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Synergistic effects of grass coverage and dam land sedimentation on runoff and sediment yields in the slope-gully system on the Loess Plateau of China

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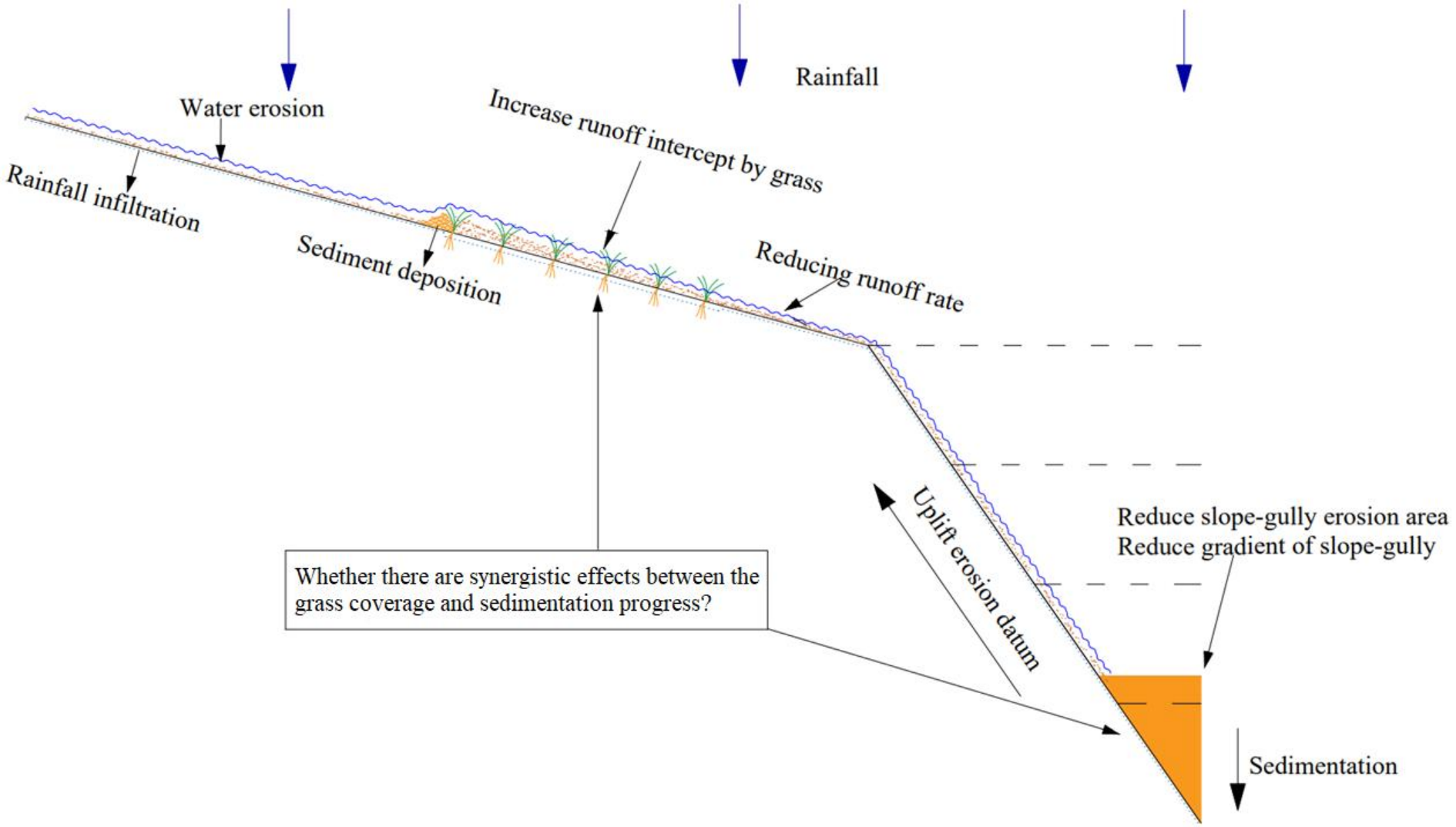
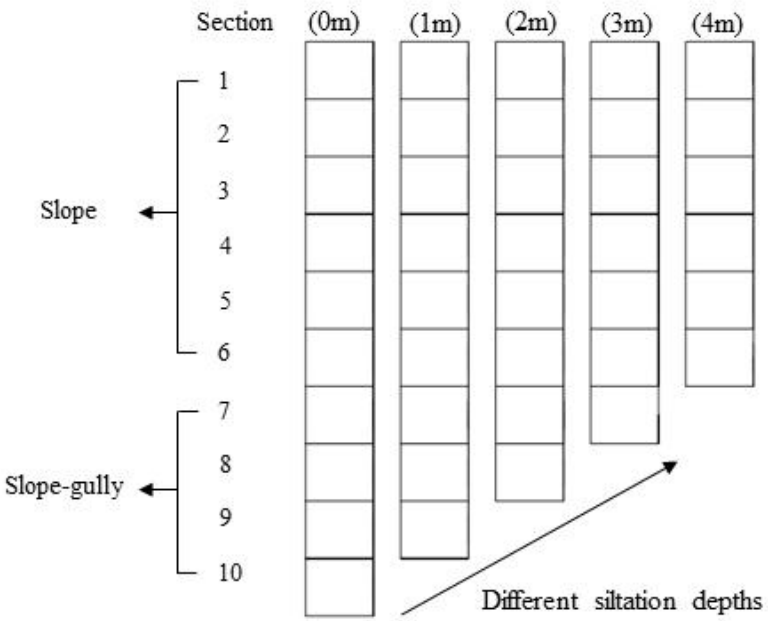
Introduction

