Tsinghua University • CHINA
Research Center for Energy Transition and Social Development

Solar PV Empower Ecological Restoration at Aral Sea

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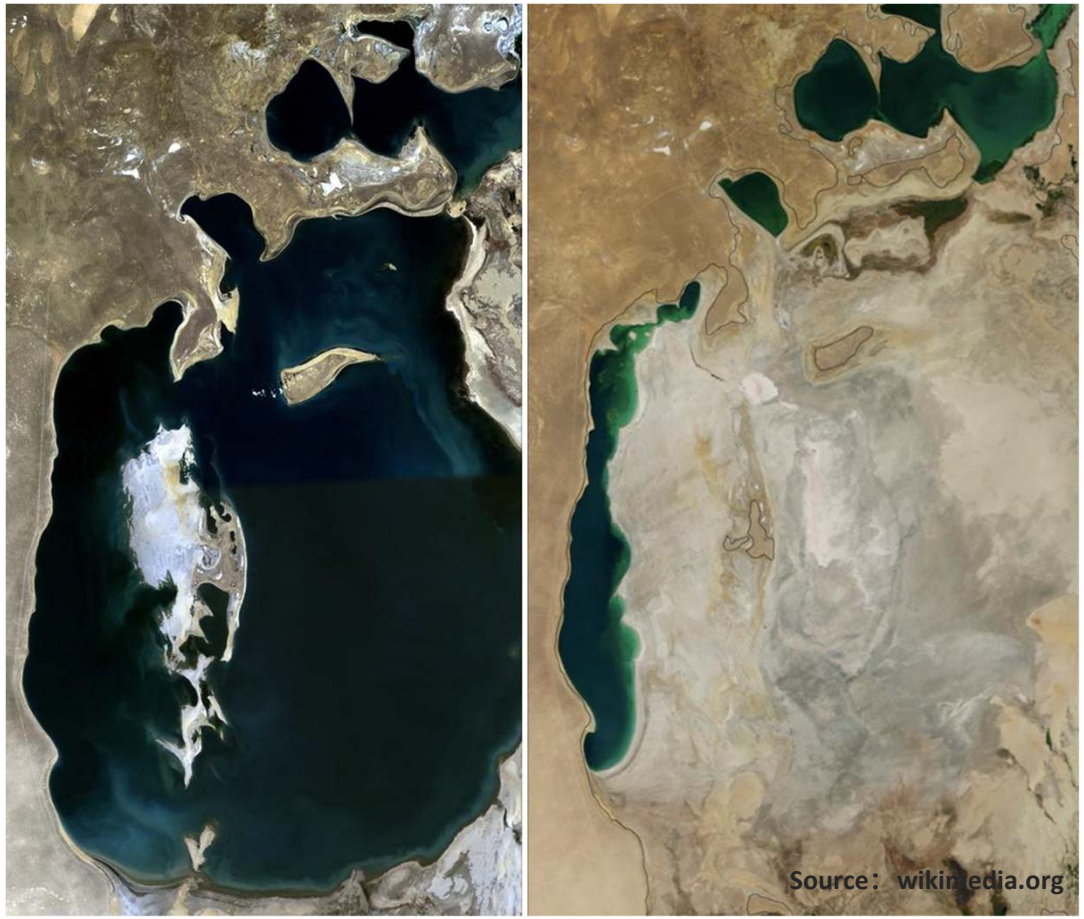
Resolve Ecological Crisis of Aral Sea



Aral Sea 1989

Aral Sea 2014

Source： Anand Gupta

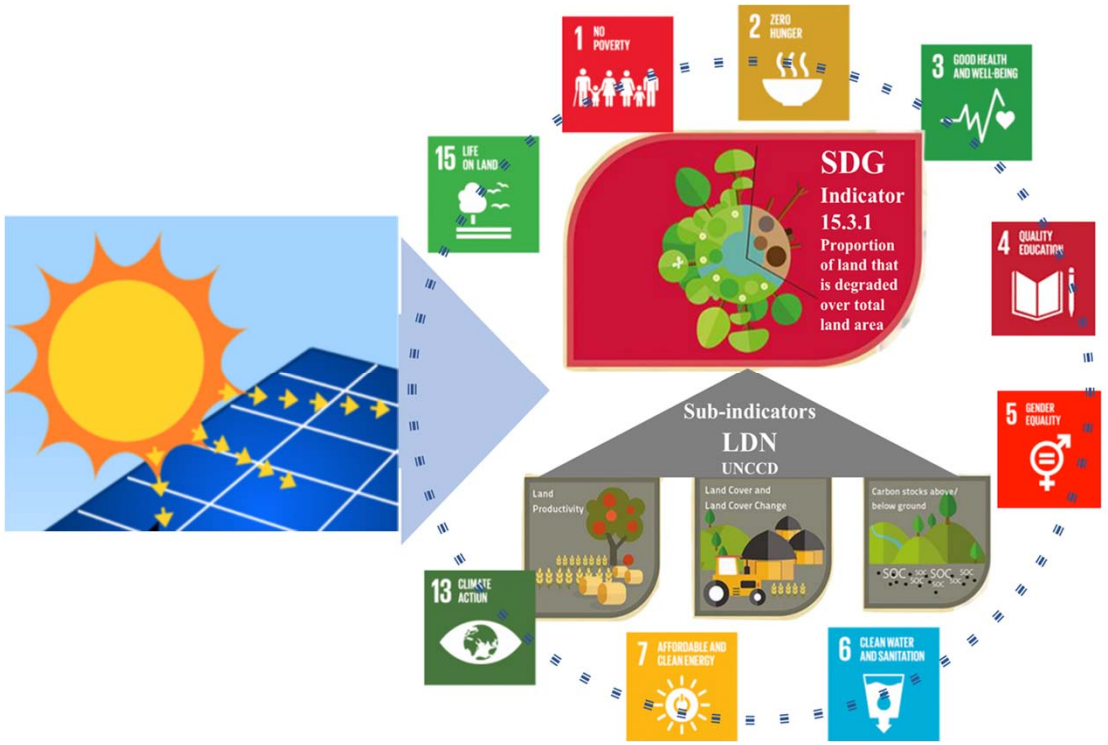
Can photovoltaics(PV) be the KEY to resolving the Aral Sea's ecological crisis?

Is it possible to restore Aral Sea region with Photovoltaics?

Functions

Renewable energy， soil restoration, vegetation coverage improvement, windbreak and sand-fixing

—— The solution to land desertification with Solar PV for the SDGs



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Land-solar Case： Natural Restoration in Pakistan

★ The edge of the Christen desert
★ More than 1800 ha
★ 900 MW PV power generation
★ Annual precipitation is 173.3mm

- The array spacing of each station is **4.6m**.
- The lower edge of the component is **50 cm** away from the ground.
- Photovoltaic spacing design is easy to vegetation growth.
- Cleaning PV modules **Monthly.**

- The average monthly generating capacity is about **42 million kWh**, and reaching **500 million kWh/annual.**
- **Provide more than 3000 Jobs**

Improved the following ways:
★ **the infrastructure facilitating the accessing,**
★ **sand fixation**
★ **grass growth**

Vegetation coverage of the photovoltaic array area:
★ **The First year: can reach 20%**
★ **The Second year: 50%**
★ **The Third year: more than 70%**

Land-solar Case： Natural Restoration in Tengger Desert

Annual precipitation： 180 ~ 367 mm.

