Rainfall soil erosion based on color image super resolution and rural revitalization design

Na Li¹ · Duanru Li² · Guanlin Luo³

Received: 11 June 2021 / Accepted: 31 July 2021 / Published online: 13 August 2021
© Saudi Society for Geosciences 2021

Abstract
Based on the super-resolution color image, this paper studies the design of rainfall soil erosion and rural revitalization. The steep slope system of the Loess Plateau is not only an important cause of soil erosion by rain, but also an important area for landslides, debris flows, and other natural disasters. In this study, high and steep slope system was used as the research object. Through indoor artificial rainfall experiments, under the conditions of intermittent rainfall, outflow and sediment yield characteristics, soil moisture content changes, and rainfall erosion dynamic parameters, the appearance of steep slope system under various conditions was studied from the beginning of rainfall to slope crack stage. At the same time, the development of agriculture and rural areas is not only an important foundation and support for the realization of national modernization, but also an important factor affecting economic and social development. At present, the development level of China’s agriculture and rural areas is still relatively backward, which is a significant defect in the development of China’s modernization. According to the relevant research results of domestic and foreign researchers, this study takes the main content of Rural Revitalization Strategy as the starting point, and, based on the explanation of development background and implication, deeply analyzes the development background of rural complex model and local economic revitalization strategy. At the same time, taking the rural complex as the main carrier to implement the rural revitalization strategy, this paper studies the theoretical source of the rural complex model in detail, and briefly summarizes the significance and characteristics of the rural complex model. This paper expounds the important role of the development of rural complex facilities in the implementation of China’s rural revitalization strategy.

Keywords Super resolution of color image · Rainfall erosion · Soil erosion · Rural revitalization

Introduction
Image resolution is an important index to measure image quality. The higher the image resolution, the more detailed information contained in the image, and better the visual effect of the image. With the continuous development of image processing technology and display technology, the demand for high-resolution image and video information is also higher and higher. However, due to the performance limit of camera equipment and the influence of environmental degradation factors, in many cases, the obtained image resolution cannot meet the practical needs. Therefore, in order to improve the quality of low-resolution degraded image, some technical means need to be used (Liu 2012). With the continuous exploration and research of scholars, the super-resolution reconstruction technology of reconstructing high-resolution image from low-resolution image was born in a historic moment (Medina et al. 2010). Based on the existing physical image equipment, super-resolution reconstruction technology can obtain high-resolution images that meet the application requirements only through software processing, which has the advantages of low cost and high efficiency. Therefore, it is more and more popular in the fields of space exploration, public security, high-definition television, medical image processing, and so on. At the same time, as an important environmental problem in China and even in the world, soil...
erosion seriously limits the sustainable development of social, economic, and agricultural production in related areas (Pal et al. 2015). The Loess Plateau, located in the middle and upper reaches of the Yellow River Basin in China, is one of the most serious loss areas of soil and water resources in the world. Soil erosion accounts for 71% of the total area of the Loess Plateau (Rajeevan et al. 2008). The sediment from soil erosion flows into the Yellow River and becomes the main sediment source of the Yellow River. On the other hand, natural disasters such as collapses and landslides often occur in the Loess Plateau, which poses a serious threat to social stability and people’s safety. Therefore, the study of soil erosion on the Loess Plateau is of high theoretical value and practical significance. In view of this, based on field investigation and indoor simulated rainfall experiment, the temporal and spatial variation characteristics of outflow and sediment yield, hydrodynamic parameters, erosion energy parameters, and soil moisture content in high and low gradient system were studied (Ramakrishnan 2001). Under the condition of intermittent rainfall, the mechanisms of erosion and deposition of steep slope and steep slope system are obviously different, from the beginning of rainfall to the occurrence of surface landslide (Valdez-Cepeda et al. 2012). Therefore, this study provides a theoretical reference and scientific basis for soil erosion prediction and disaster prevention and mitigation in the Loess Plateau of China. Based on this, this paper studies the development mode of rural community from the perspective of rural revitalization strategy, explores its development background, main content, and characteristics, and refers to the development status of agriculture and animal husbandry at home and abroad to understand the difficulties in the development process. At present, we are faced with the development of national rural complex facilities; we need to deepen and expand the theory of agriculture and rural development, and further promote the rural activation and modernization of agriculture and rural areas (Rangarajan and Sant 2004). Rural complex model is a new industrial development model of agricultural comprehensive development with the development of modern agriculture and new urbanization. The research on the development of rural complex model helps to enrich and develop the development theory of China’s urban-rural relationship, and contribute to the comprehensive implementation of China’s rural revitalization strategy (Sen Roy and et al. 2018).

