grown; however, pioneer research projects are needed to assess the feasibility of terraces of the level (detention) type to conserve rain water in these two zones for a more successful rainfed farming venture.

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1. Introduction

Declining soil productivity and contamination of surface water resources are two major outcomes of cropland erosion by water. Research is often needed to establish erosion control measures suitable to a particular region.

Terracing for water erosion control may become necessary when farming on the moderate and steep slopes. The application of this

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practice has increased recently due to population growth in regions with limited land resources (Petanidou, Kizos & Soulakellis, 2008). Soil erosion modeling and economic analysis may be used to explore the necessity for terrace farming in agricultural areas (Beven & Conolly, 2010; Peterson, Miller, Milligan & Withers,1981). For the small land holders, benefits of terraces come only in the long term (Angima, Stott, O'Neill, Ong & Weesies, 2003). Terraces are also used for water conservation on all types of slopes. Lu, Zhu, Skaggs, and Yu (2009) reported that development of narrow terraces on lands that sloped 5° and 10° reduced soil losses by 57.9% and 89.8% and nutrient losses by 89.3% and 95.9%, respectively, in a semiarid region in China. Additionally, soil bulk density was reduced by 4%, soil moisture increased by 20.7%, soil fertility increased by 42.4% and yield increased by 22.4–37.3%. In another study, Yang et al. (2010) found that the average annual sediment yield from a watershed decreased exponentially with the increase in flow diversion terrace protection.

Most developing countries lack the necessary data base to establish a suitable criterion for terrace design. Terrace design formulas derived elsewhere (e.g. FAO, 1979; NRCS, 2004) are often valid only within the region where they were developed for. The Universal Soil Loss Equation (USLE) (Wischmeier & Smith, 1978) and its revised version (RUSLE) (Renard, Foster, Weesies, McCool & Yoder, 1997) are being used to find terrace spacing in regions where an estimation of the equation parameters is available. Since the parameters for this equation in the rainfed region of Iraq are generally available (Hussein, 1986, 1998; Hussein & Kariem, 1988) we will use the RUSLE to obtain a first approximation for terrace spacing in the region. Basic hydraulic principles for channel flow will be used to estimate terrace channel specifications. Terraces are generally expensive to build and maintain, hence the feasibility of any proposed terrace system should be determined.

2. Background

2.1. The rainfed region in Iraq

The rainfed region in Iraq is located to the north of the 300 mm isohyet with a total area of more than 5 million ha. The region has a semiarid Mediterranean type climate characterized by a wet cold winter and a dry hot summer. Rainfall season in the region normally starts in early or mid fall and ends in mid or late spring. Problems with rainfall in the region include the delay in the fall rain which affect seeding time and seedlings, the limited usefulness of rain during the cold period because of slow growth and the insufficiency of spring rain necessary for an economic yield.

Forests cover more than 1.5 million ha of mostly mountainous areas located to the north and northeast of the region with mean seasonal rainfall exceeding 600 mm. They are mostly degraded oak forests with the Querus aegilops being the dominant tree species. Water erosion is slight to moderate.

More than 2 million ha in the region is under rainfed farming mainly in the foothills region. Topography is level to rolling. Farm size varies considerably and ranges from few hectares to several hundreds hectares. Wheat, barely and legumes are the major crops grown. Current tillage practices used are mostly moldboard plowing and/or disking for seedbed preparation. Aridisols, Mollisols and Vertisols are the major soil orders in the rainfed farming zone. Sheet and rill erosion are common.

The rest of the rainfed region is mostly grazing land. Overgrazing is common resulting in a degraded rangeland. Sheet, rill and gully erosion are active. Severe gully erosion occurs in the Adhaim river valley located in the southeastern part of the region.

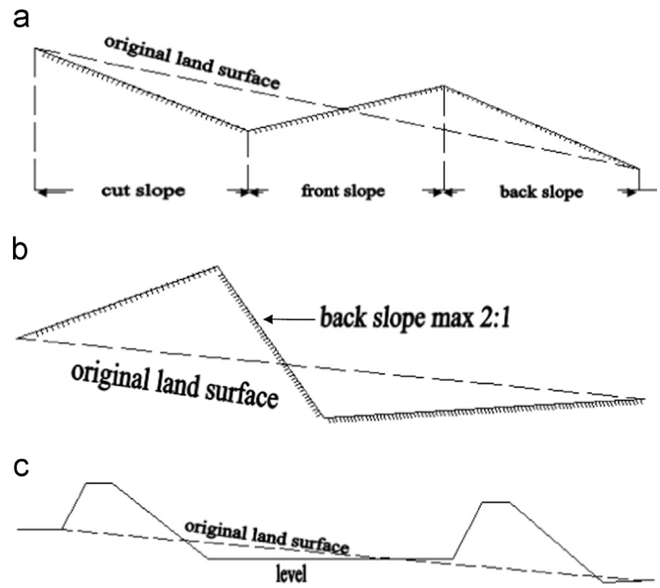

Fig. 1. Typical terrace cross section; a – broad base, b – steep backslope, c – bench.

2.2. Terraces and their use

Terraces are embankments or a combination of embankments and channels constructed across the slope to control erosion and/or conserve water by diverting and temporarily storing surface runoff instead of permitting it to flow uninterrupted down the slope (SWCS, 1982). Terraces may be classified by their alignment, gradient, outlet and cross section. Alignment may be parallel or nonparallel. Gradient may be level or graded. Outlets may be soil infiltration only, vegetated water ways, tile outlets or combination thereof. Cross section may be narrow base, broad base, bench and steep backslope (ASAE, 1989).

On gently to moderately sloping land (i.e. slope $\leq$ 12%), the broadbase type of terraces (Fig. 1a) may be used. On moderately steep land (i.e. 12% < slope < 20%), the steep backslope type of terraces (Fig. 1b) may be used; in this type of terraces, the backslope is usually kept in grass. Both types can be farmed; for the narrow base type of terraces, the entire cross section is frequently seeded to permanent vegetation. On steep land, the bench type of terraces (Fig. 1c) may be used (ASAE, 1989; FAO, 1979; Jacobson, 1981); however, the high cost of bench terraces limits their use for commercial agriculture in rainfed regions (Posthumus & Stroosnijder, 2010). In addition, stone bunds (Nyseen et al., 2007) and stone walls (Panagos, Borrelli, Meusburger, van der Zanden, Poesen & Alewell, 2015) are being used as an effective water erosion control practices on sloping land.

The graded (diversion) type of terraces is primarily used for water erosion control mainly by reducing the field slope length. The level (detention) type retains runoff and it is primarily used for water conservation. Both types can be farmed. Terraces are preferably constructed parallel to facilitate farming operations. It was found (Abu Hammad, Haugen & Borresen, 2005a) that

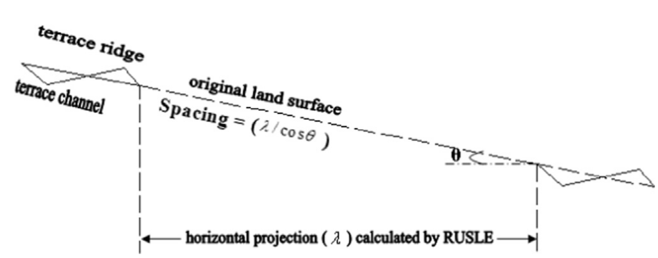

Fig. 2. Terrace spacing (after NRCS, 2010).