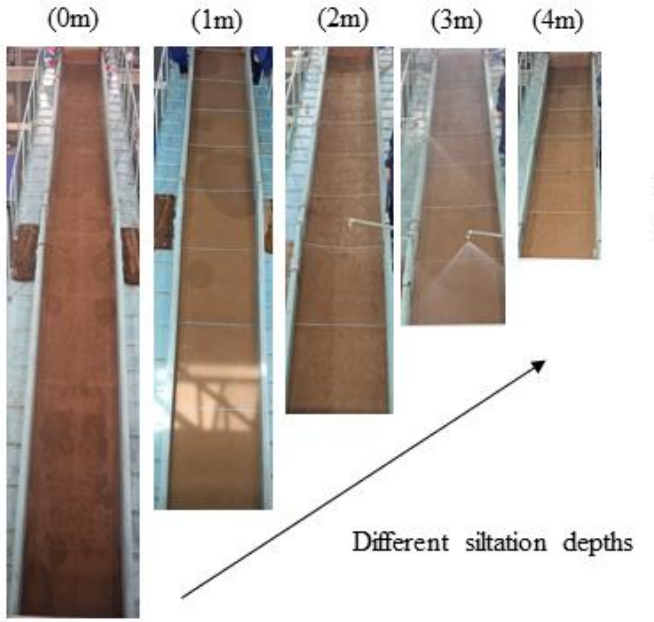
- Soil and water conservation measures of vegetation restoration and check dams are effective to control soil erosion.
- Existing studies focused on the effect of single measure; however, synergistic effects of mult-measures are unclear.

