Technology for Conservation of Soil and Water Resources in Korea

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Abstract

Soil and water conservation is an integral part of slopeland agricultural development and management of soils. In Korea, unfavorable natural environmental and socio-economic factors contribute to the acceleration of soil and water loss in farmland. Korea is a mountainous country with two-thirds of the total land area consisting of steep mountain slopes. In addition, slopeland is prone to soil erosion due to the coarse texture of soil and concentrated heavy rainfall during the monsoon season. Slopeland agriculture is practiced in small farms. Due to the low level of consolidation, agriculture is labor-intensive because it is difficult to use machines and is characterized by low profits and techniques. Slopeland development may create social, ecological and environmental risks and thus does not meet the criteria of sustainability if not properly managed. Slopeland management requires more care to manage soils in terms of erosion and water deficit due to the characteristics of steep slope, shallow soil depth and heavy rainfall.

A project for the development of technology for soil and water conservation in Korea was initiated by the Association for Korean Reclamation Project within the framework of the UN Special Fund in 1961. A soil survey was conducted for slopeland development. In 1962, the Reclamation Promoting and Farm Conservation Law was enacted to promote the prevention of soil and water loss. Land development was conducted by using the original topography for reclamation into arable land including contour terracing and bench terracing to control soil erosion.

The technologies for soil and water conservation in Korea included soil and water loss measurement for different cropping systems, soil management, slope length and steepness using lysimeters, technology for artificial rain simulation, and also iso-erosion maps by analyzing rainfall characteristics. Monitoring of soil, water and nutrient loss was conducted in an agricultural watershed for the development of a simulation model. Recently, a comprehensive soil conservation project has been conducted in sloped farmland in Korea. For the project, engineering technologies and agronomic conservation practices were applied to control serious erosion problems in an alpine vegetable cultivation area.

Introduction

Korean agriculture may be characterized by the operation of small rice farms in paddy land and the cultivation of vegetable crops in the upland areas of semi-monsoonal Far East Asia. The area of cultivated fields in farm households is so small that homestead production,

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aimed primarily at self-supply prevails. Requirements for a staple food and the monsoonal climate have led to agricultural dependence on rice production. High population density and limited cropland area have made it difficult to produce enough food in Korea.

Much emphasis has been placed on the increase of crop production and expansion of cropland area. For the expansion of the cropland area, slopeland reclamation was initiated in the late 1950s. Several laws promoting farmland development had been promulgated earlier, and the Government initiated a project to establish demonstration farms and provide technical training on reclamation.

Soils in Korea display a low fertility because they are derived from granite and granite gneiss which account for two-thirds of the lithosphere in this country. Average annual rainfall ranges from 1,000 mm to 1,330 mm per year. Since two-thirds of rainfall are concentrated in the summer season, soil erosion is accelerated by intense rainfall. In addition, development of slopeland has progressed to expand the arable land area. It is understood that slopeland development is limited when soil and water conservation practices are not implemented. In this paper slopeland resources and development in Korea are presented along with some recent research activities on soil and water conservation in slopeland.

Slopeland resources

Korea has a total area of 9,930 thousand hectares, of which 20.8% consist of agricultural land while forests account for 65.1% and 14.1% are devoted to other uses (MAFF, 1993), (Table 1).

Table 1 Area of land use according to gradient

(Unit : 1,000 ha)

Land use	Slope (%)						
	< 2	2-7	7-15	15-30	30-60	60 <	Total*
Paddy fields	550	478	215	45	-	-	1,288
Upland fields	78	260	340	175	23	3	879
Orchards & Mulberry fields	18	28	42	26	4	1	119
Grasslands	3	23	40	21	14	2	103
Forests	11	44	206	571	2,106	3,847	6,425
Total	660	833	843	838	2,147	3,853	8,814
Ratio (1%)	7.5	9.4	9.6	9.5	24.4	39.6	100.0

*Area based on soil survey data from 1964 to 1990.
Source: ASI, 1992.

The most intensive agricultural area consisting of paddy and upland fields is concentrated in lowlands with a slope less than 7% and at an elevation below 100 meters above sea level (Table 2).

