



CAZRI Agrivoltaic system

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Agri PV plants, RE Grid Integration and Green Hydrogen**

Organised by CBIP, New Delhi

Date: 17th March, 2023

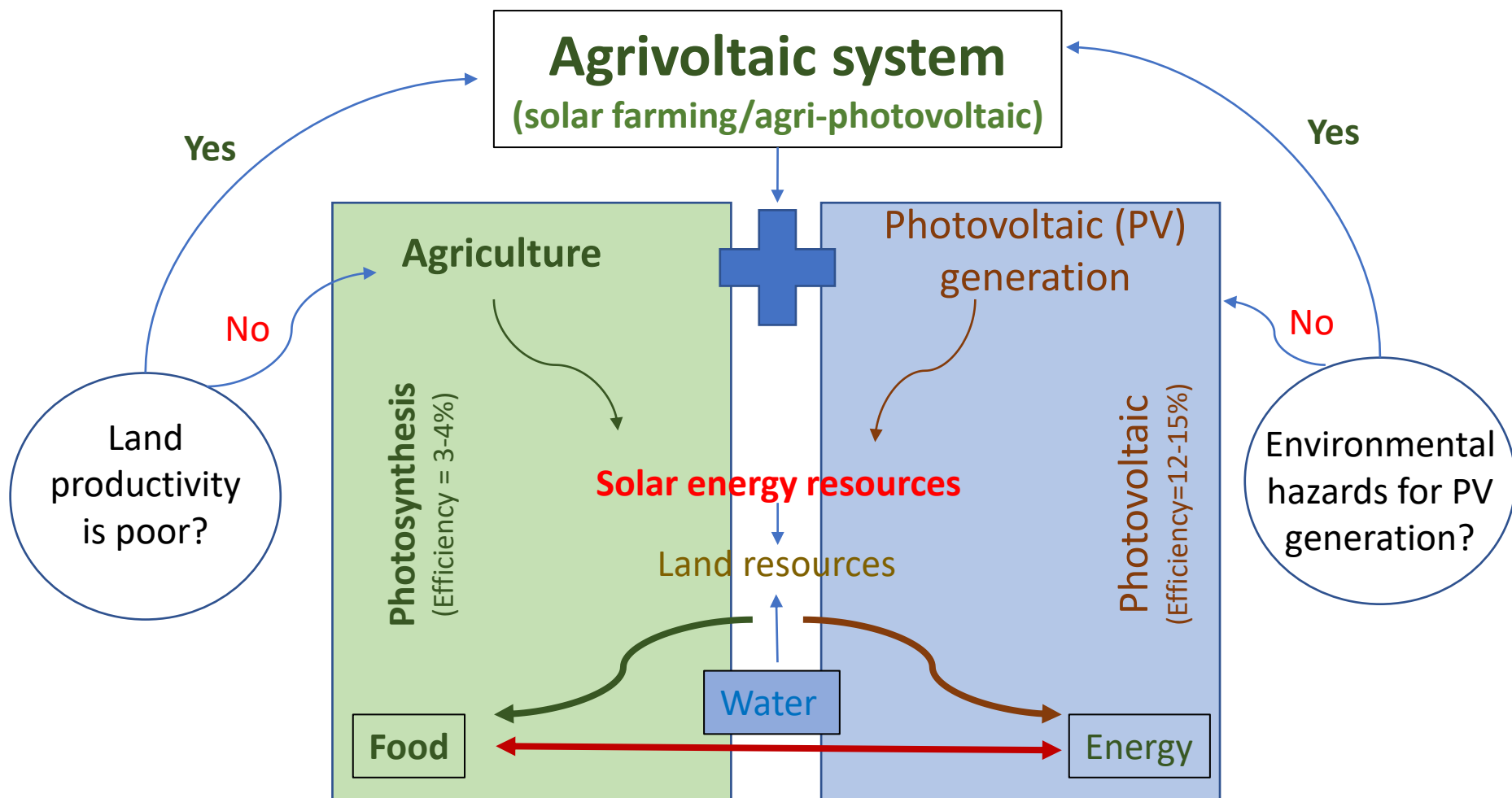
Venue: Hotel Fairfield by Marriott, Jodhpur



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Why Agrivoltaic system?



CAZRI Agrivoltaic system



Three designs

Single row model

Double row model

Triple row model

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Crops in CAZRI Agrivoltaic system

Kharif crops: Growth and yield of *Vigna radiata* was not affected by the shade of PV module, whereas rest two are affected

Rabi crops: Growth and yield of *Plantago ovata* and *Cuminum cyminum* are significantly affected by shade of PV module

Medicinal crops: Performance of medicinal crops were superior in the interspace area than over control