Annual evaporation： 1930 ~ 2172 mm.

Annual total solar radiation value： about 5000 ~ 6300 MJ/m2.

Annual accumulated temperature： 3720℃.

Generate 535 million kWh/year
Reduction of 533 thousand tons carbon emission.

More than 100 people have been employed.
60 people： workers in PV power station
More than 40 workers

- photovoltaic module cleaning,
- winter grass cleaning,
- agricultural planting,
- staff canteen cooking and cleaning.

Migrant workers earn about $10,000 a year,which well above the local average.

Adopting the grass grid sand fixation method (60cm×60cm)

- the vegetation coverage reached 90% after three years

The height of the lower edge of the panel is 150 cm from the ground. (30cm for some stations).

- Haloxylon and solar panel

- Camel spine and solar panel

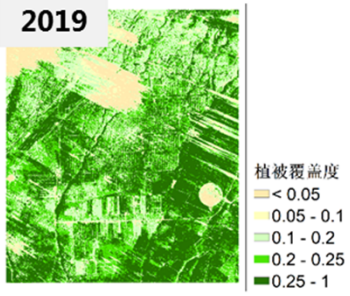
Land-solar Case： Natural Restoration in Qinghai

850WM/54Km2

Eco-Benefits

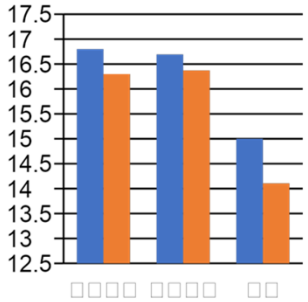
- **Average Temperature4.1℃**
- **Annual precipitation is 246.3mm**
- **Annual evaporation 1716.7 mm**
- **Annual average windy days 207 days**
- **Annual average solar radiation 6654.26 MJ / m²**

Ecological Restoration



15% vegetation coverage increased, on July and August

Improve Soil-moisture



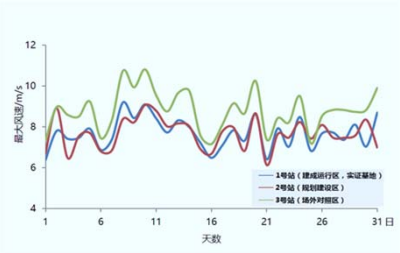
78%、43%、40% soil moisture increased at depth of 10、20、40 cm under PV panel respectively. 11.6 times organic matter and 11.3 times total nitrogen content increased compared to the before in summer.

Carbon Reduction

1.2 million tons Carbon Emission Reduction annually

Carbon Sink To be assessed

Micro-Climate Adjustment



40.3% wind velocity decreased than outside of the park.

2.8% air relative humidity higher than outside of the park

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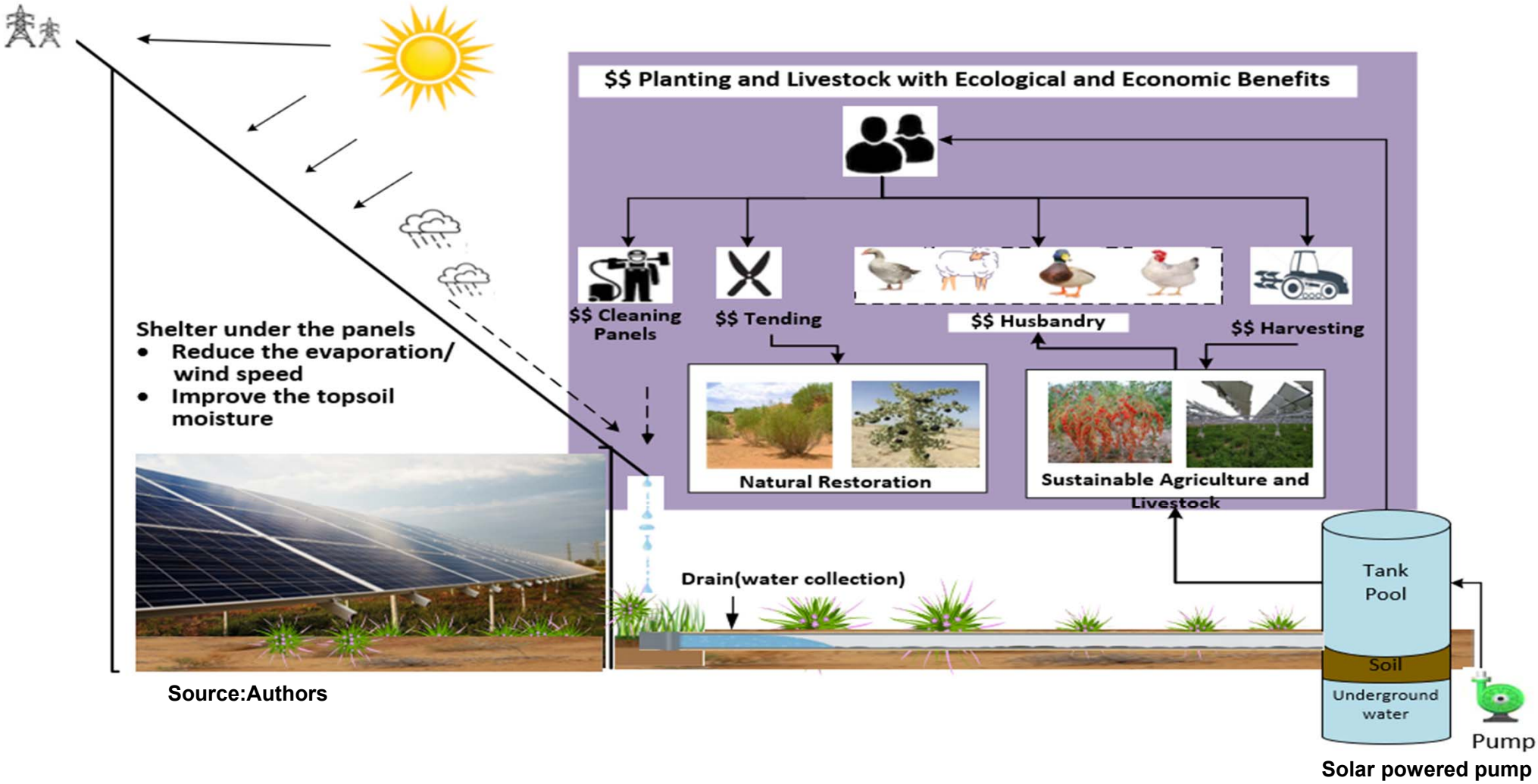
Mechanism of Land Restoration with PV Power Panels