Introduction

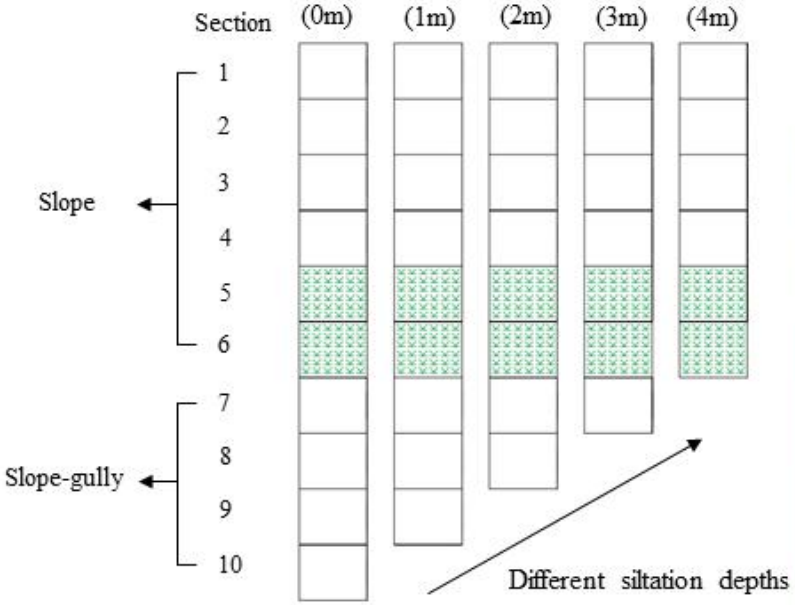


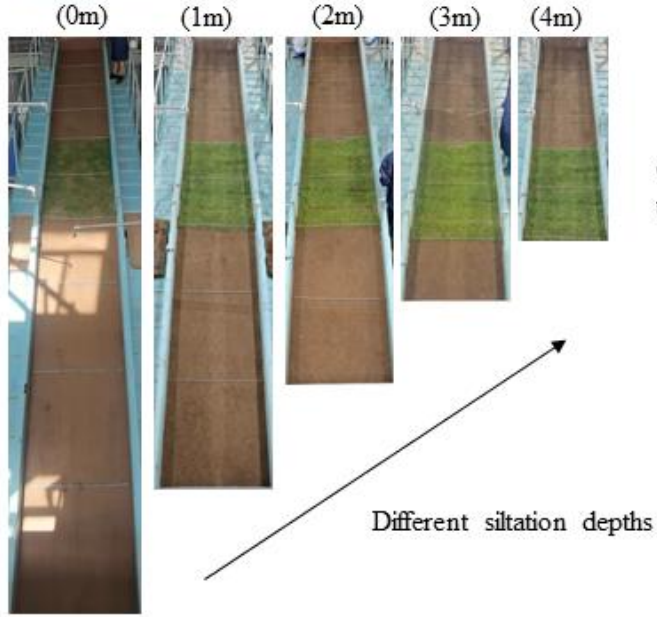
Material and methods





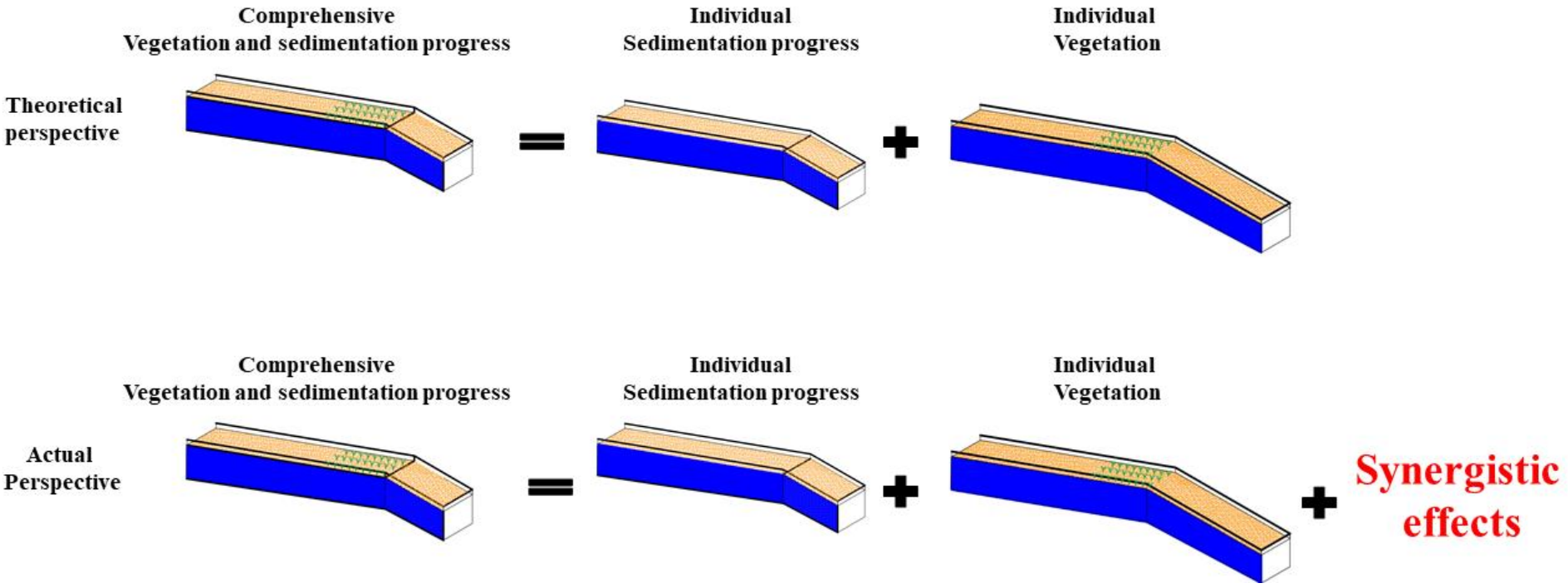
No grass cover on the slope





Grass cover on the slope

Material and methods



- Theoretically, comprehensive grass coverage and sedimentation was: 1+1=2.
- Additionally, the synergistic effect was ignored: 1+1>2.

Material and methods

1. Calculated the reduction in runoff and sediment yields by grass coverage:

$$VRR = \left(\frac{R_{co} - VR}{R_{co}}\right) \times 100 \qquad VSR = \left(\frac{S_{co} - VS}{S_{co}}\right) \times 100$$

2. Calculated the reduction in runoff and sediment yields by sedimentation process:

$$S_iRR = \left(\frac{R_{co} - S_iR}{R_{co}}\right) \times 100 \qquad S_iSR = \left(\frac{S_{co} - S_iS}{S_{co}}\right) \times 100$$