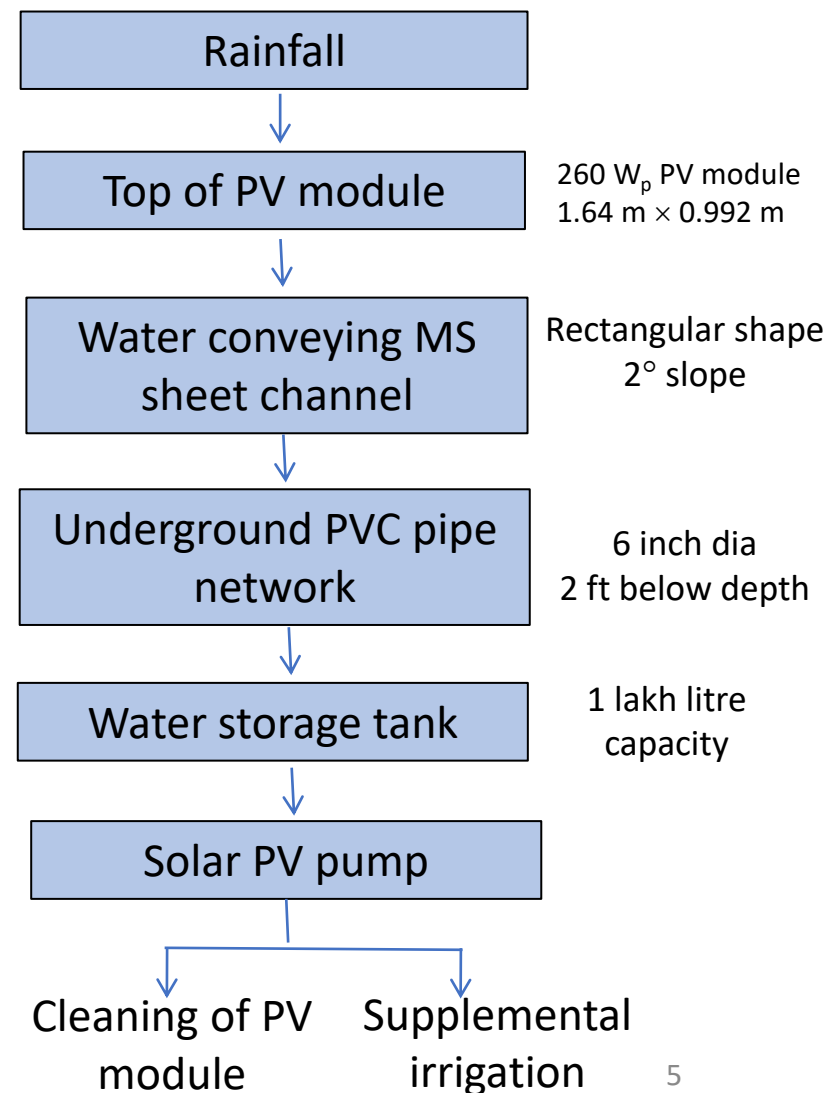
Vegetable crops: Growth and yield of *Solanum melongena* was significantly affected by shade of PV module



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Rainwater harvesting in CAZRI Agrivoltaic system



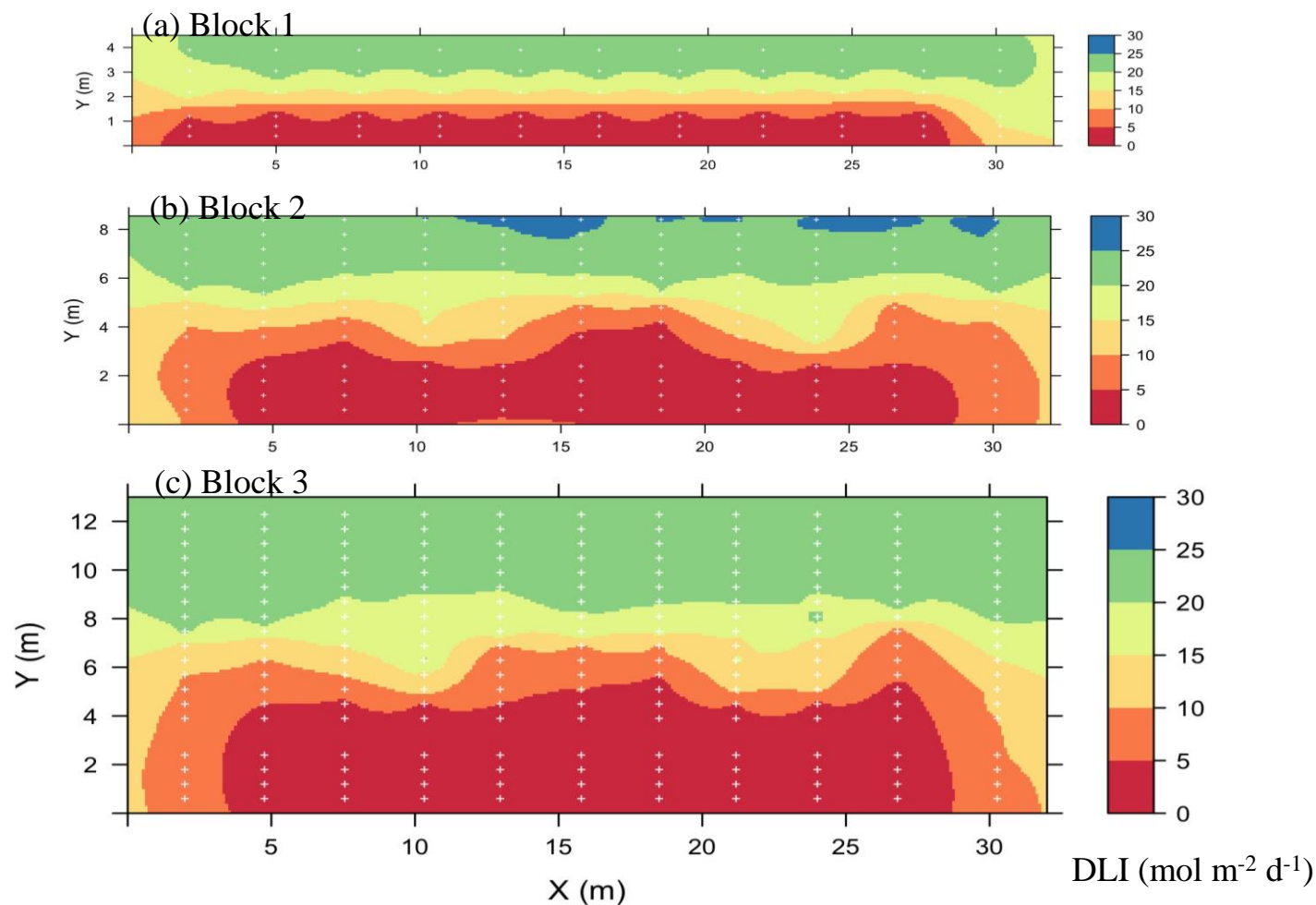
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Daily light integral in Agrivoltaic system