Source:Authors

Carbon Emissions Reduction and Offset

Solar PV Power Plant

Clean Power
Substitution of Coal

Carbon Sequestrations

Vegetation restoration

Shrub

Grass

Biomass energy

Salix

Roots of Crop

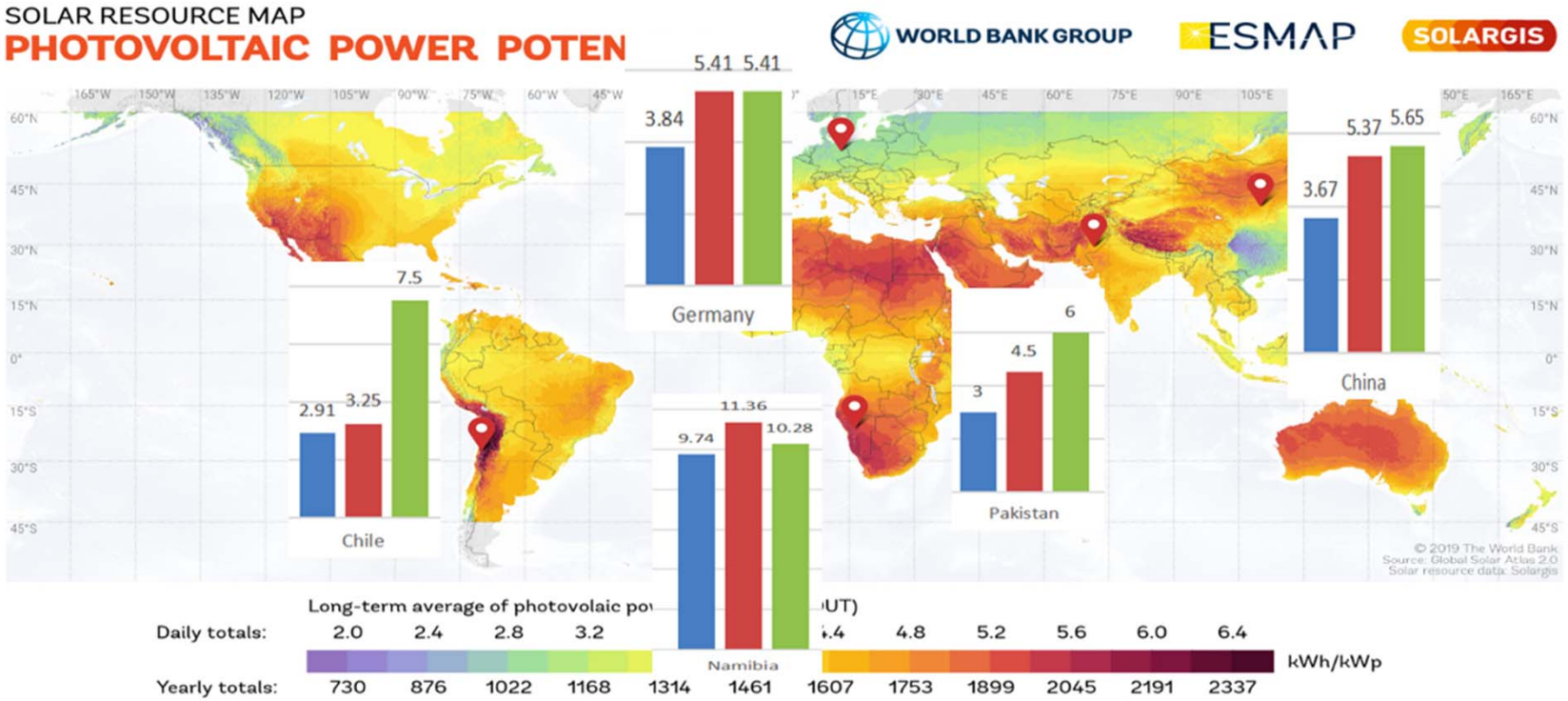
Soil
Organic
carbon

Crop
tubers

Lower Price of Solar Electricity

- **Comparison of Photovoltaic Electricity Prices between Five Countries**

Unit: Cents



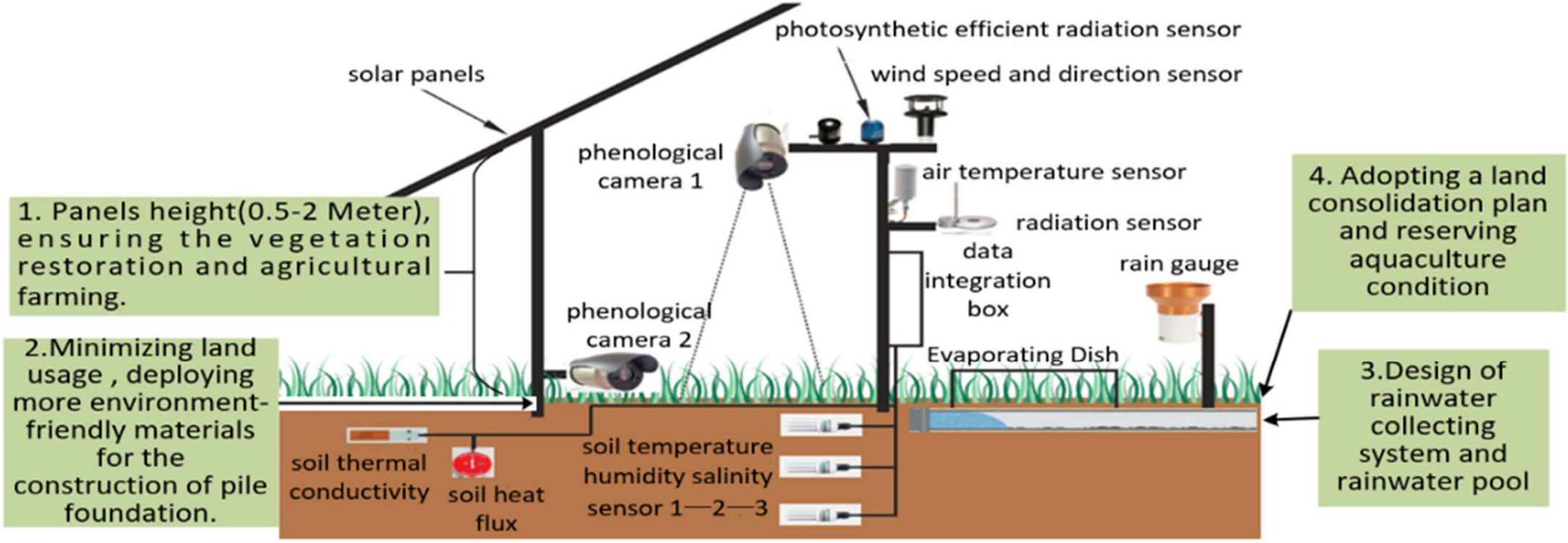
■ Lowest photovoltaic price ■ Average photovoltaic price ■ Average coal-fired electricity price

Source: https://www.globalpetrolprices.com

- **1.The lowest price of PV power has been lower than the price of coal power;**
- **2.The average price of PV power has been very close to the average price of coal power.**

Why can PV power plants restore desertified land?

