Study on the allocation of soil and water conservation measures for photovoltaic power station in rocky desertification mountainous area of Guizhou province

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Abstract: Stony desertification is widespread and, and the ecology is very fragile in the southwest Guizhou province. The careless and unreasonable water and soil conservation measures have caused serious water and soil loss and serious damage to the ecological environment. This paper takes a photovoltaic project in this area as an example to study soil and water conservation measures. Based on the author's practical experience, a scientific and reasonable arrangement system of soil and water conservation measures and preventive management measures are proposed, which can not only provide reference for the prevention and treatment of soil and water conservation of similar projects, but also can be used to guide the main design and site construction, which has a strong guiding significance.

1. Introduction
Since 2014, China's cumulative installed capacity of photovoltaic power generation has ranked first in the world for six consecutive years. With the proposal of carbon peak and comprehensive carbon goal, photovoltaic power generation has taken an increasingly large proportion in the energy structure, and has begun to gradually transform from supplementary energy to alternative energy.

Guizhou is located in the eastern slope of the Yunnan-Guizhou Plateau. The annual average total solar radiation of the whole province ranges from 3149.16 to 4594.80MJ/m\textsuperscript{2}. The total solar is highest distribution in the west and southwest area and gradually decreasing to the east. The resources in the central and northeast of the province are relatively poor. In recent years, photovoltaic power station to vigorously develop in QianXiNa region and has obtained certain result. However photovoltaic power also brought some derivative problems such as Construction started without approval and use without acceptance. Guizhou is full of rocky deserts and extremely fragile ecology, which has cause serious soil and water loss problem and serious ecological environment destruction, because scientific and reasonable soil and water conservation measures are not allocated in the project construction. Therefore, with the continuous advancement of the concept of green development, soil and water
conservation in rocky desertification areas must become the focus in photovoltaic construction, and the prevention and control of soil and water loss is the top priority.

In this paper, a photovoltaic power station project in rocky desertification area of Anlong County is taken as an example. The allocation of soil and water conservation measures for the photovoltaic project is studied which based on a full understanding of the project overview and geographical environment, and combined with the project design and construction technology, so as to provide reference for the prevention and treatment of soil and water conservation in similar projects.

2. Project overview

2.1. Geographic environment of project
The project is located in Puping Town, about 21km to the north of Anlong County, Southwest Guizhou Autonomous Prefecture, Guizhou Province. 313 Provincial Road is located about 5km to the south of the project area. It is connected to the approach road of the project through rural roads, which makes the external transportation more convenient.

The original landform of the project construction area is dominated by low mountains and hills, with an elevation of 1193~1406m. The overall terrain is high in the west and low in the east. The land use pattern is wasteland and shrub land. The climate in the project area is mild and belongs to the subtropical monsoon humid climate area, with an average temperature of 15.3℃, annual average sunshine hours of 1586.4 hours, annual average rainfall of 1195.4mm, and average wind speed of 2.3m/s. The soil type is mainly yellow soil, and the vegetation is mainly natural secondary vegetation and artificial forest, and the coverage rate of forest and grass is 58.25%. The phenomenon of rocky desertification is more serious in the project area, and the soil layer is thin. Water and soil erosion in the project area is dominated by water erosion, with surface erosion and slight erosion intensity. The average soil erosion modulus is 461t/(km²•a). The project is located in the national key soil and water loss control area of karst rocky desertification in southwest Guizhou, and the implementation level of the prevention and control standard is the first-level standard of karst area in southwest Guizhou.

2.2. The design of project
The installed capacity of the project is 80MWP, which is divided into 20 photovoltaic sub-arrays. The modules are composed of 445WP and 530WP monocrystalline silicon cell modules. The 445WP modules are arranged in 15 photovoltaic arrays, and each of 28 photovoltaic modules is connected in series to form a photovoltaic cluster. Each of 24 clusters is connected to a cluster serial inverter (14 inverters are needed for each array), and 14 inverters are connected to a 3150kVA box transformer.530WP modules are arranged in 5 photovoltaic arrays. Every 28 photovoltaic modules are connected in series to form a photovoltaic cluster, and every 20 clusters are connected to a cluster series inverter (14 inverters per square array), and 14 inverters are connected to a 3150kVA box transformer. The voltage level of the collector line is selected as 35kV. The photovoltaic field is connected to the 220kV booster station through a total of three 35kV collector lines. The 220kV booster station was built by the Nantianmen Agricultural PV Power Station constructed at the same time, which is not part of the construction content of this project. The construction of this project mainly includes photovoltaic array, collector line, road inside the site, construction site, etc. The planned construction period is 8 months.