**DLI is integral of
photosynthetic
photon flux density
(PPFD) or
photosynthetically
active radiation
(PAR) for a day**

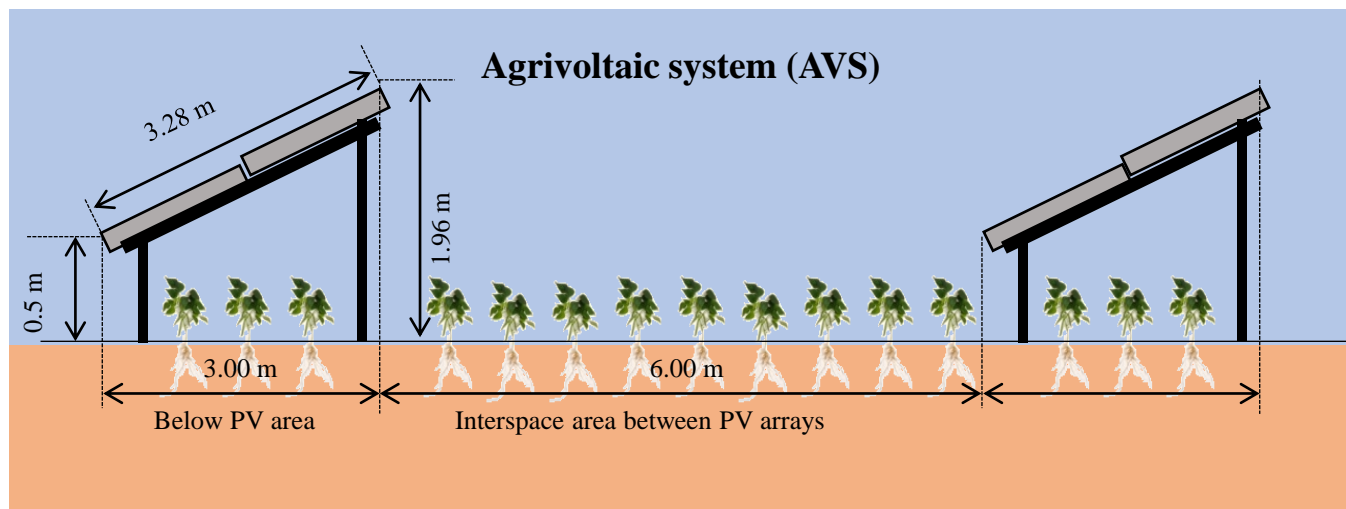


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Agrivoltaic system: Option to achieve LDN targets in drylands

(PV generation+agriculture+rainwater harvesting)



PV array design (double row)

Agrivoltaic system has the potential to improve all three global indicators of LDN

- Increases the surface cover
- Expected to improve SOC status
- Increases NPP of the land



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Economics of agrivoltaic system (double row model)