Ecological monitoring system of Photovoltaic Panels



Source： Authors -- case study in Qinghai,China

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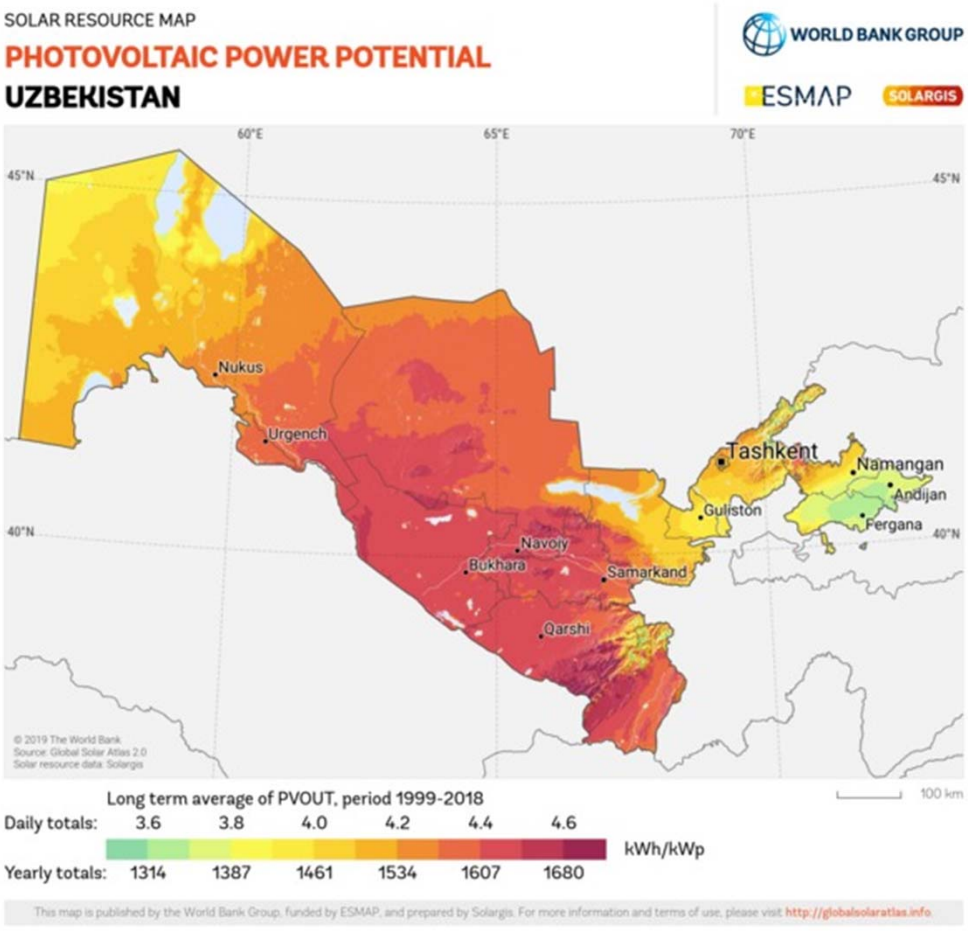
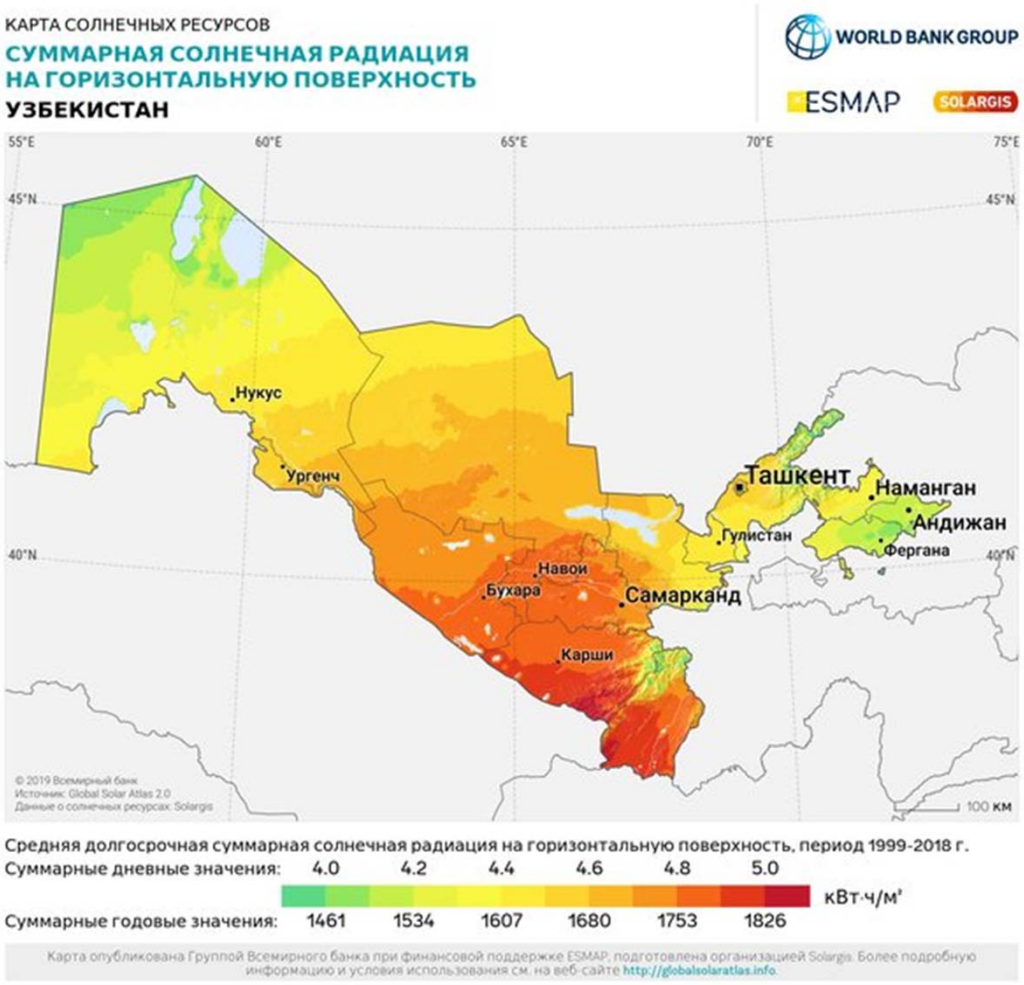
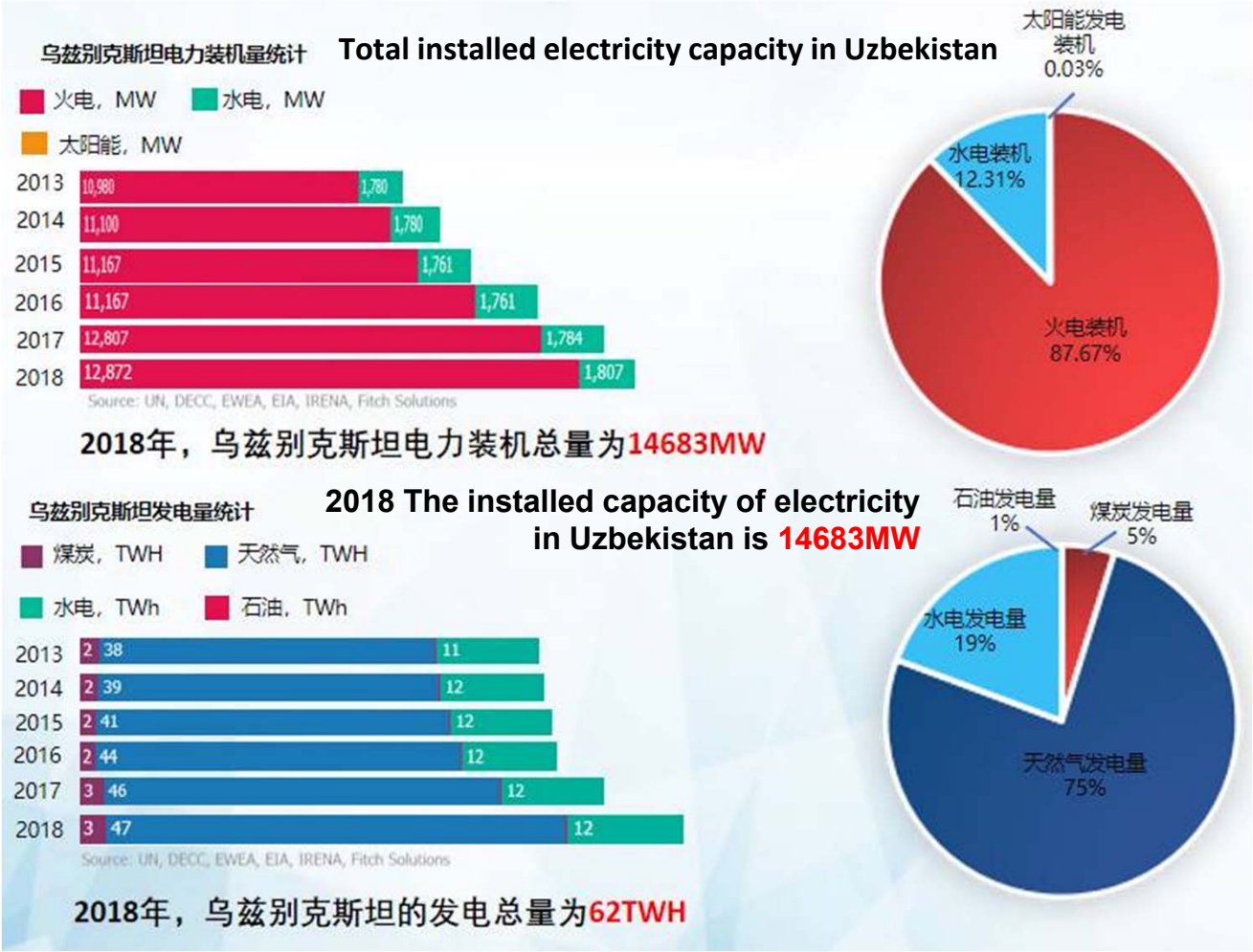
Potential for Photovoltaic Development in Uzbekistan