**Materials and methods**

**Test materials**

The soil used in this study is loess soil. After sampling and measuring on the spot, the dry bulk density of the undisturbed soil in the soil sampling site is 1.32–1.38 g/cm³. Therefore, the average value of the field survey results is 1.35 g/cm³ when the soil is filled.

The indoor simulated rainfall device uses the downspray simulation rainfall device. The slope of the high and steep slope system required in this experiment is gentle slope 12°. Steep slope gradient is taken as 50°, 55°, 60°, 65°, and 70°. After the experiment of high and steep slope is completed, the supplementary test of the gentle slope section is carried out according to the maximum number of cracks in the high and steep slope system with different steep slope slopes (the maximum number of fields in this study is 6). The bulk density and initial moisture content of the gentle slope are consistent with the system test of high and steep slope, with a slope of 12°. The slope length is 1m.

**Test design**

According to the results of field investigation, the test design slope is gentle slope 12°. The steep slope section is 50°, 55°, 60°, 65°, and 70°. The experimental rain intensity is 1.5mm/min, and the rainfall time of each rainfall is 60min. The rainfall test starts from rainfall to the end of the crack field on the slope, and the interval between each rainfall is 24h. According to statistics, the slope of steep slope in this study is 55°. The rainfall frequency of the project is 6, and the gradient of steep slope is 55°, 60°, and 65°. The rainfall field of the project is conducted in five fields, with a steep slope of 70°. Three rainfall events were conducted. Repeat the test once for each simulated rainfall test. According to statistics, 48 simulated rainfall tests of high and steep slope system are conducted in this study. The schematic diagram of high steep slope system is shown in Figure 1.

![Fig. 1. Schematic diagram of high and steep slope system](image)
Before filling soil in soil tank, remove the impurities such as grass root and crushed stone in the original soil for test, then screen the soil with 1cm sieve. The initial moisture content is determined by drying method. If the initial water content is less than 15%, the water added to the test water is determined according to the quantity of soil used for test and the initial water content measured. Spray the added water to the surface of the test soil with a spray pot, then the test after watering is mixed with soil evenly, and then covered with colored strip cloth, and the test is still for 24 h; If the initial moisture content measured is higher than 15%, the test soil shall be dried after the ground is leveled. When the moisture content of the drying soil reaches 15%, the air drying soil shall be covered with colored strip cloth and kept for 24 h. When filling soil ditch, the soil layer with 15% water content in the initial stage is stacked in the soil ditch, and the density of soil is about 1.35g/cm³ and the layer thickness is about 10cm. After filling the soil trough, the normal cutting treatment is carried out according to the determined relaxation slope and steep gradient. After cutting off the slope, flatten the slope to confirm that the test conditions of each test are consistent.

Before the formal start of each simulated rainfall experiment, the simulated rainfall intensity needs to be corrected. It is confirmed that the experimental rainfall intensity is about 1.5mm/min and the rainfall uniformity is more than 85%. After the beginning of each simulated rainfall experiment, the generation time of the first outflow of the slope was recorded when the catchment trough at the exit of the steep slope system with high gradient began to flow out. In the process of the test, the collecting bucket used to collect the muddy water collected by the collecting trough at the outlet of the high and steep slope system every minute, and the wide mouth bottle with known volume is used to collect the muddy water samples at the outlet every minute. After the test, the volume of muddy water in each collecting bucket was measured by measuring cylinder; Use electronic balance to weigh the total mass of each wide mouth bottle (the weight of bottle is known) and the muddy water in each bottle; The sediment mass in each jar was measured by drying method, and then the sediment concentration of runoff at the exit of high and steep slope system in each minute during the test was obtained; By subtracting the sediment mass from the total mass of each wide mouth bottle + muddy water, the mass of the water in the bottle can be obtained, and the volume of the water in the bottle can be calculated, and then the percentage of the pure water volume in the muddy water volume of the wide mouth bottle can be calculated. The sediment yield and runoff yield at the exit of the high and steep slope system in this period are obtained by multiplying the sediment concentration of runoff and the percentage of pure water volume in the volume of muddy water in each minute measured by the measuring cylinder.

**Color image super resolution reconstruction algorithm design**

For the input low-resolution color image, the purpose of super-resolution reconstruction is to reconstruct the corresponding high-resolution color image XH. According to the quad sparse representation model, the quad sparse HR/LR dictionary is obtained. It is assumed that the input LR color image block and the reconstructed HR color image block have the same Quad sparse coefficients. Then, through the calculation, the sparse representation coefficient a of the input LR image block is obtained.

\[
\min \| \alpha_x \|_1 \ \text{s.t.} \ \| F \hat{D}_i \hat{\alpha}_x - F y_h \|_2 \leq t
\]  

(1)

Using high-resolution dictionary \( D_h \) and sparse coefficient \( \hat{\alpha}_i \), the corresponding reconstructed HR image block is obtained \( x_h \).