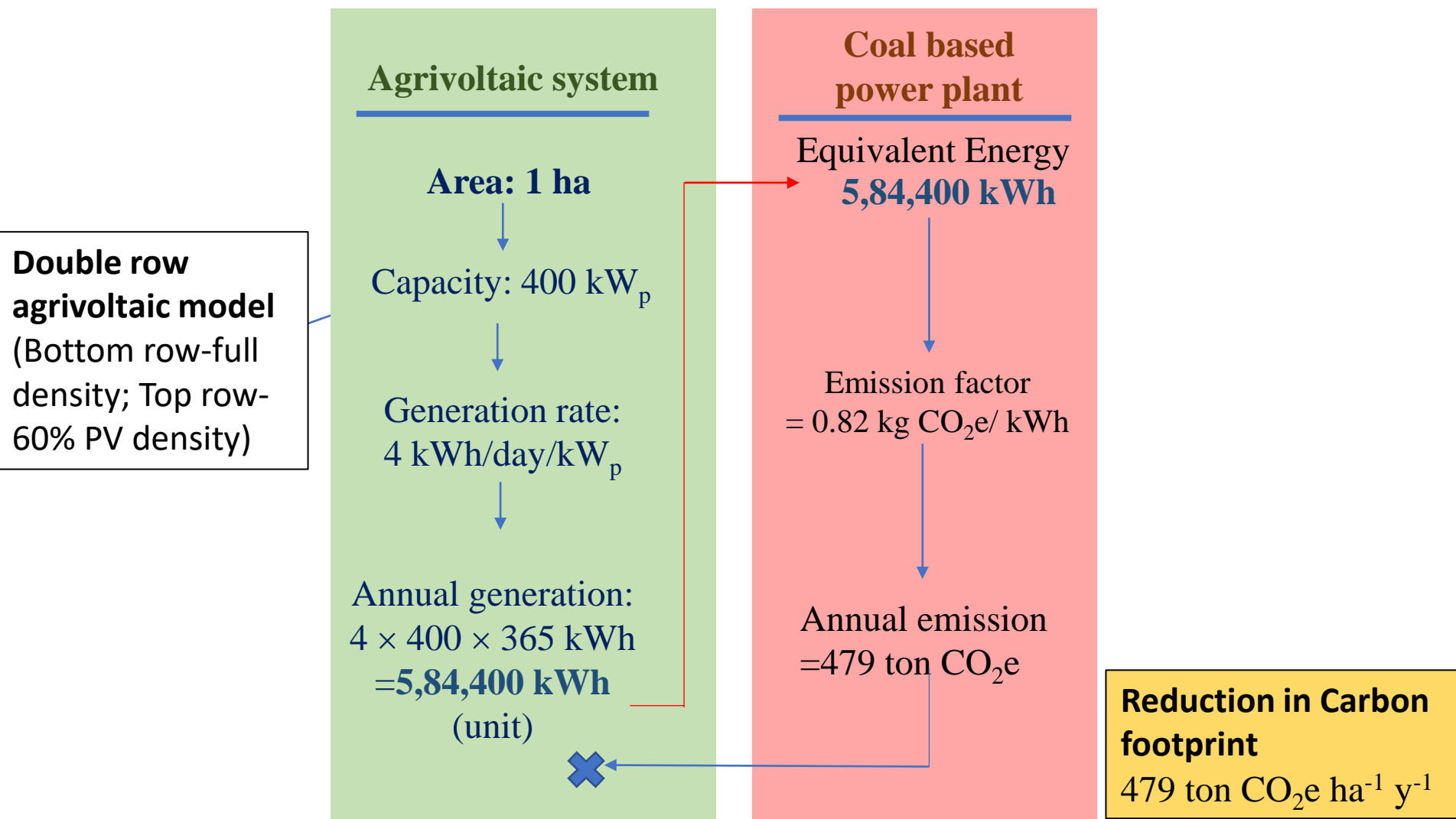
Sr. No.	Item	Value
1.	Area	1 ha
2.	Capacity (Double row model)	400 kW _p
3.	Life cycle	25 years
4.	Cash outflow for ground mounted PV system (Rs 42,000/kWp)	Rs 1,68,00,000/-
5.	Cash outflow for replacement cost of inverter (once in life cycle) (Rs 6/Watt of inverter)	Rs 30,00,000/-
6.	Cash outflow for repair and maintenance cost @0.1% of initial investment	Rs 16,800/-
7.	Cash outflow for crop cultivation (Moong bean during kharif and isabgol during rabi) (Rs/ha/y)	Rs 52,450/-
8.	Annual generation (@4 kWh/day/kWp with 1% decrease per year)	5,84,000 kWh
9.	Electricity sale price (Rs/kWh)	Rs 5.00/-
10.	Cash inflow from PV component (Rs/ha/y)	Rs 29,20,000/-
11.	Cash inflow from crop component (Moong bean and isabgool) (Rs/ha/y)	Rs 80,349/-
12.	Simple payback period	5.87 years
13.	Discounted payback period	10.40 years
14.	Internal rate of return	16%
15.	Net present value at a discount rate of 10%	Rs 70,15,128