Source:SolarGIS

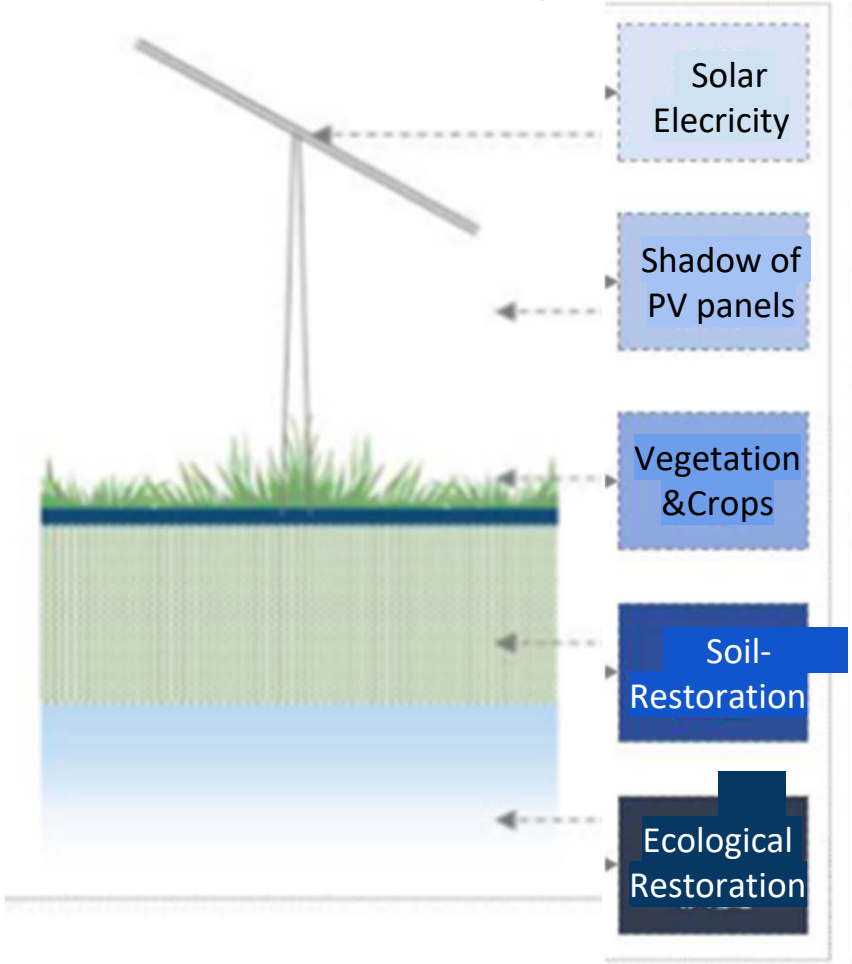
Status of Photovoltaic Development in Uzbekistan