3. Combination of the grass coverage and sedimentation to reduce runoff and sediment yields:

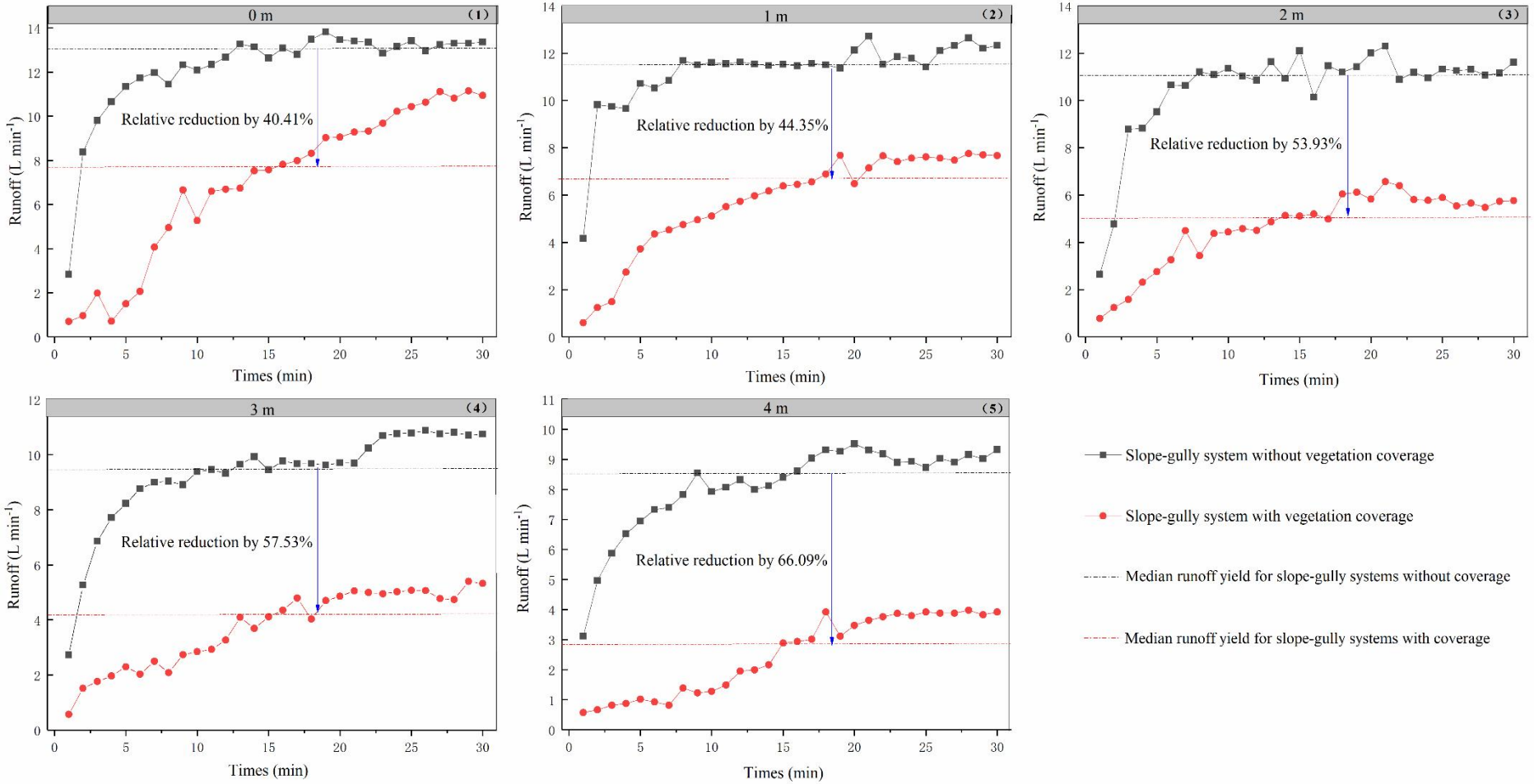
$$S_iVRR = \left(\frac{R_{co} - S_iVR}{R_{co}}\right) \times 100 \qquad S_iVSR = \left(\frac{S_{co} - S_iVS}{S_{co}}\right) \times 100$$