\[
x_h = \hat{D}_h \hat{\alpha}_i
\]  

(2)

In the process of solving equation (1), L1 rule constraint is easy to introduce additional errors in the estimation of analytic representation coefficients, so the solution is not analytic, and the analytic approximation effect cannot get good results for the observed image data polluted by noise. In the process of super-resolution reconstruction of HR/LR dictionary pairs, a common dictionary training algorithm is usually used. However, if this algorithm is used to obtain high-resolution and low-resolution dictionary pairs, the error will not be minimal. For a pair of images used for HR/LR training, the resolution coefficient is inconsistent with that of a single LR or HR image. Therefore, the accuracy of the reconstructed HR image cannot be guaranteed. To sum up, in order to solve the non-dilution problem of the modern solution of color image super-resolution reconstruction in quaternion space, this chapter will import 11 max2 specification constraint instead of dictionary learning and image L1 specification constraint. At the same time, in the process of dictionary training, the dictionary separation training algorithm is used to construct 4-element LR sparse dictionary and 4-element HR sparse dictionary, respectively, which effectively improves the quality of color image reconstruction.

**Calculation method of runoff mechanics and hydrodynamic parameters**

The objective function of the over complete dictionary generation model based on quaternion sparse representation is defined as follows.

\[
\{ \hat{D}, \hat{\alpha} \} = \min_{\hat{D}, \hat{\alpha}} \| \hat{D} \hat{\alpha} - y \|_2^2 + \lambda \| \hat{\alpha} \|_1
\]  

(3)
Since the solution generated by L1 rule constraint is usually not enough analytic problem, it is necessary to establish better rule constraint conditions. However, L1/2 rule constraint conditions further induce the analyticity of vector, which has strong robustness to noise in image reconstruction and is more stable than the solution of L1 rule constraint. Therefore, in this chapter, based on the over complete dictionary generation model represented by quadrant slice, the L1/2 rule constraint is introduced to construct a four-element sparse full dictionary model:

$$ \{ \hat{D}, \hat{A} \} = \underset{D, \hat{A}}{\text{min}} \| \hat{D} \hat{A} - \hat{y} \|^2_2 + \lambda \| \hat{A} \|^2_1 $$  \hspace{1cm} (4) $$

In order to overcome some shortcomings of the dictionary joint training algorithm, this chapter first trains the quad sparse LR dictionary, and then obtains the quad sparse HR dictionary directly, then the objective function of the four-variable sparse LR dictionary generation model is defined as follows:

$$ \{ \hat{D}, \hat{A} \} = \underset{D, \hat{A}}{\text{min}} \| \hat{Y} - \hat{D} \hat{A} \|^2_2 + \lambda \| \hat{A} \|^2_1 $$  \hspace{1cm} (5) $$

The training of quad sparse LR dictionary can be divided into two stages: parsing coding and dictionary atom updating. In the sparse coding stage, the low-resolution dictionary ID is fixed, and the half threshold repeat algorithm is used to solve the sparse coefficient matrix A.

$$ A^{n+1} = H_{\lambda, \mu, 1/2} \left( \hat{A} + \mu \hat{D}^T (\hat{Y} - \hat{D} \hat{A}) \right) $$  \hspace{1cm} (6) $$

It is deduced from equation (6):

$$ h_{\lambda, \mu, 1/2} (\hat{A}) = \begin{cases} f_{\lambda, \mu, 1/2} (\hat{A}) |\hat{A}| \geq \frac{\sqrt{5}}{4} \lambda \mu \hat{\alpha}^2 & \lambda \mu > 0 \\ 0 & \text{other} \end{cases} $$  \hspace{1cm} (7) $$

The quaternion singular value decomposition (q-ksvd) algorithm is used to decomposed it:

$$ E_k^R = U A V^H $$  \hspace{1cm} (8) $$

After obtaining the quad sparse representation coefficient matrix a corresponding to the quad sparse LR dictionary, the quad sparse HR dictionary will be obtained by the following formula.

$$ \hat{D} = (\hat{Y} - \hat{D} \hat{A}) \hat{A} $$  \hspace{1cm} (9) $$

**Data processing and analysis**

Excel 2010 was used for statistical analysis of test data, SPSS 2017 was used for analysis of test data, and origin 2017 was used for mapping.

**Results**

**Runoff and sediment yield characteristics of slope system under rainfall condition**

In the process of simulated rainfall, because the water depth of the slope flow is very shallow, it is not easy to observe directly. The average depth of runoff in this study is obtained by using the measured slope flow and the average velocity of runoff using the inverse algorithm. Because the high and steep slope system in this study has two slope sections, gentle slope section and steep slope section, and the slope of the two slope sections are quite different, this study studies the variation characteristics of average water depth of gentle slope section and steep slope section, respectively.