Table 2 Distribution of paddy and upland fields by altitude

(Unit : 1,000 ha)

Land use	Total	<100	100-200	200-300	300-400	400-500	500-600	600<
Paddy	1,288	955	206	73	30	16	6	2
Upland	879	515	175	89	44	22	15	19
Total	2,167	1,470	381	162	74	38	21	88,821

Topography influences greatly soil erosion and soil moisture which are major constraints on slopeland utilization. Upland fields are predominantly distributed in local valleys, mountain foot and hillside within 100 meter above sea level.

Orchards and mulberry fields are widely distributed in every physiographic zone and forests are mostly located on hilly to mountainous regions in which grasslands are generally managed under non-cultivated practices (Table 3).

Table 3 Distribution of land use by topography

(Unit : 1,000 ha)

Land use	Alluvial plain	Alluvial fan	Local valley	Dilluvial terrace	Mt. foot slope	Hill	Mountain
Paddy fields	507	40	591	51	89	2	(57)
Upland fields	74	66	285	19	215	145	34
Orchards & Mulberry fields	16	8	28	2	22	28	6
Grasslands	3	0.425	2	0.176	8	13	13
Forests	11	8	48	19	261	1,505	4,528

*Area excludes tidal flat, volcanic ash and others.
Source: ASI, 1992.

The available soil depth of slopeland is generally shallow compared to optimum depth for crop cultivation. Soil hardness and bulk density are relatively high, yet both porosity and clay content are low (Tables 4, 5).

Table 4 Physical properties of slopeland soil

	Av. soil depth(cm)	Slope (%)	Plow depth(cm)	Hardness (mm)	Bulk density (tg/m^3)	Porosity (%)	Clay content(%)
Present	<50	15-60	11	24	1.4	48	16
Target	>50	7-15	20	18	1.3	51	20

Source: ASI, 1992.

Table 5 Chemical properties of slopeland soil (1976-1980)

Crop	Sample size	pH(1:5)	O.M. (%)	Avail. P_2O_5(ppm)	Ext. cation (cmol/kg) K	Ca	Mg
Cereals	18,314	5.7	2.0	114	0.47	5.0	1.9
Vegetables	757	5.9	2.1	357	0.60	4.5	2.1
Target		5.9	2.1	236	0.50	4.8	2.0

Source: ASI, 1992.

Technology for soil and water conservation

The magnitude of soil erosion on slopeland is determined by the interaction of four factors: climate, topography, vegetation and soil. Each factor has been evaluated in numerous studies in different ways. The amount of soil loss depending on the soil texture, slope, cropping systems and conservation practices was determined in Korea.

Adequate amount of straw mulching for soil erosion control was tested during a period of three years in small field-plots with 15% slope. The increase in the amount of straw mulching reduced markedly soil erosion and runoff. The adequate level of straw mulching for effective erosion control was 200 kg/10 a in the barley-soybean cropping system (Fig. 1).

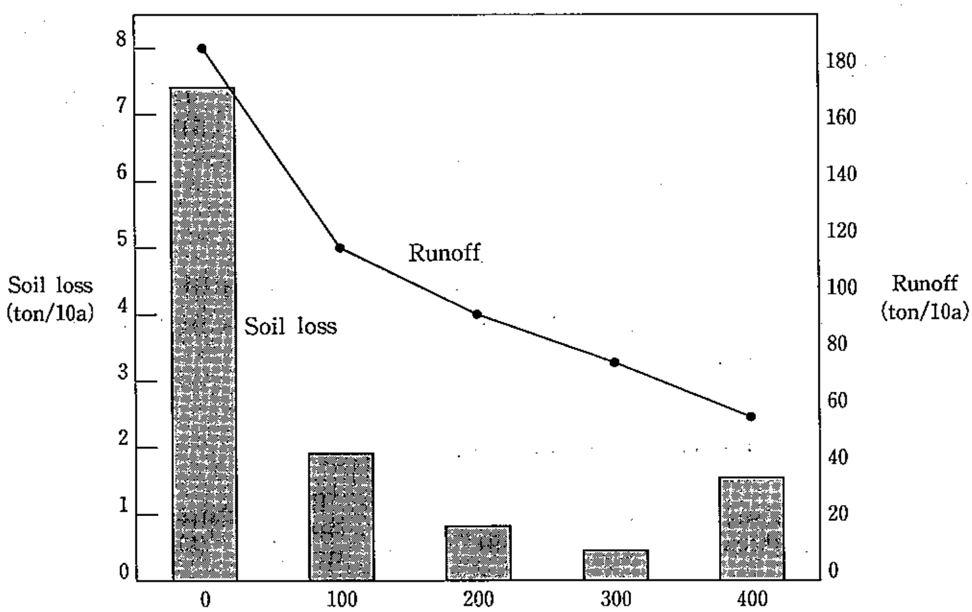

Fig.1 Soil loss and ranoff ot different levels of atraw mulching

Source, ASI. 1989.