3. Division of control zone
Reasonable division of control zones within the scope of control responsibility is the basis of the design of soil erosion control measures. The zoning of soil and water conservation prevention and control is mainly based on the landform type of the project, considering the timing sequence and layout of the main project, the characteristics of new soil and water loss, and combining with the leading factors such as the connection with the main project and the convenience of the arrangement and implementation of soil and water conservation measures, the zoning of soil and water loss
prevention and control is carried out. The results of this project division are as follows:

Table 1  Achievements of project control zoning table

| Division of control zone       | Characteristics of soil and water loss                                      |
|-------------------------------|--------------------------------------------------------------------------------|
| Primary partition             | Site leveling, pile foundation construction, mechanical occupation           |
| Secondary partition           | Site leveling, pile foundation construction, mechanical occupation           |
| Photovoltaic (pv) area A      | Pile foundation construction, a small amount of rotary hole residual residue backfill |
| Photovoltaic (pv) area B      |                                                                                  |
| Area of Box-type transformer  | Excavation and backfilling of Box-type transformer foundation                |
| Area of electrical circuit    | direct burial cable                                                        |
|                               | Excavation and burying of cable ditch                                       |
| Overhead line area            | Kentucky construction                                                      |
| Area of newly-construction load| Roadbed digging filling                                                     |
| Area of expansion of the land | Roadbed digging filling                                                     |
| Area of construction plant    | Rolling area of construction                                                |
| Undisturbed area              | No construction disturbance                                                 |

It should be noted that the increase or decrease of secondary partitions can be considered in the photovoltaic array area according to the dispersion of the layout and the difference of the terrain. The area of booster station can be added according to the construction of booster station.

4. Researching on the configuration of soil and water conservation measures

4.1. Principle

The configuration of water and soil conservation measures shall comply with relevant national and local water and soil conservation policies and regulations, comply with the principles of science and rationality, practicality, significant effects, and ease of implementation, and coordinate with the main project to avoid conflicts. Based on the evaluation of the existing water and soil conservation measures of the main project, according to the characteristics of different soil erosion prevention and control zones and the soil erosion status, the prevention and control priorities and the configuration of measures for each zone are determined. At the same time, taking into account the natural environment of the project area and the characteristics of the construction and operation of the project, the arrangement of measures adopts the method of combining engineering and plant measures to prevent and control soil erosion. The main principles are as follows:

(1) In combination with the actual situation of the project and the current situation of soil erosion in the project area, measures should be taken according to local soil erosion conditions, achieve the goal of comprehensive layout and scientific configuration.
(2) Minimize the damage to the original surface and vegetation and make full use of topsoil resources;

(3) Temporary protection measures shall be taken during the construction of the project to reduce human disturbance and waste soil generated during the construction;

(4) The project, plant and temporary measures should be rationally allocated and integrated to form a comprehensive protection system;

(5) Local materials should be selected as far as possible in engineering measures, so as to be technically reliable and economically reasonable.

(6) Plant measures should try to select plant varieties which could adapted to the local conditions, and take into account the effect of greening and beautification.

(7) The arrangement of prevention measures should be closely coordinated with the main project, and coordinated with each other to form a whole.

4.2. Water and soil conservation measures allocation

The scientific and rational allocation of soil and water conservation measures can not only guide the design and on-site construction of the project, but also assist the compilation of soil and water conservation plan, which is of practical significance. Based on the experience of soil and water conservation measures arrangement of several photovoltaic projects in Guizhou, the author summarized the configuration of soil and water conservation measures suitable for rocky desertification areas.

1. Photovoltaic array area

Soil erosion of photovoltaic array area mainly occurs in the stage of site leveling and pile foundation construction. The topsoil in rocky desertification areas is rare and precious, so it is necessary to take good measures to protect the topsoil. At the same time, due to the large difference in topography, in order to avoid large-scale damage to the original landform, it is not suitable for full-scale leveling, and it is recommended to use a combination of manual digging piles and mechanical construction according to local conditions. The specific soil and water conservation measures are as follows:

Before construction, the topsoil in photovoltaic array area and the possible disturbed area shall be stripped and stacked in the idle area of the site, and the stripped topsoil shall be temporarily covered and blocked by temporary soil bags. In the process of construction, the disturbed area shall be fully covered with soil and leveled, rosa roxburghii Tratt. and grass seeds shall be planted in the leveled area, and the prevention measures for disasters shall be increased, The placed rockfill retaining wall built along the contour line in the steep slope area of photovoltaic array area should be effectively blocked, and the placed rockfill can be obtained from nearby materials.