Because the gradient and soil bulk density of the gentle slope section of the high and steep slope system are the same with different steep slopes, the average water depth of the gentle slope section of the high and steep slope system is only affected by rainfall frequency. In this study, the maximum rainfall field of different steep slope systems is 6. Therefore, supplementary experiments are used to study the runoff depth variation of gentle slope section and the slope depth variation of 6 continuous rainfall fields.

Figure 2 shows the variation process of the average water depth of the gentle slope section of the high and steep slope system with rainfall time under intermittent simulated rainfall conditions. It can be seen from Figure 2 that in the six simulated rainfalls in this study, the average depth of the relaxed part of the high and low gradient system first increases, and then tends to be relatively stable. The reason for the above phenomenon is that in the early stage of rainfall experiment, the slope infiltration rate gradually decreases, the outflow yield gradually increases, and the outflow velocity changes accordingly, so the average water depth increases in the early
stage of outflow generation. Due to continuous rainfall, the slope outflow gradually reaches a stable level, and the average velocity changes according to the slope erosion degree; the average water depth changes.

Through statistical analysis, the average water depth of the six simulated rainfall in the gentle slope section of the high and steep slope system in this study is 0.19mm, 0.22mm, 0.23mm, 0.25mm, 0.26mm, and 0.27mm, respectively. Therefore, the average water depth on the gentle slope of high and steep slope system increases with the increase of rainfall frequency. This is because the initial water content of slope is different before the beginning of each rainfall, and the

![Graphs showing the variation of runoff yield of different rainfall fields in high and steep slope system with different slope gradients: (a) field 1, (b) field 2, (c) field 3, (d) field 4, (e) field 5, (f) field 6](image-url)
difference is small after the runoff velocity of gentle slope reaches the stable runoff yield. Therefore, the average water depth of gentle slope increases with the increase of rainfall.

The formation of slope outflow is the result of rainfall and surface factors. Soil water content, rainfall intensity, rainfall time, and slope have great influence on the formation of runoff. Figure 3 shows the process of runoff variation due to the variation of rainfall time in different high gradient and steep slope systems under intermittent simulated rainfall conditions. Under the test conditions, the runoff is mainly affected by rainfall field number and steep slope of high steep slope system. The total runoff produced in each rainfall process of high steep slope system with different steep slope slopes is summarized in Table 1.

Table 1 Statistical table of total runoff yield of high and steep slope system under different rainfall field times and steep slope gradient

| Steep slope | Rainfall frequency | 50° | 55° | 60° | 65° | 70° |
|-------------|-------------------|-----|-----|-----|-----|-----|
| Scene one   | 45,115            | 41,610 | 39,367 | 37,296 | 38,997 |
| Scene two   | 57,026            | 53,136 | 51,282 | 42,685 | 43,746 |
| Scene three | 61,188            | 54,494 | 52,267 | 43,653 | 39,833 |
| Scene four  | 60,511            | 54,590 | 51,725 | 42,915 | --   |
| Scene five  | 60,696            | 53,667 | 45,838 | 39,206 | --   |
| Scene six   | 24,341            | --   | --   | --   | --   |

Figure 5 shows the variation of Froude number with rainfall time from the beginning of rainfall to the occurrence of cracks. It can be seen from Figure 5 that in the first few minutes after runoff generation, the Froude number of the steep slope section decreases rapidly, resulting in the rapid decline of Froude number. With the progress of rainfall, the slope runoff is gradually stable. As rills are generated on the slope, the development of rills requires the shear force of runoff on the soil, and the slope topography changes greatly. Therefore, the velocity fluctuates and the average water depth changes in a small range. According to the Froude number calculation formula, the Froude number on the slope presents the above changes under the combined action of the two factors.

Figure 6 shows the variation of the resistance coefficient with rainfall time from the beginning of rainfall to the occurrence of cracks. It can be seen from Figure 6 that in the first few minutes after runoff generation, the resistance coefficient curve of steep slope presents an increasing trend. With the rainfall test, the resistance coefficient fluctuates. The reason is that in the early stage of rainfall, the runoff shear slope and a part of sediment generated by gentle slope adhere to the steep slope, which makes the resistance increase. Therefore, the drag coefficient fluctuates. By comparing and analyzing the change curve of the resistance coefficient before and after cracks, it is found that the slope resistance coefficient increases after cracks appear. This is because after cracks appear on the slope, a part of runoff enters into the cracks, which makes the slope runoff decrease and the resistance of runoff flow on steep slope increases.

Variation characteristics of soil erosion water content under rainfall condition

Therefore, this study only analyzes the variation characteristics of soil moisture with time in the first rainfall based on the test data measured by the probe in the gentle slope section and the probe in the steep slope section of the high and steep slope system.