4. Synergistic effects of the grass coverage and sedimentation on the reduce runoff and sediment:

$$S_iVRS = S_iVRR - S_iRR - VRR \qquad S_iVSS = S_iVSR - S_iSR - VSR$$

Results

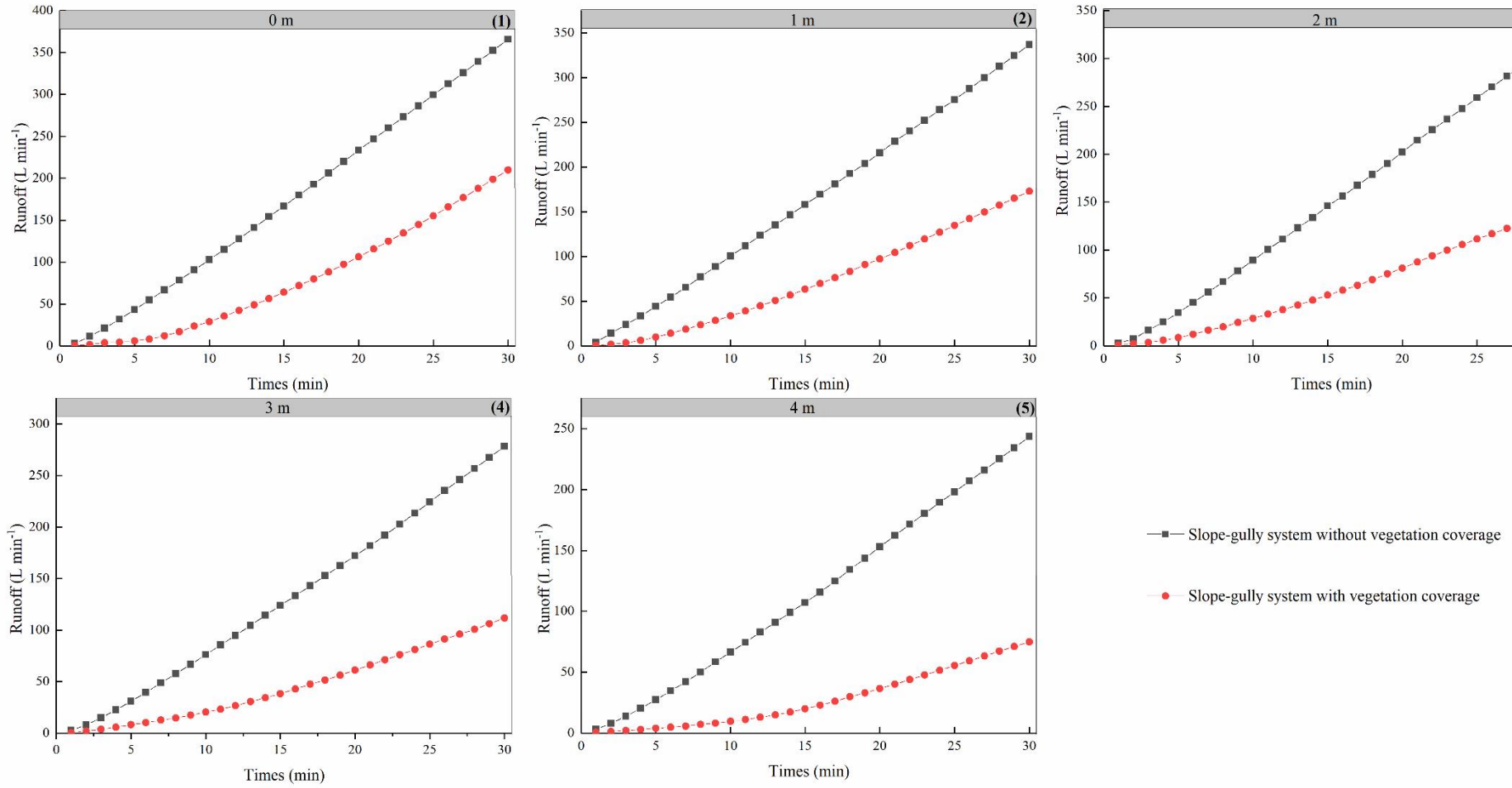
Runoff series



- Runoff series increased rapidly in the first few minutes of rainfall and then stabilizes.
- The relative decreases were all greater than 40% between grass coverage and no grass, and the change increased with sedimentation process.