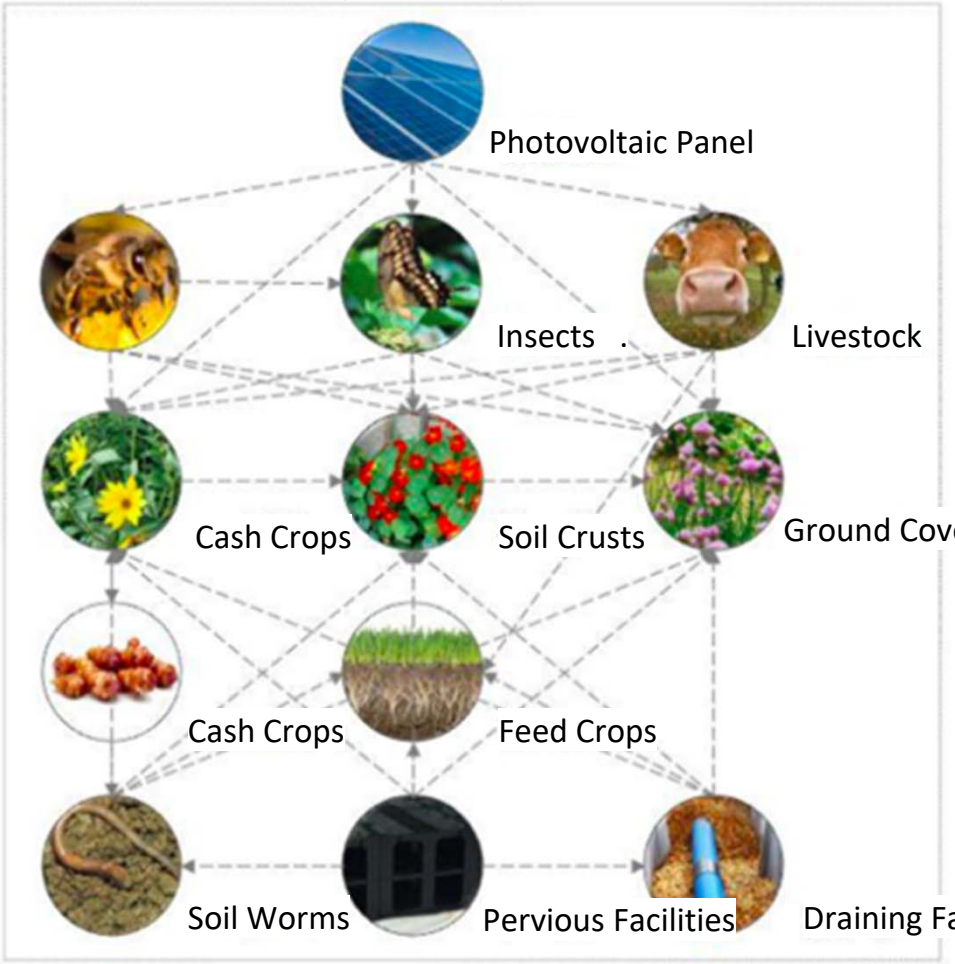


Source： Hydropower and Water Resources Planning & Design General Institute, China

Apply Photovoltaic Solar Power in Aral Sea Region

Arid Agriculture combined with PV power plants





Source Authors

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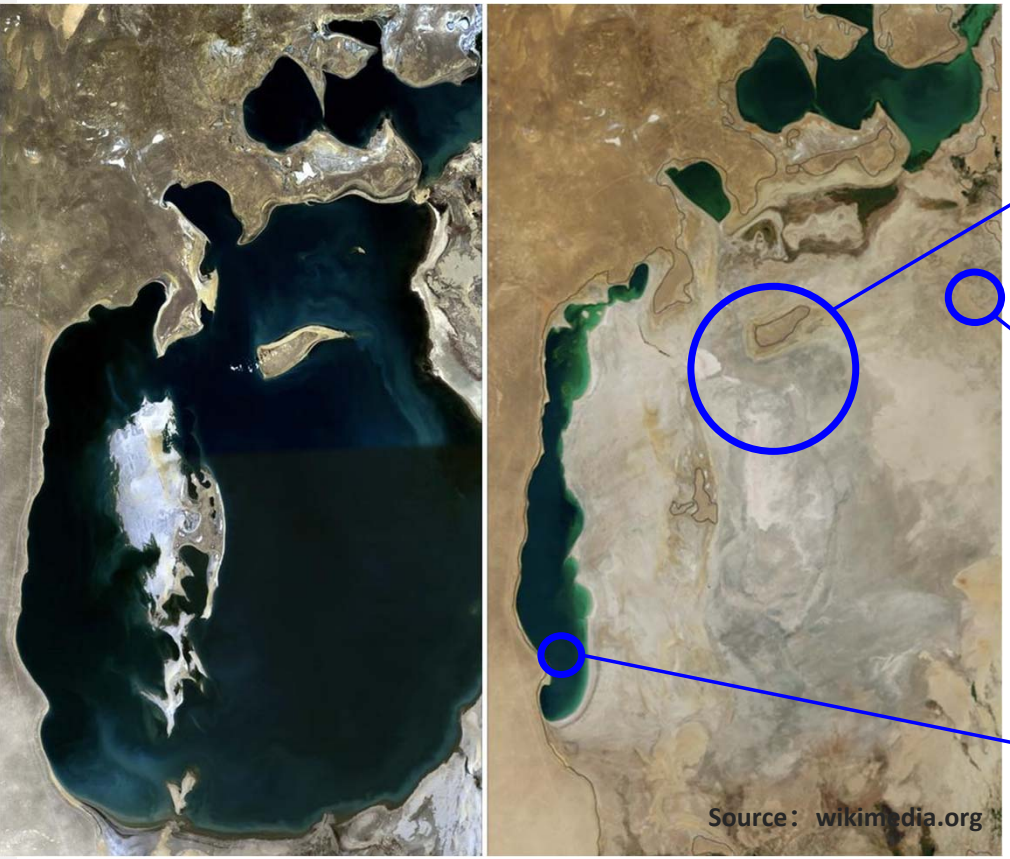