The change curve of water content with time measured by the probe of gentle slope in the first rainfall is shown in Figure 7. It can be seen from Figure 7 that the approximate time of moisture content change of upper probe on gentle slope is the 16th minute, and the approximate time of moisture content change of upper probe on slope is the 21th minute.

It can be seen from Figure 8 that in the first rainfall, the approximate time result of moisture content change of upper and lower probe in steep slope section of high and steep slope system is as follows: 50°, 55°, 60°, 65°. The change time of soil moisture content in the upper layer of high and steep slope system is 20 min and 44 min, 22 min and 47 min, 24 min and 53 min, 23 min and 49 min, and 28 min and 55 min, respectively.
Figure 9 shows the variation of average infiltration rate of high and steep slope system with rainfall time under different slope gradient and rainfall times. It can be seen from Figure 9 that in each rainfall event, the average infiltration rate of each steep slope system first decreases and then fluctuates with the increase of rainfall duration. In the first few minutes after runoff generation, the average infiltration rate decreased rapidly, and then the average infiltration rate showed a relatively stable trend with the continuous rainfall. This is because in the process of rainwater infiltration, the water content of the soil surface first reaches saturation, and the average infiltration rate is stable and fluctuates. When cracks occur on the slope surface, the runoff flows into the cracks along the cracks, which reduces the runoff yield. Therefore, when calculating the average infiltration rate of steep slope, the overall infiltration rate is greater than the average infiltration rate before cracks occur.
Figure 10 shows the variation of soil water storage capacity of high and steep slope system with accumulated rainfall time. It can be seen that from the beginning of rainfall to the end of the cracks on the slope, the water storage of the high and steep slope system presents an increasing trend, and the water storage in the first rainfall increases the fastest, because the soil in the first rainfall is relatively dry, and the soil infiltration rate is larger, so the increase rate of the water storage in the soil layer is greater than that in other fields. For other rainfall events except the first rainfall, the soil water storage at the beginning of rainfall is less than that at the end of the previous rainfall, which reduces the water storage of 20 cm in the surface layer of the high and steep slope system in this study. Under the condition of the same rainfall frequency, the steep slope has a...

Fig. 5. Variation of Froude number of different rainfall fields in steep slope system with different steep slope gradients: (a) field 1, (b) field 2, (c) field 3, (d) field 4, (e) field 5, (f) field 6
greater impact on the soil water storage of the high and steep slope system. This is because the difference of slope makes the difference of erosion form, which affects the slope infiltration and makes the difference of soil water storage larger.

The summary of critical characteristic values of different steep slope systems under simulated rainfall conditions is shown in Table 3.

Figure 11 shows the variation process of runoff shear stress with rainfall time for six rainfall events on gentle slope of different steep slope systems. It can be seen from Figure 11 that in each rainfall event, the runoff shear stress curve of the gentle section of

**Variation characteristics of soil erosion energy parameters under rainfall conditions**

Figure 11 shows the variation process of runoff shear stress with rainfall time for six rainfall events on gentle slope of different steep slope systems. It can be seen from Figure 11 that in each rainfall event, the runoff shear stress curve of the gentle section of
the high and steep slope system presents a rapid increase at the beginning of rainfall and then reaches a relatively stable trend, and tends to fluctuate in a small range with the rainfall. The reason is that in the early stage of rainfall, the runoff yield of gentle slope is small, and the erosion ability of runoff to soil is small. With the rainfall, the runoff yield gradually increases and stabilizes, resulting in the above results. The results show that the mean values of runoff shear force of six rainfall events are 0.080 Pa, 0.091 Pa, 0.104 Pa, 0.107 Pa, 0.110 Pa, 0.115 Pa. On the whole, the runoff shear force increases with the increase of rainfall frequency, but the increase range is small.

Figure 12 shows the variation of runoff shear force of different steep slope systems with rainfall time from the beginning of rainfall to the end of cracks on the slope under intermittent rainfall. It can be seen from Figure 12 that in each simulated rainfall, in the first few minutes after runoff generation, the runoff shear force increases with the increase of rainfall duration, and fluctuates with the continuous rainfall. The reason is that in the initial stage of runoff generation, the average depth of runoff increases gradually with the rainfall process, and the erosion ability of runoff to soil increases. By comparing and analyzing the runoff shear stress curves before and after the appearance of cracks, it is found that the runoff shear force decreases after the appearance of cracks. This is because after the appearance of cracks, part of the runoff enters the cracks, which reduces the runoff shear force.