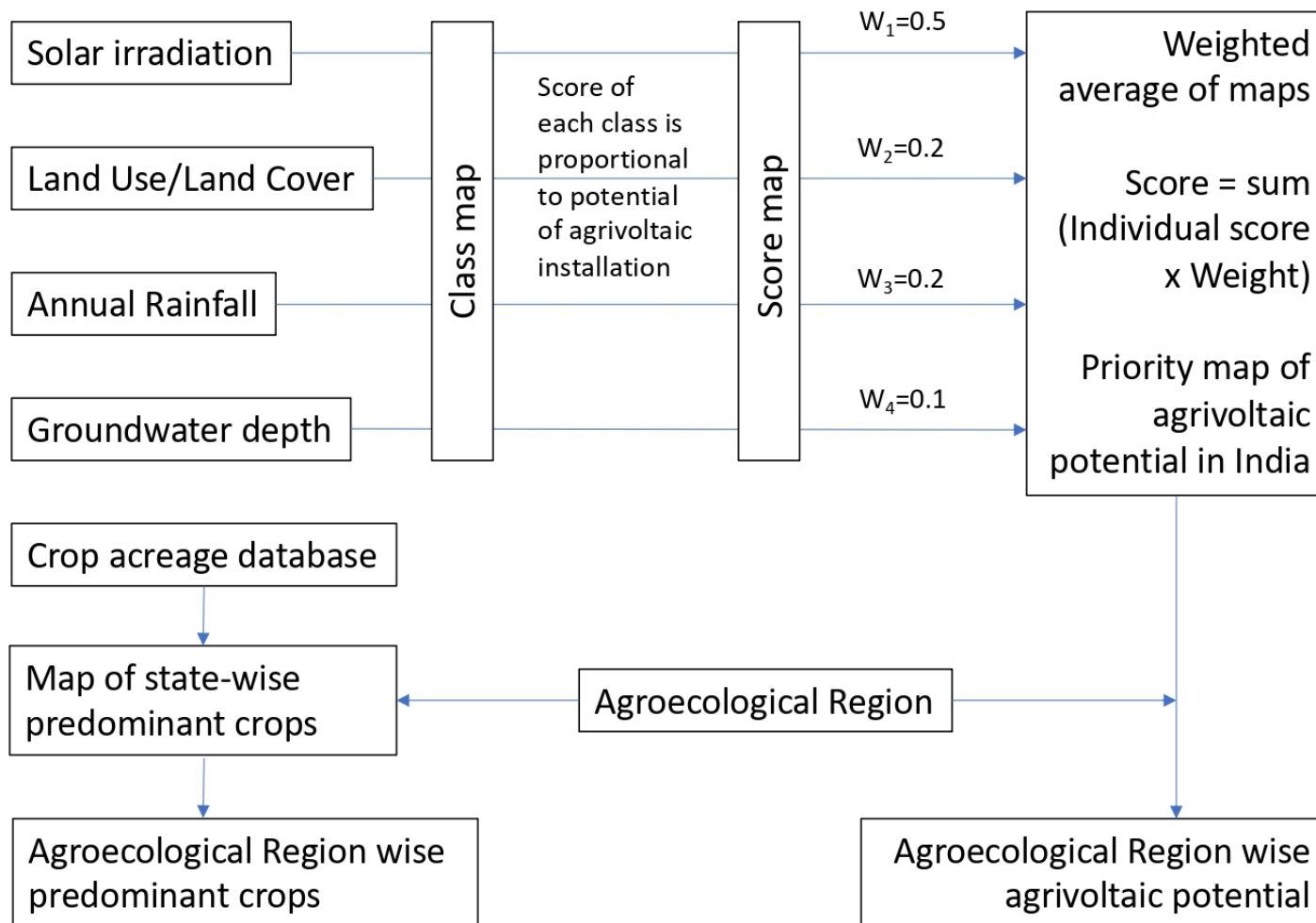
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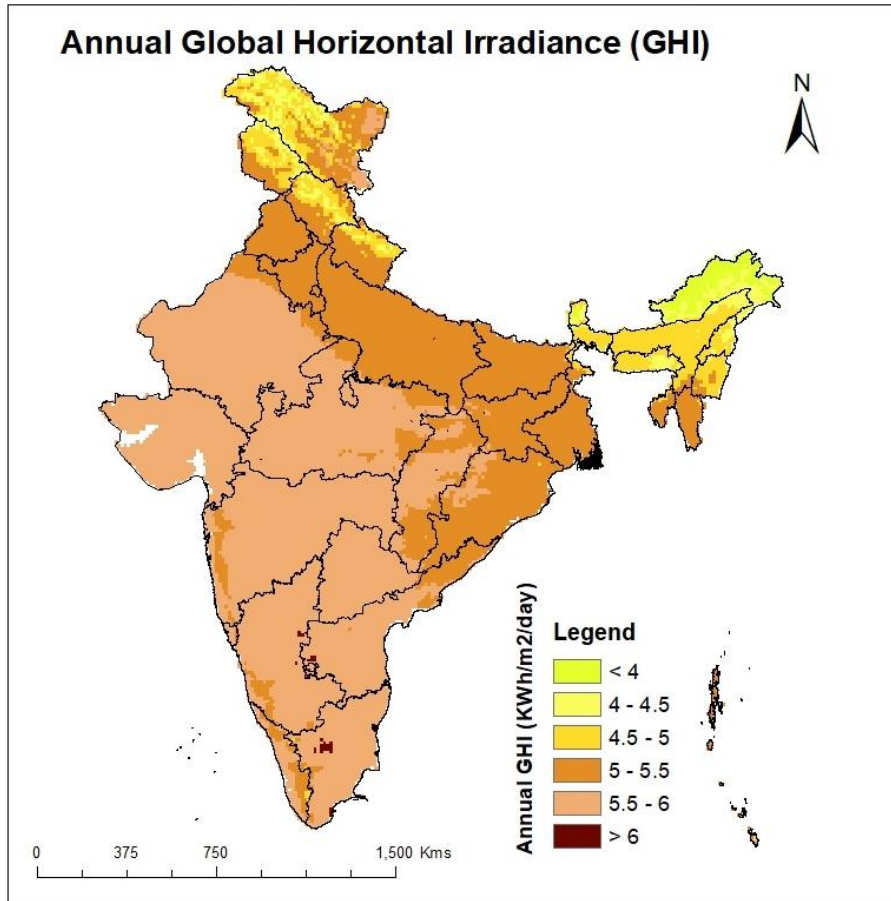
Green energy generation: Agrivoltaic system