Results

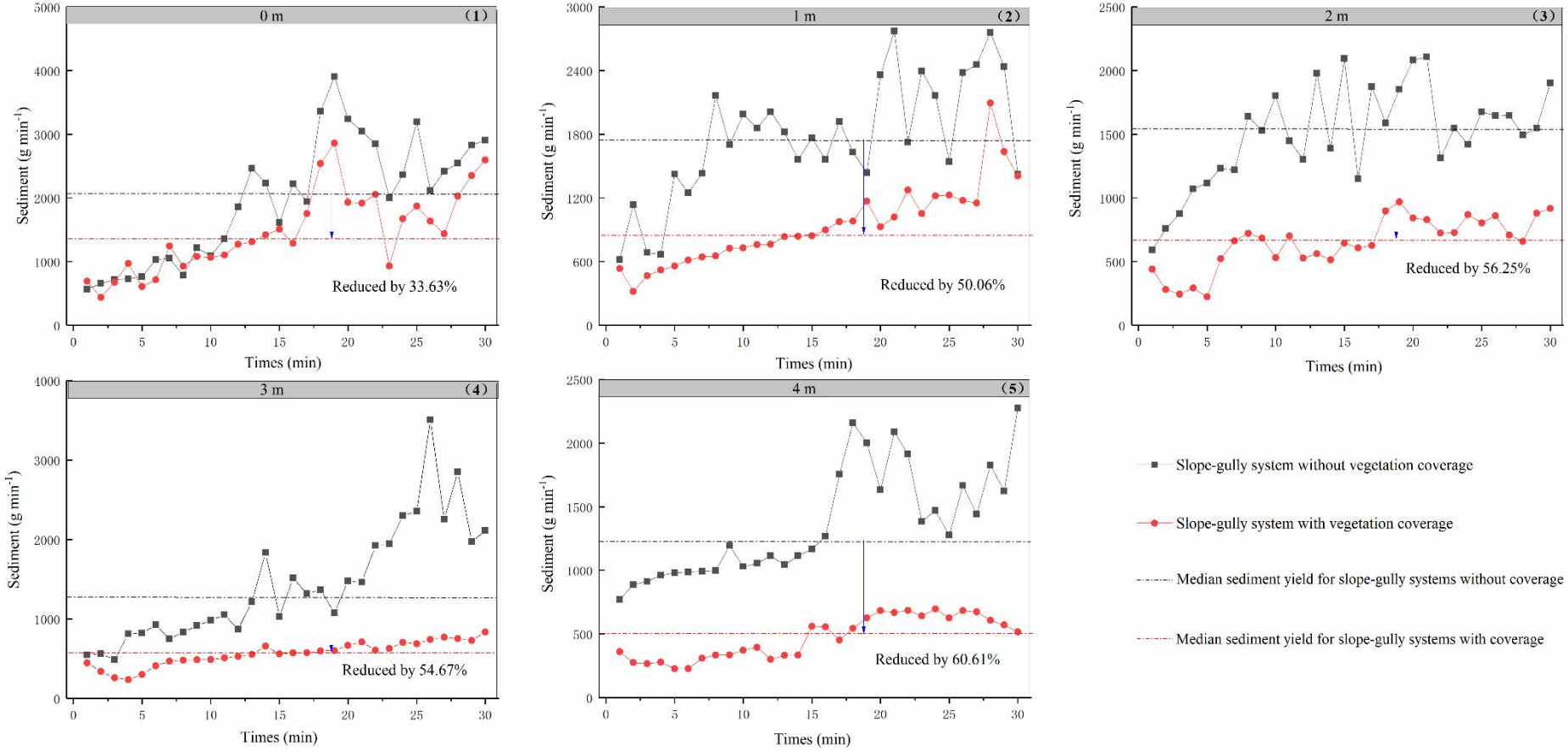
Runoff series



- The accumulated runoff yields decreased with the sedimentation process: 4 m < 3 m < 2 m < 1 m < 0 m.
- Grass coverage had a lower accumulated runoff yield than no grass.