Table 4 shows the mean value of runoff shear force of different steep slope systems under intermittent rainfall. It can be seen from Table 4 that the runoff shear force fluctuates with the increase of steep slope. This is because with the increase of slope, the hydraulic energy slope increases, but from the above analysis, it can be seen that with the increase of slope, the water depth decreases, and the two contributions to the runoff shear force restrain each other, which eventually leads to the fluctuation of runoff shear force with the increase of slope. With the increase of rainfall frequency, the runoff shear force increases correspondingly, but the increase range is small. This is due to the increase of runoff yield with the increase of rainfall frequency, which leads to the increase of runoff shear force.

Figure 13 shows the change process of runoff power with rainfall time in gentle slope section of high and steep slope system with different steep slopes under the condition of indirect rainfall.

Table 5 shows the mean change of runoff power of steep slope in different steep slope systems of different fields. From Table 5, it can be seen that runoff power increases with the increase of steep slope, but the increase amplitude is small.

Discussion

Contents of Rural Revitalization Strategy

According to the report of the 19th Party Congress, the rural revitalization strategy is an important means to promote

![Fig. 7. Change of probe moisture content in gentle slope section of the first rainfall](image)

![Fig. 8. Water content change at the middle probe of the first rainfall steep slope section: (a) upper probe, (b) lower probe](image)
China’s rural economic development and industrial revitalization. Under the background of urban-rural integration development, to implement the rural revitalization strategy, we must speed up the construction of urban-rural integration, establish the rural civilization of industrial integration development mechanism according to the general requirements of industrial prosperity and ecological residence, and finally realize the effective rule, rich life, and realize the modernization of agriculture and rural areas.

Industrial activation is not only the key to realize local activation, but also the foundation of agricultural modernization. The integrated development of industry and the promotion of agricultural activation are the main routes for the implementation of the local revitalization strategy, and the
diversified agricultural development goals put forward on the basis of adapting to the new development concept. For a long time, in order to meet the requirements of “production and development” in China’s new rural construction, the agricultural production in most rural areas mainly adopts the traditional agricultural development mode, and agricultural development is limited to crop production (Ashok and Saji 2007). It cannot be denied that in the process of China’s agricultural modernization, the development mode of traditional agriculture has played an important role in promoting agricultural technology, increasing farmers’ income and improving the construction of new countryside. However, with the change and upgrading of social and economic structure, so far, the agricultural development mode has gradually exposed a series of disadvantages (Bal and Bose 2010).

With the continuous deepening and expansion of China’s agricultural development, the consumption of natural resources is relatively large. Traditional agricultural development blindly pursues the economic benefits of production and management, and overuses land resources, which directly causes various degrees of damage to the rural natural ecological environment. At the same time, in the process of agricultural production, excessive use of chemical fertilizer, ignoring the protection of arable land, results in serious agricultural ecological pollution. With the rapid development of industrialization and urbanization, agriculture is facing more and more pressure of resources and environment (Das and Goswami 2003). Therefore, it is an inevitable choice for rural areas to adapt to the concept of green development and realize sustainable development to change the development mode of rural areas and build a green ecosystem of mountains and lakes under the dual constraints of existing farmland destruction and water pollution.

**Table 3** Statistical table of critical value of cracks on high and steep slope system

| Steep slope | Where the cracks appear | Accumulated rainfall when cracks appear (ml) | Cumulative infiltration amount when cracks appear (ml) | Water storage capacity when cracks appear (ml) | Percentage of infiltration | Percentage of water storage |
|-------------|-------------------------|----------------------------------------------|-------------------------------------------------------|-----------------------------------------------|---------------------------|-----------------------------|
| 50°         | 80cm from the top of the steep slope | 579690                                      | 259827                                                | 108125                                        | 44.8%                      | 18.7%                       |
| 55°         | 60cm from the top of the steep slope | 467460                                      | 224103                                                | 103261                                        | 47.9%                      | 22.1%                       |
| 60°         | 70cm from the top of the steep slope | 420255                                      | 188225                                                | 92003                                         | 44.7%                      | 21.9%                       |
| 65°         | 70cm from the top of the steep slope | 365820                                      | 187133                                                | 95990                                         | 51.1%                      | 26.2%                       |
| 70°         | 88cm from the top of the gentle slope | 220365                                      | 93233.4                                               | 90563                                         | 42.3%                      | 41.1%                       |

**Rural revitalization design advantages based on rural complex**

Under the background of building a comprehensive rich society, the key to realize China’s modernization is to solve the contradiction in rural development. The rural complex model is proposed by the party and the state under the new
development concept, and plays an important role in promoting the realization of the local revitalization strategy.

Promote the extension of agricultural industry chain

On the premise of ensuring the combination of agricultural production, rural production, and ecological life, the rural complex has created new business types and formed excellent industrial clusters by constantly innovating the agricultural industry (Goswami et al. 2006). In the process of construction, we should grasp the leading role of leisure agriculture development, emphasize the “bright spot” of agricultural development concept, and plays an important role in promoting the realization of the local revitalization strategy.