2. Box-type transformer foundation area

Due to the small construction disturbance in the foundation area of box type transformer, there is generally no large-scale soil erosion. The soil and water conservation measures are as follows:

Before construction, strip the topsoil of Box-type transformer foundation area, stack them around the box-type transformer, and temporarily cover the stripped topsoil; after the completion of the construction, carry out soil covering and remediation in the area where the vegetation can be restored, and sow grass seeds in the soil covering area.

3. Collector lines area

The Collector lines area is divided into the direct buried cable area and the overhead line area. The soil erosion in the directly buried cable area is mainly due to the excavation of the cable trench, while the soil erosion in the overhead line area is mainly due to the foundation construction of the tower. Usually the former has a larger disturbance range. At present, it is possible to use trough box cables instead of directly buried cables, which can greatly reduce the disturbance range. The water and soil conservation measures are configured as follows:

Direct buried cable area: Before construction, the topsoil of the direct buried cable area shall be stripped, stacked on the side of the cable trench, and the stripped topsoil shall be temporarily covered;
after the construction is completed, the area where the vegetation can be restored shall be covered with soil and grass seeds shall be sown in the covered area.

Overhead line area: Before construction, the topsoil can be stripped in this area, stacked around the tower foundation, and the stripped topsoil shall be temporarily covered; after the construction is completed, the construction work surface and surrounding backfill areas in this area except the tower foundation and the surrounding backfill area shall be covered with soil and grass seeds shall be sown.

(4) Photovoltaic field road area

Photovoltaic field road area includes new roads and expansion of existing roads. The soil erosion of the two areas mainly occurs in the excavation and filling of the subgrade, which is a large disturbance part of the photovoltaic power station in the rocky desertification area. The configuration of soil and water conservation measures are as follows:

Before construction, strip the topsoil and stack it on the side of the road, and temporarily cover the stripped topsoil; During the construction period, a drainage ditch should be arranged along one side of the road, a drainage pipe connected across the road, and a grit basin arranged at the end of the drainage ditch; after the completion of the construction, the road side slope should be covered with soil and grass seeds should be spread, and climbing plants should be planted under the side slope.

(5) Construction site area

The construction site area is usually fully occupied, and the original landform of the occupied area would be destroyed. To prevent serious soil erosion, measures for topsoil stripping, temporary protection and vegetation restoration are required. The specific water and soil conservation measures are as follows:

Before construction, strip the topsoil of the occupied area, stack them in the free area of the site, and temporarily cover the stripped topsoil; During construction, arrange temporary drainage ditches along the periphery of the construction site; After the completion of the construction, the re-cultivated area shall be covered with soil and renovated, and grass seeds shall be sowed for timely restoration.

(6) Undisturbed area

For areas that are not disturbed by photovoltaic construction, the original landform should be maintained, and no new water and soil conservation measures should be added.

Table 2  The table of arrangement system of photovoltaic water and soil conservation measures in rocky desertification mountain area

| Division of control zone | System of soil erosion control measures |
|-------------------------|----------------------------------------|
| Photovoltaic array area | Engineering measures: Topsoil stripping, comprehensive site preparation, soil preparation, placed rockfill retaining wall  |
|                         | Plant measures: Planting honeysuckle, planting prickly pear, sowing grass seeds |
|                         | Temporary measures: Temporary retaining works, Temporary cover |
| Box-type transformer foundation area | Engineering measures: Topsoil stripping, Cover soil remediation |
|                         | Plant measures: Sowing grass seeds |
|                         | Temporary measures: Temporary cover |
| Collector lines area    | Engineering measures: Topsoil stripping, Cover soil remediation |
|                         | Plant measures: Sowing grass seeds |
|                         | Temporary measures: Temporary cover |
Photovoltaic field road area

| Engineering measures                                      | Topsoil stripping, Cover soil remediation, Drainage ditch, Drain pipe, Sand settling basin |
|-----------------------------------------------------------|------------------------------------------------------------------------------------------|
| Plant measures                                            | Sowing grass seeds, Plant climbing plants                                                  |
| Temporary measures                                        | Temporary cover                                                                          |

Construction site area

| Engineering measures                                      | Topsoil stripping, Cover soil remediation                                                |
|-----------------------------------------------------------|------------------------------------------------------------------------------------------|
| Plant measures                                            | Sowing grass seeds                                                                        |
| Temporary measures                                        | Temporary retaining works, Temporary cover                                              |

It should be noted that the arrangement system of photovoltaic water and soil conservation measures proposed in this article for rocky desertification mountainous land has great reference significance for similar projects, but in the actual use process, it should be combined with the external environment and the main design of the project.