Aral Sea 1989

Aral Sea 2014

Desertified Land

Land Restoration by Biological Soil Crusts &Desert ground cover

Arid Farmland

Solar Arid Agriculture with Jerusalem artichoke

Fishery Areas

Photovoltaic Fisheries & floating solar farm

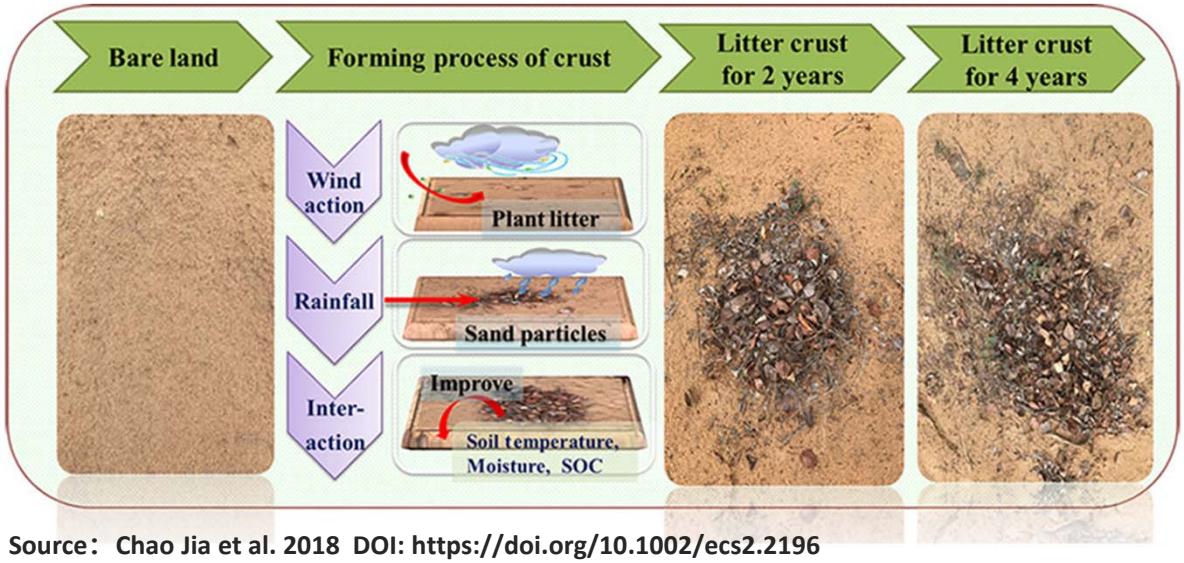
Solar PV+ Biological Soil Crusts

Desertified Land

Land Restoration by Biological Soil Crusts

Biological Soil Crusts – Holding the Desert in Place

Source：Brodie Environmental Microbiology Group @ LBNL



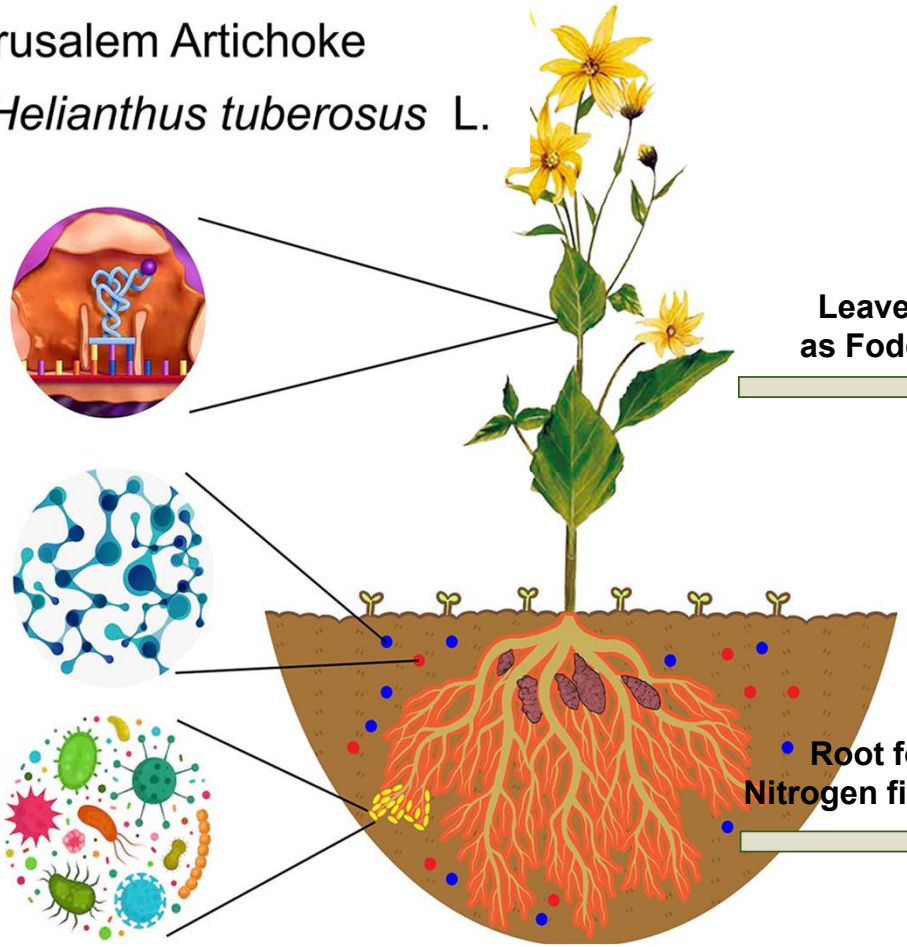
Source：Chao Jia et al. 2018 DOI: https://doi.org/10.1002/ecs2.2196

Photovoltaic panels contribute to the formation of soil crusts

Solar PV+ Jerusalem artichoke

Jerusalem Artichoke

Helianthus tuberosus L.