Table 4  Statistical table of mean value of runoff shear force in steep slope section under different gradient and rainfall frequency

| Steep slope | Rainfall frequency | 50° | 55° | 60° | 65° | 70° |
|-------------|-------------------|-----|-----|-----|-----|-----|
| Scene one   | 0.271             | 0.272 | 0.242 | 0.341 | 0.332 |
| Scene two   | 0.346             | 0.374 | 0.260 | 0.347 | 0.343 |
| Scene three | 0.397             | 0.377 | 0.286 | 0.351 | 0.353 |
| Scene four  | 0.363             | 0.330 | 0.289 | 0.359 | --   |
| Scene five  | 0.357             | 0.376 | 0.241 | 0.361 | --   |
| Scene six   | 0.358             | --   | --   | --   | --   |

Fig. 12. Runoff shear force change under rainfall field in steep slope section of high steep slope system with different steep slopes: (a) field 1, (b) field 2, (c) field 3, (d) field 4, (e) field 5, (f) field 6
development, explore with the core of various functions and potential values of agriculture, and organically combine agricultural production and agricultural product processing, leisure, tourism, and other related industries to realize the vertical extension and development of agricultural industry chain.

Promote the cross-integration of agriculture and the second and third industries

On the basis of the healthy development of agriculture, the rural complex is a new development mode which is mainly green and ecological, and promotes the development of new business types through the industrial penetration (Hosseinizadeh et al. 2015). In the first mock exam, we must achieve the goal of integrating the agricultural industry chain and realizing the double interest of industry by adjusting the agricultural industrial structure.

Develop the rural complex and promote the green development of the countryside

Good natural environment is an important factor to realize the prosperity of rural economy. Therefore, ecological residence is the key to implement the strategy of rural revitalization. Now, as the main carrier of rural activity, the development of rural complex is the starting point to meet the needs of people for rural ecological products. Through the innovative agricultural development method, the natural ecological resources of the countryside are transformed into ecological agricultural products, and finally the unity of farmers’ wealth and rural beauty can be realized.

Rural revitalization and development strategy based on rural complex

At present, China is in the decisive stage of building an all-round well-off society. Speeding up the development of agriculture and rural areas is the basis for realizing the great rejuvenation of the Chinese nation. In the new era, with the development of China’s agriculture and rural economy, we must accelerate the transformation of agricultural development mode and promote the activation of industry based on the reality of rural development. Rural cultural economy is accompanied by the development of rural complex, and ultimately achieves the goal of sustainable development of agriculture and rural areas. In the process of rural complex construction, we must always take farmers as the main body, gradually change the situation of single traditional agricultural development mode, and further promote the comprehensive development of rural industry. At the same time, the protection of rural ecological environment and cultural construction should be strengthened to create a new situation of rural development.

Rural complex is a comprehensive industrial development system; its construction purpose is to make full use of the rich resources of rural areas, and wake up the economic and cultural revitalization of rural areas. In this process, we must focus our resources on the overall planning of rural areas (Kiros et al. 2016). We must adhere to the principle of taking farmers as the main body of development, put the interests of farmers in an important position, and build a livable and beautiful rural area under the condition of ensuring the prosperity and development of ecological environment (Kothawale et al. 2007). The development of rural complex must be based on farmers and ensure the participation of farmers. We should adhere to the principle and basic concept of taking farmers’ cooperatives as the main carrier, expand the business scope of new agriculture, closely link with farmers’ production and life, and improve farmers’ material living standards. We should seriously protect the rights and interests of farmers and encourage them to start businesses in the process of economic development through organizational training and other forms.

Conclusion

Based on the super-resolution color image, this paper studies the design of rainfall soil erosion and rural revitalization. With

| Steep slope | 50° | 55° | 60° | 65° | 70° |
|-------------|-----|-----|-----|-----|-----|
| Scene one   | 0.032 | 0.034 | 0.038 | 0.052 | 0.062 |
| Scene two   | 0.039 | 0.043 | 0.045 | 0.054 | 0.061 |
| Scene three | 0.041 | 0.045 | 0.052 | 0.054 | 0.063 |
| Scene four  | 0.041 | 0.042 | 0.051 | 0.053 | --   |
| Scene five  | 0.042 | 0.043 | 0.039 | 0.045 | --   |
| Scene six   | 0.037 | --   | --   | --   | --   |
the continuous development of sparse representation theory, color image super-resolution reconstruction algorithm based on sparse representation has attracted more and more attention. This paper focuses on the super-resolution reconstruction algorithm of sparse standard model, mainly aiming at the problems of insufficient sparse representation of image, insufficient correlation of color channel, weak robustness of feature extraction, and so on. In the field of super-resolution reconstruction, this paper makes deep research on super-resolution reconstruction based on sparse representation. Based on the above research, taking the indoor physical model of high and steep slope system as the research object, the characteristics of runoff and sediment yield, soil moisture content, and dynamic parameters of high and steep slope and soil erosion were studied by using indoor simulated rainfall experiments. From the beginning of rainfall to the end of rainfall, the slope of the steep slope system changes significantly. Finally, from the perspective of environmental protection and rural revitalization, this paper puts forward the methods of improving agricultural efficiency, improving rural ecological protection, and increasing farmers’ income. Rural complex is a new mode of local industrial development under the background of China’s economic development entering the new normal and new urbanization making great progress. Therefore, studying the development of rural complex model, deeply discussing its main content and characteristics, and exploring the successful experience from the practice of rural complex construction at home and abroad play an important role in promoting the implementation of China’s rural revitalization strategy.