4.3. Preventive measures of soil and water conservation

4.3.1. Preventive measures of construction

Construction site management should be strengthened, and civilized construction should be achieved in the process of project construction. Earthwork should be reasonably allocated, construction time sequence should be optimized, and brutal construction should be eliminated. Packing sites of soil, stone and sand used for construction shall be under centralized management with obvious signs, and it is strictly prohibited to dump them at will.

1. Construction time should avoid strong wind and rainstorm weather.
2. The temporary protection measures should be implemented during the construction period, such as temporary protection, temporary drainage.
3. Project construction should be in strict accordance with the program design procedures to excavate, pile up, fill soil, resolutely put an end to random abandonment of soil and stone and not according to the program of construction.
4. Construction should optimize the construction process according to local conditions.

4.3.2. Preventive and management measures of soil and water conservation

In the project construction, the soil and water conservation policy of "prevention first, protection first, comprehensive planning, comprehensive management, measures according to local conditions, highlighting key points, strengthening management and paying attention to benefits" should be earnestly carried out and implemented to ensure the implementation of soil and water conservation projects and give full play to the benefits of soil and water conservation projects. Specific preventive and management measures are as follows:

1. We must resolutely implement the "three simultaneous" system of water and soil conservation, and truly ensure that water and soil conservation facilities and the main project are designed, constructed and put into operation at the same time.
2. Establish the responsibility system for soil and water conservation, list soil and water conservation as one of the contents of project progress and quality assessment, and formulate detailed implementation plans for soil and water conservation programs.
3. The construction unit shall require the construction unit to purchase sand and stone materials from legitimate manufacturers, and clarify the responsibility of soil erosion prevention and control in the sand and stone fields during the construction period.
4. During the construction period, the construction unit shall be responsible for maintaining...
contact with the design, construction, supervision and monitoring units, coordinating the relationship between the water and soil conservation program and the main project, ensuring the normal and smooth development of the water and soil conservation project, and completing the project on time, so as to reduce or avoid the soil erosion and ecological environment damage that may be caused by the project construction.

(5) The construction process should optimize the construction process, follow the principle of overall arrangement, and minimize on-site disturbance.

(6) Soil and stone for foundation excavation should be piled up in a centralized manner, the amount of earthwork should be allocated as a whole, and repeated excavation and filling should be eliminated.

(7) Establish and improve various archives, accumulate, analyze and compile data, and provide relevant data for the acceptance of soil and water conservation projects. Establish and improve various archives, accumulate, analyze and compile data, and provide relevant data for the acceptance of soil and water conservation projects.

5. Conclusions
In the rocky desertification mountainous areas of Guizhou province, it is common for photovoltaic projects to be built before approval or putted into operation before acceptance check. This paper discusses and studies the soil and water conservation measures, and puts forward the scientific and reasonable arrangement system of soil and water conservation measures and preventive management measures, which provides reference for the prevention and treatment of soil and water conservation of similar projects, and can also guide the main body design and site construction, which has a strong guiding significance.

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Here are some examples:
[1] Ma Shijun. (2013). Discussion on design of soil and water conservation measures for photovoltaic power station project. 2013 Annual Meeting of Planning and Design Committee of Soil and Water Conservation of Chinese Society of Soil and Water Conservation. Nanchang, 297-302.
[2] Zhang Xia, Liu Xiaqing, Wang Yaping, et al. (2012). Evaluation on Benefits of Soil and Water Conversation in Ecological Function Region of Qinling Mountain. Research of Soil and Water Conservation, 2012:86-90.
[3] Liu Wei, Dan Xinqiu, Liu Shihao, et al. (2014). Review of the Cause and Treatment Measures of Rocky Desertification in Guizhou Province. Journal of Anhui Agricultural Sciences, 25:8736-8739, 87
[4] Guo Suoyan, Jiang Dewen, Shen Xuejian, et al. (2019) Standard of soil erosion control for production and construction projects. China Planning Press, Beijing.
[5] Wang Zhiguo, Shi Zhiping, Ji Qiang, et al. (2014) Code for design of soil and water conservation engineering. China Planning Press, Beijing.
[6] Shi Lin. (2018) Problems and Suggestions of Water and Soil Conservation Scheme for Photovoltaic Power Generation Project. Technology of Soil and Water Conservation, 6:34-35.
[7] Wang Luwei, Luo Ding. (2019) Analysis on Soil and water conservation measures of Xinqiao agricultural photovoltaic power station in Yilong New District of Qianxinan Prefecture. XianDai NongYe KeJi, 22:149-152.