Results

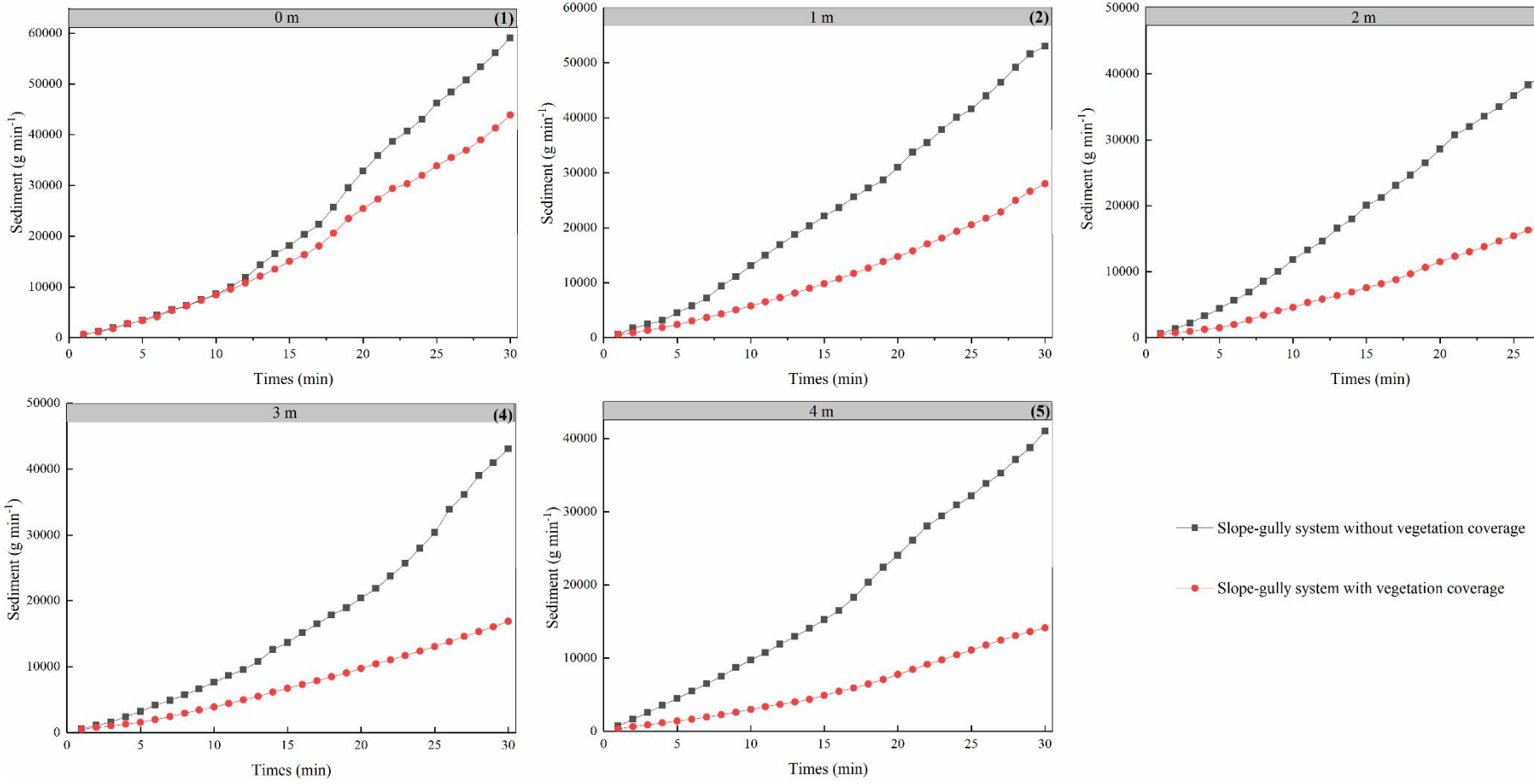
Sediment series



- Without grass coverage, the sediment yield fluctuated strongly and had multiple peaks.
- With grass covergage, the change curve of sidiment process was gentle.
- The relative decreases were greater than 33% between grass coverage and no grass, and the change increased with sedimentation process.

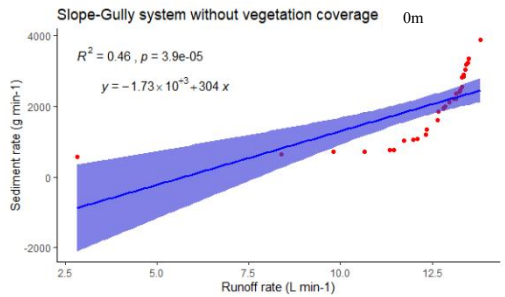
Results

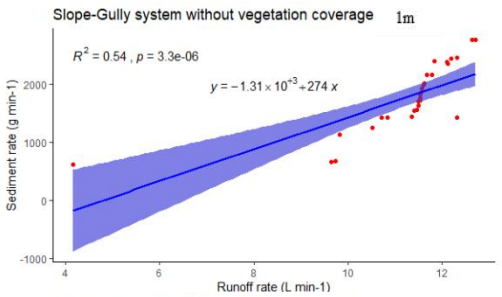
Sediment series

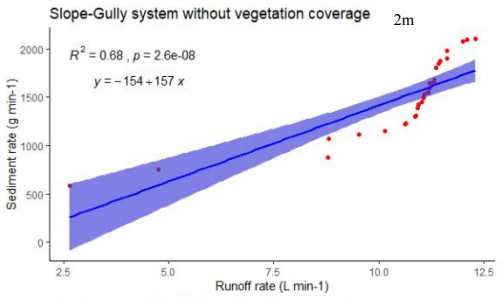


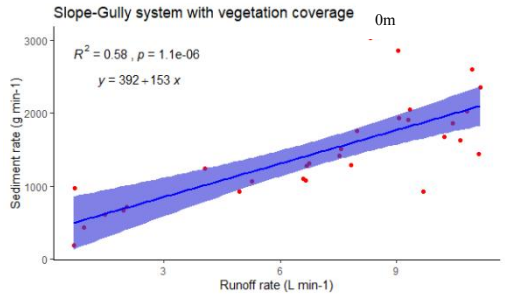
- The accumulated sediment yield decreased with sedimentation process: 4 m < 3 m < 2 m < 1 m < 0 m.
- Grass coverage had a lower accumulated sediment yields than no grass.