Alpine vegetables were cultivated in a monoculture system during the summer season. Summer vegetables consist mainly of Chinese cabbage, radish and cabbage which are suitable for cool climate and high altitude. Mechanical conservation practices were employed to control serious erosion problems in the alpine vegetable cultivation area of Jeongseon Gun. They included hillside ditch, grass and rock or stony barriers, drop spillways, terrace channels, farm roads, open and subsurface drainage systems which are safer practices.

This steep slopeland was reclaimed by the Government for three decades. The land was reclaimed by applying the bench terracing method on steep slopes with an average of 30%. However bench terraces were removed by farmers who used machines on the farm. As a result, soil erosion is severe.

When the land was first reclaimed, black organic layer of soil measured one meter and now only a few centimeters. According to soil suitability classification, these areas should be used as grazing pastures or forests.

General soil characteristics of the representative alpine vegetable cultivation area at Bang Je Ri, in Jeongseon Gun located at 850 m above sea level are shown in Table 6.

Table 6 Soil characteristics of alpine vegetable land

Slope length (m)	Soil depth (cm)	Gravel (%)	Clay (%)	pH (1 : 1)	O.M. (%)	CEC (cmol/kg)	Available P_2O_5(ppm)	Permeability (mm/hr)
20	35	36.4	26.0	4.7	4.9	15.1	150	6.8
50	25	33.4	30.0	4.3	4.3	13.3	293	5.2
100	15	32.4	30.0	4.2	3.2	13.1	291	4.8
150	5	31.4	32.0	4.2	2.7	12.4	98	4.4

Source: Jung *et al.*, 1994.

Soil is characterized by a shallow depth and high content of gravels and stones. Heavy rainfall and poor management promote soil erosion (Table 7).

Table 7 Estimation of soil erosion by USLE in alpine vegetable land

Area	R	K	LS	C	P	Soil loss (ton/ha)	Decrease of soil depth (mm/year)
Jeongseon	450	0.21	9.07	0.15	0.5	77.1	6.4
Pyongchang	450	0.21	4.45	0.15	0.5	33.1	2.7
Muju	464	0.21	6.60	0.15	0.5	48.2	4.0

Source: ASI, 1992.

The estimation of soil erosion was calculated by USLE in the alpine vegetable land. The land shows serious erosion problems. The rate of soil loss was 2.7-6.4 mm per year which is very rapid compared to the rate of soil formation.

Table 8 Soil loss and runoff in alpine vegetable area as affected by mechanical conservation practices

Item	Absence of conservation practices (A)	Conservation practices (B)	A/B
Soil loss (ton/ha)	102.5	12.3	8.3
Runoff (ton/ha)	1,614.0	892.0	1.8
Runoff ratio (%)	56.4	30.2	1.9

Rainfall: 295mm (June 8 - July 10, 1994), Slope steepness; 25%, Slope length; 200m, Sea level; 800m, Soil; silt loam.
Source: Jung *et al.*, 1994.

Soil loss and runoff in the alpine vegetable area as affected by mechanical conservation practices are shown in Table 8. After the adoption of the practices, soil loss and runoff decreased drastically compared to the absence of conservation practices. We could observe rills and gully erosion after heavy rainfall in this area.

Conclusion

Soil conservation and slopeland development have been promoted in Korea for about thirty years. Soil erosion from slopeland not only reduces soil fertility and crop productivity but is also associated with main sources of pollution. Chemicals and fertilizers carried with soils are the sources of water pollution. Slopeland management needs more care to manage soils in relation to their erosion and water deficit due to the characteristics of steep slope, shallow soil depth and heavy rainfall. Thus, the potential productivity of sloped farmland decreases as a result of ongoing degradative processes, and technology for soil and water conservation must be applied to the land.

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