Declarations

Conflict of interest  The authors declare no competing interests.

Open access This article is licensed under a Creative Commons Attribution 4.0 International License, which permits use, sharing, adaptation, distribution, and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons license, and indicate if changes were made. The images or other third party material in this article are included in the article’s Creative Commons license, unless indicated otherwise in a credit line to the material. Material is not included in the article’s Creative Commons license and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this license, visit https://creativecommons.org/licenses/by/4.0/.

References

Ashok K, Saji NH (2007) On the impacts of ENSO and Indian Ocean dipole events on sub-regional Indian summer monsoon rainfall. Nat Hazards 42:273–285. https://doi.org/10.1007/s11069-006-9091-0
Bal S, Bose M (2010) A climatological study of the relations among solar activity, galactic cosmic ray and precipitation on various regions over the globe. J Earth Syst Sci 119:201–209. https://doi.org/10.1007/s12040-010-0015-8
Das PJ, Goswami DC (2003) Long-term variability of rainfall over north-east India. Ind J Land Sys Ecol Stud 26(1):1–20
Goswami BN, Venugopal V, Sengupta D, Madhusoodanan NP, Xavier PK (2006) Increasing trend of extreme rain events over India in a warming environment. Science 314(5804):1442–1445. https://doi.org/10.1126/science.1132027
Hosseinizadeh A, SeyedKaboli H, Zarrei H, Akhondzadeh A, Farjad B (2015) Impact of climate change on the severity, duration, and frequency of drought in a semi-arid agricultural basin. Geoenvironmental Disasters 3(2015). https://doi.org/10.1186/s40677-015-0031-8
Kiros G, Shetty A, Nandagiril GM, Jharki A (2016) Analysis of variability and trends in rainfall over northern Ethiopia. Arab J Geosci 9(6):451(2016). https://doi.org/10.1007/s12517-016-2471-1
Kothawale DR, Mungot DP, Borgonkar HP (2007) Temperature variability over the Indian region and its relationship with Indian summer monsoon rainfall. Theor Appl Climatol 92:31–45. https://doi.org/10.1007/s00704-006-0111-z
Liu Z (2011) Economics of interdecadal climate variability: a historical perspective. J Clim 25:1963–1995. https://doi.org/10.1175/2011jcl10980.1
Majumder S, Hodze RA Jr, Kumar A, Niyogi D (2010) Summer monsoon convection in the Himalayan region: terrain and land cover effects. Q J R Meteorol Soc 136:593–616. https://doi.org/10.1002/qj.601
Mazumdar D, Chakraborty PK (2015) District-wise trend analysis of rainfall pattern in last century (1901-2000) over Gangetic region in West Bengal, India. JANS 7:750–757. https://doi.org/10.31018/jans.v7i2.678
Rajeevan M, Bhat J, Jaswal AK (2008) Analysis of variability and trends of extreme rainfall events over India using 104 years of gridded daily rainfall data. Geophys Res Lett 35:L18707. https://doi.org/10.1029/2008gl035143
Ramakrishnan PS (2001) Increasing population and declining biological resources in the context of global change and globalization. J Biosci 26:465–479. https://doi.org/10.1007/bf02704747
Rangarajan G, Sant DA (2004) Fractal dimensional analysis of Indian climatic dynamics. Chaos, Solitons Fractals 19(2):285–291. https://doi.org/10.1016/s0960-0779(03)00042-0
Sen Roy S, Balling RC (2004) Trends in extreme daily precipitation indices in India. Int J Climatol 24(4):457–466. https://doi.org/10.1002/joc.995
Valdez-Cepeda RD, Aguilar-Campos AA, Macias FB, de Leon G, de GM J, Mendez-Gallegos S, Magallanes-Quintanar R (2012) Analysis of precipitation in central Mexico: trends, self-affinity and important frequencies. Int J Phys Sci 7:5324–5326. https://doi.org/10.5897/ijps12.421