Leaves as Fodder

Root for Nitrogen fixation

Arid Farmland

Solar Arid Agriculture
with Jerusalem artichoke

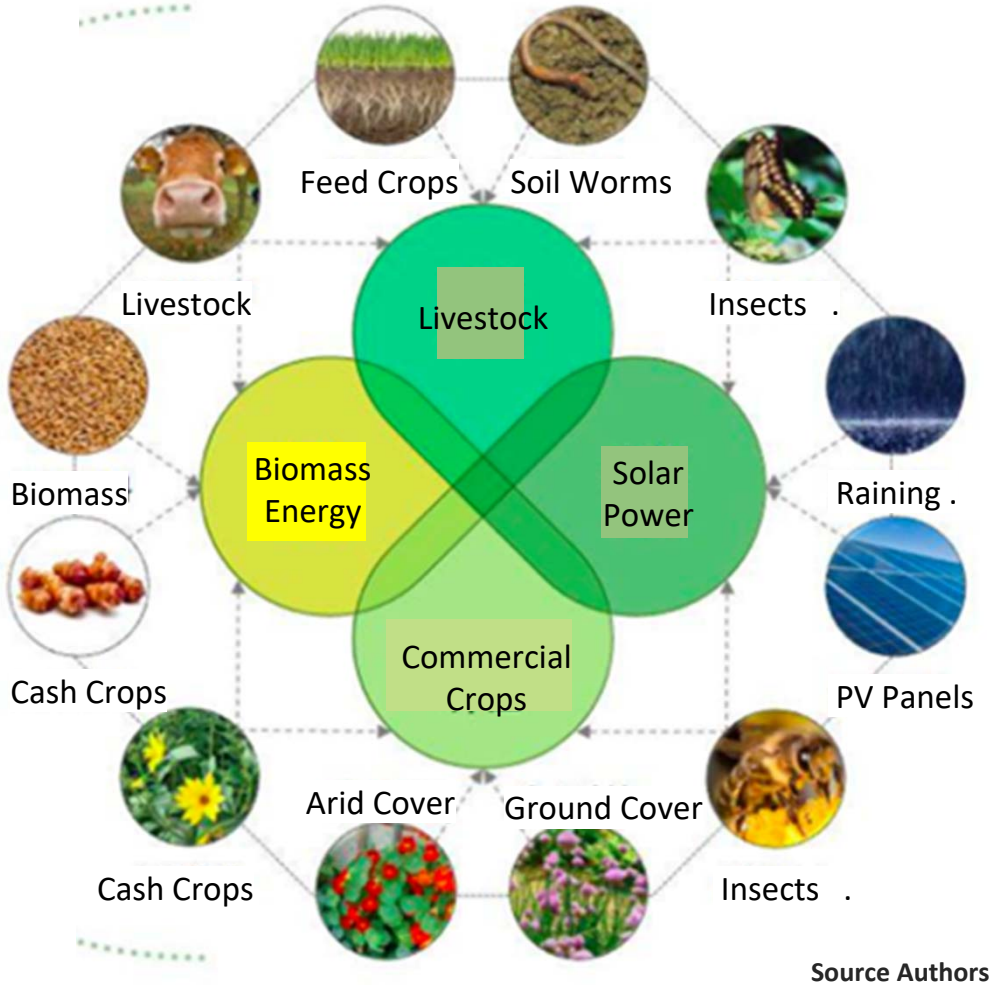
Livestock

Biomass Energy

Commercial Crops

Soil Restoration

Arid agriculture combined with PV power plants



Source Authors

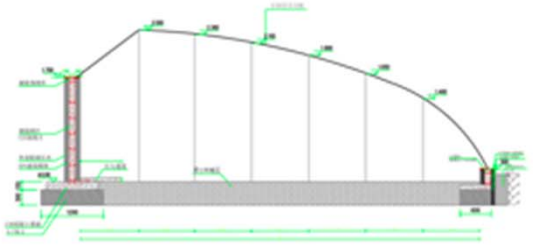
Photovoltaic Heliostat Facility Arid Agricultural

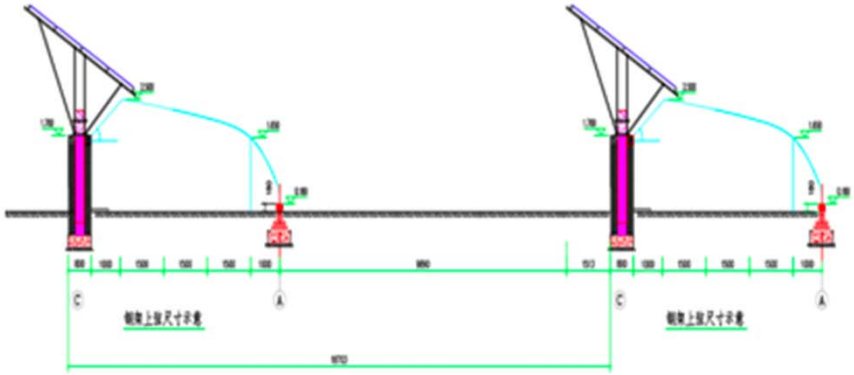
Source： Case study of Tongchuan,Shanxi,China

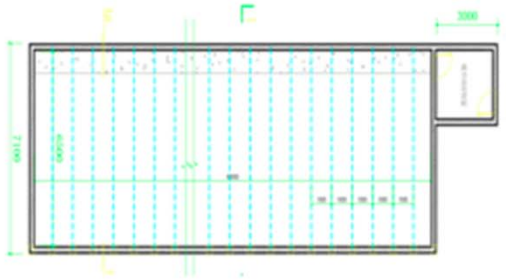
Photovoltaic Heliostat Facility Arid Agricultural

Photovoltaic heliostat facility agricultural park

- A total of 200 high-specification greenhouses for winter warmth in photovoltaic agricultural greenhouses, where modern factory nurseries and mixed-season vegetable planting are proposed.
- In 12 of these greenhouses, digital facility agriculture will be built, with digital displays at the entrance showing the temperature, humidity, illumination, soil temperature, soil moisture content, soil physical and chemical levels, as well as water and electricity consumption inside the greenhouse.







Source： Case study of Tongchuan,Shanxi,China

Photovoltaic Heliostat Facility Arid Agricultural

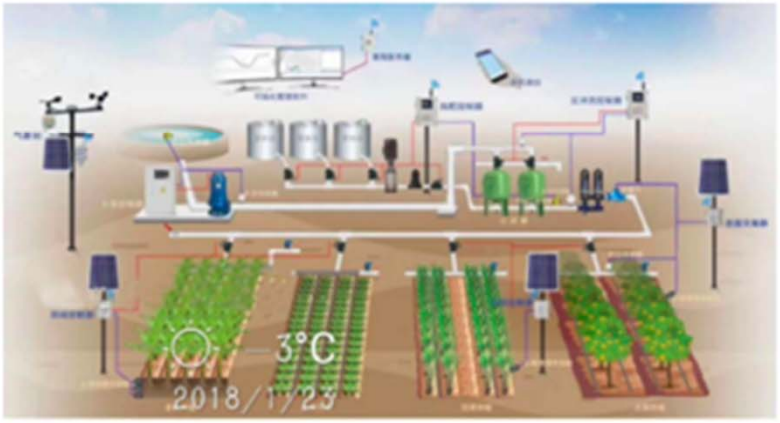
Source： Case study of Tongchuan,Shanxi,China

Apply Photovoltaic Solar Power in Aral Sea Region

Water-saving Arid Agricultural with Photovoltaic

Efficient water-saving drip irrigation facilities under fixed PV modules

- Water-saving irrigation systems are planned for open-field planting areas, forming field water distribution branch pipe networks and terminal drip irrigation belts.
- Drip irrigation facilities are planned to cover an area of 9,000 mu, with a total of 49 new water storage cells, 1 for office area, 24 for greenhouse area and 24 for open field planting area.
- According to the planting area, 12 irrigation districts are divided, and a mobile head system is designed (modular pumping, filtering and pressurizing equipment is transported by vehicles).



Source： Case study of Tongchuan,Shanxi,China

Photovoltaic boosting fisheries production

source： China Daily, Case of Cixi,Zhejiang,China

- Fish manure and feed residue are used as fertilizer for vegetables and rice
- Fish manure recovery up to 80%

source： China Daily, Case of Cixi,Zhejiang,China

Contents

6. UNCCD-Tsinghua REPER project

United Nations Convention to Combat Desertification

REPER：Renewable Energy Power Ecological Restoration

Science Studies

Photovoltaic power station

- 1.Technical standard for ecological Construction
- 2.Industry standard for ecological Effect Assessment

Photovoltaic pump

- 3.Evaluation software for sustainable utilization of water resource and selection design

Capacity Building

Development of training materials

- 1.Photovoltaic and ecological restoration:
- 2. Photovoltaic water pump:
- 3.Photovoltaic ecological Village
- 4.Explore the video version of training materials

Design of training program

- 5.Workshop
- 6.Internet-based Collaborative and Active learning

Pilot

Pilot project of Photovoltaic and ecological restoration

- Step 1: four or five projects in China ;
- Step 2: Middle East, Africa
- Step 3: Pilot in other countries

Pilot photovoltaic water pump

- Pilot projects will be carried out first in Africa, South Asia, Southeast Asia and China

Photovoltaic Ecological Village

- Coordinated with China's Fund for South-South Cooperation

Tsinghua University and partners support the Aral Sea land-solar plus project

Research Institute

Renewable Energy Enterprise

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INSTITUTE OF ELECTRICAL ENGINEERING CHINESE ACADEMY OF SCIENCES

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Thank you for your attention!

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