Mapping agrivoltaic potential in India



Criteria Map-1: Global Horizontal Irradiance



Weight = 0.5

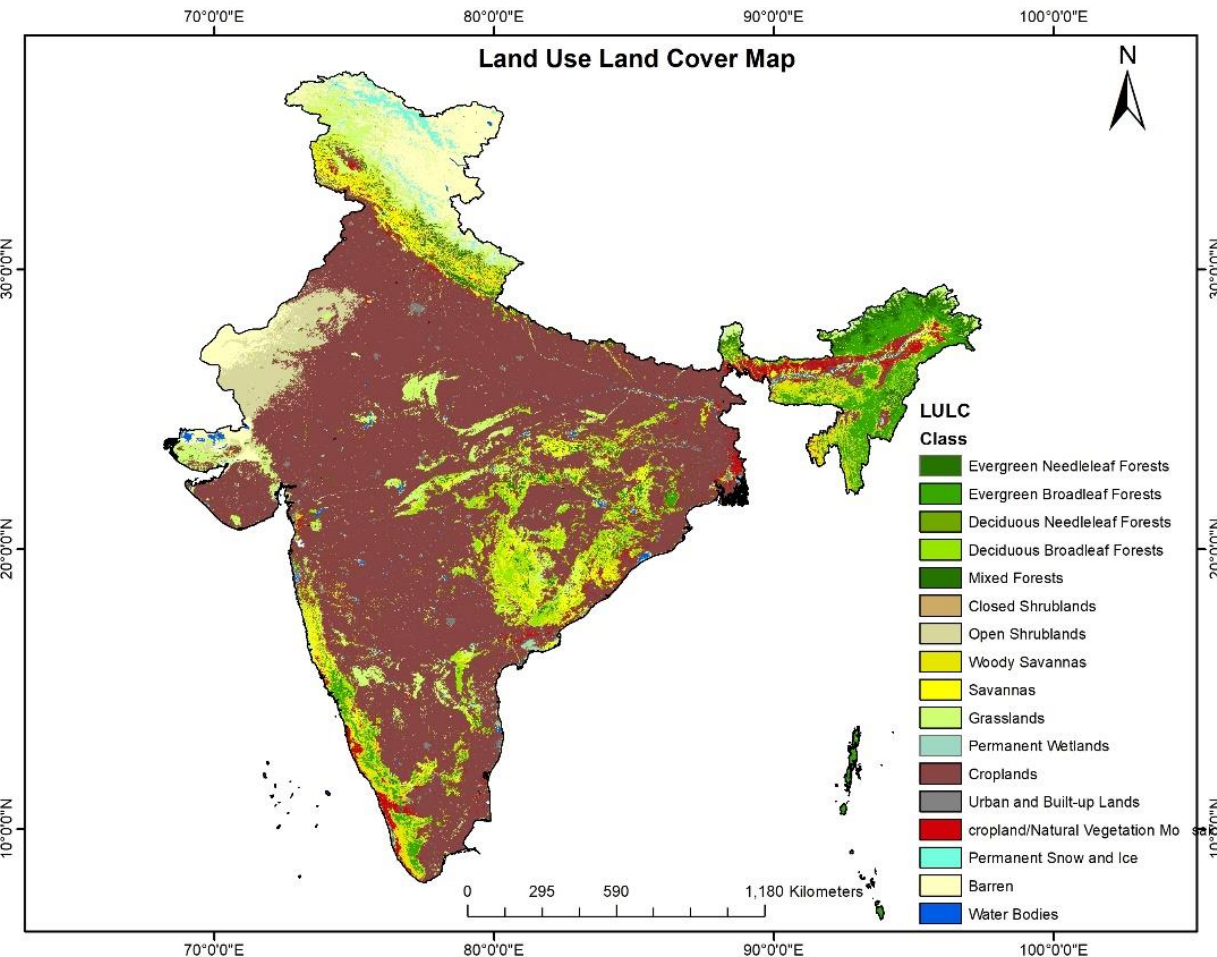
GHI	Score
2	2
4-4.5	4
4.5-5.0	6
5.0-5.5	8
>5.5	10