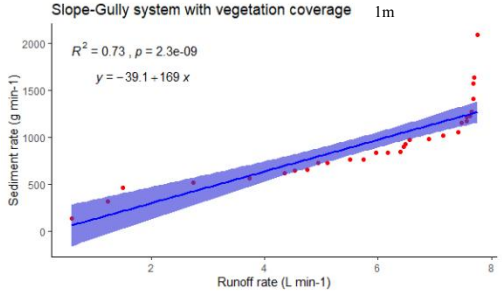
Results

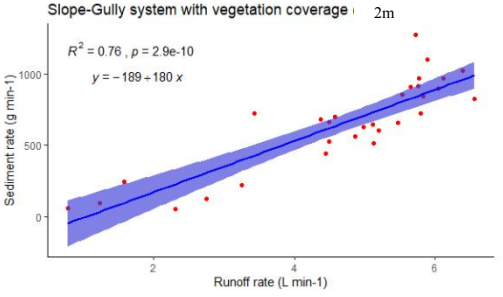


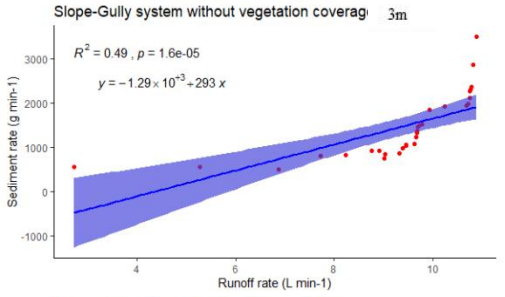


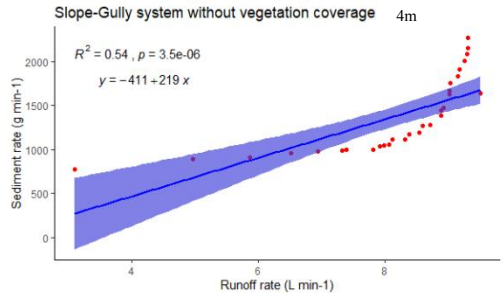


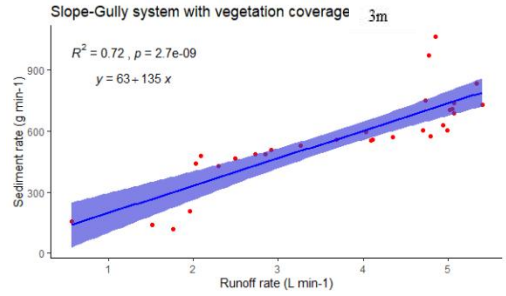


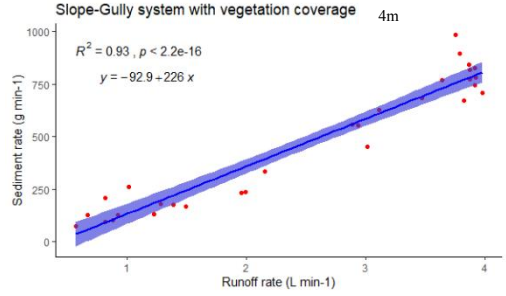












- Runoff and sediment can be fitted by a linear equation : Y=AX+B.
- The slope (A) decreased with sedimentation process.
- Grass coverage had a lower slope (A) than no grass.

Results

	Slope-Gully system without vegetation coverage								Slope-Gully system with vegetation coverage	
	1m		2m		3m		4m		0m	
	Runoff (L)	Sediment (G)	Runoff (L)	Sediment (G)	Runoff (L)	Sediment (G)	Runoff (L)	Sediment (G)	Runoff (L)	Sediment (G)
Reduction	28.77	6027.13	50.37	14173.79	87.48	15990.79	122.21	18056.73	155.91	15155.33
Percentage	7.87%	10.20%	13.77%	24.00%	23.92%	27.07%	33.42%	30.57%	42.63%	25.66%

	Slope-Gully system with vegetation coverage							
	1m		2m		3m		4m	
	Runoff (L)	Sediment (G)	Runoff (L)	Sediment (G)	Runoff (L)	Sediment (G)	Runoff (L)	Sediment (G)
Reduction	192.85	31045.09	226.04	39598.47	254.24	42179.70	290.78	44922.88
Percentage	52.73%	52.56%	61.81%	67.04%	69.52%	71.41%	79.51%	76.05%

	Synergistic effect of different erosion datum levels							
	1m		2m		3m		4m	
	Runoff (L)	Sediment (G)	Runoff (L)	Sediment (G)	Runoff (L)	Sediment (G)	Runoff (L)	Sediment (G)
Reduction	8.16	9862.63	19.76	10269.35	10.84	11033.57	12.65	11710.82
Percentage	2.23%	16.70%	2.40%	17.39%	2.96%	18.68%	3.46%	19.83%

- Grass cover and sedimentation process had synergistic effects on runoff and sediment.
- The synergistic effects increased with the sedimentation process: 4m>3m>2m>1m.
- Synergistic effects of sediment (16.70%-19.83%) was greater than runoff (2.23%-5.40%).

Discussion

Regulation of runoff and sediment yields by each measure

- The reduction effect of sedimentation process on sediment was higher than that on runoff.
- The reduction effect of grass coverage on runoff was higher than that on sediment.

Synergistic effects of grass and sedimentation on hydrological process

- Grass coverage and sedimentation process had synergistic effects on runoff and sediment.
- Grass coverage had in-situ and out-situ effects on runoff and sediment reduction:
  Grass coverage + sedimentation process showed: 1+1>2

Implications for water and soil conservation

- The synergistic effect between different measures should be considered.
- Single soil and water conservation measures have limited capacity to reduce water and sediment.
- Grass coverage on the slope and building check dams in the gully should be combined to form a soil and water conservation systerm with single effects and synergistic effects.

Conclusion

- Grass coverage and sedimentation had a synergistic effect on runoff and sediment reduction.
- With the sedimentaiton process, the synergistic effects increased.
- Grass coverage on the slope and building check dams in the gully should be combined to form a soil and water conservation systerm.

Thank you!