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Criteria Map-2: Land Use/Land Cover



Weight = 0.2

LULC	Score
Fallow land	10
Grassland	8
Barren land	6
Waste land	4
Cropland	2

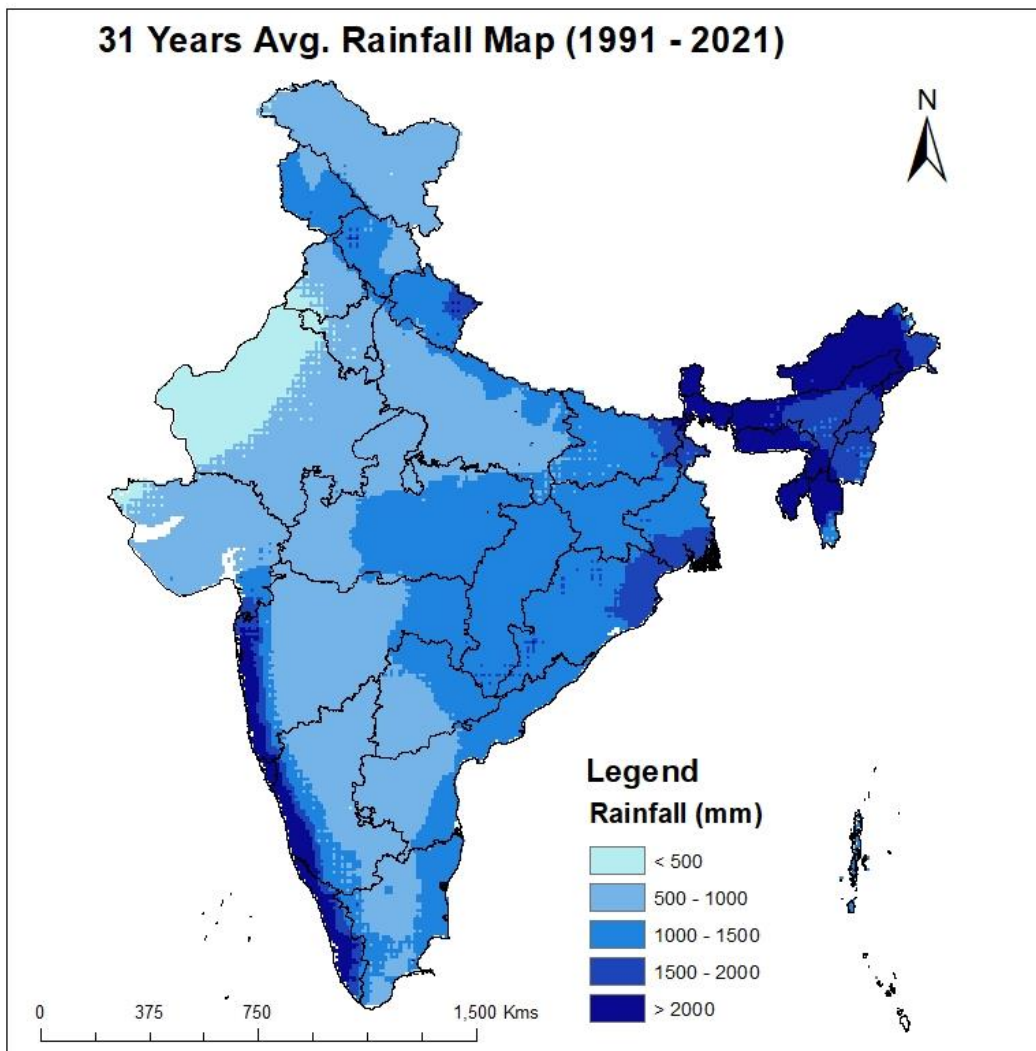


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Criteria Map-3: Annual Rainfall

31 Years Avg. Rainfall Map (1991 - 2021)

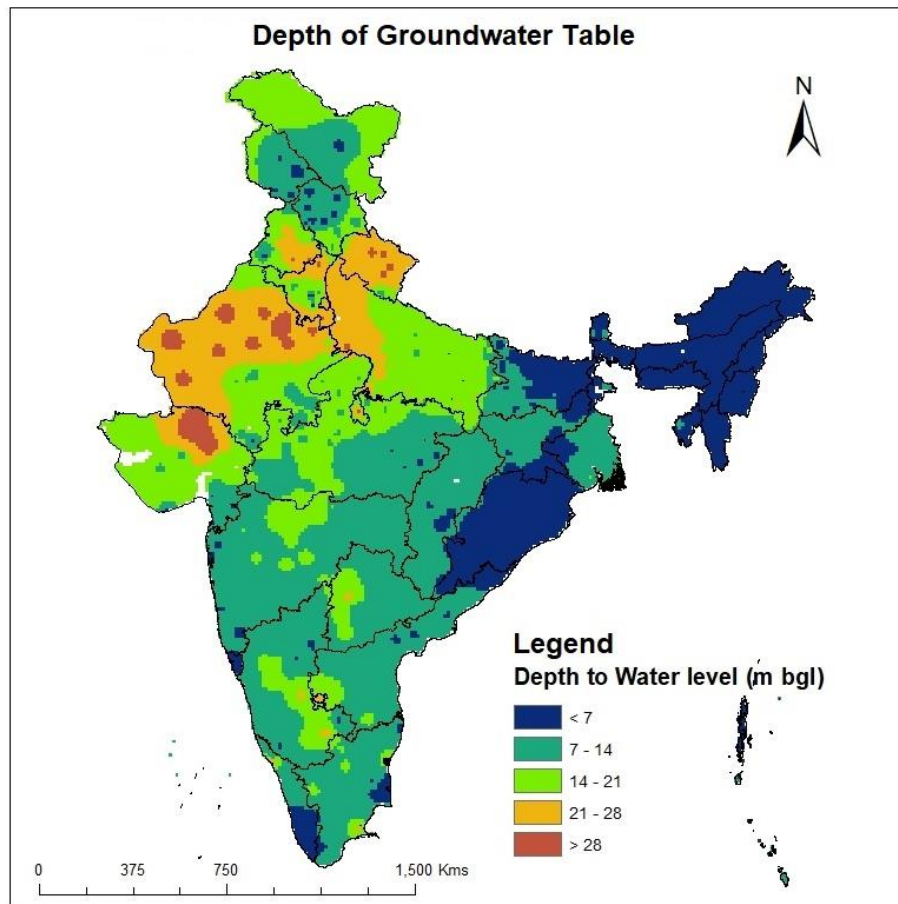


Weight = 0.2

Rainfall (mm)	Score
< 500	2
500 - 1000	4
1000 - 1500	6
1500 - 2000	8
> 2000	10



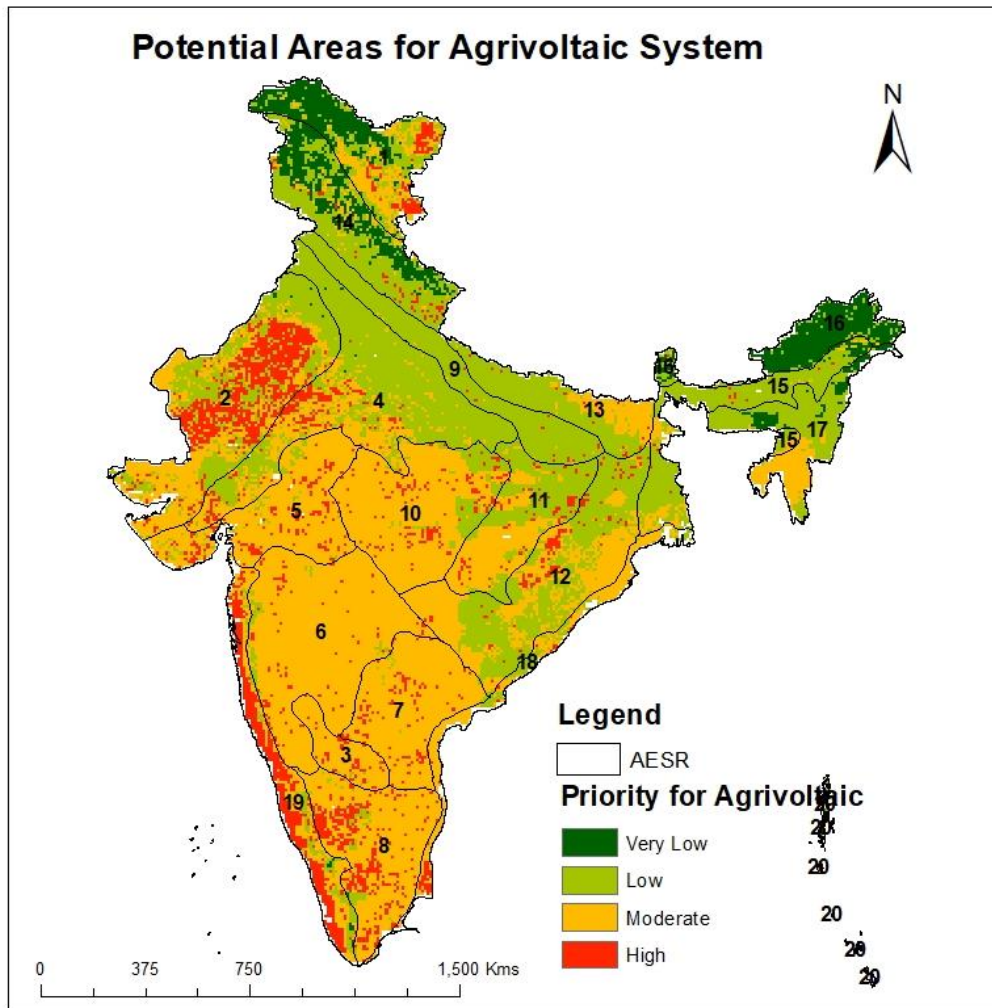
Criteria Map-4: Depth of groundwater table



Weight = 0.1

Groundwater depth bgl (m)	Score
<7	10
7-14	8
14-21	6
21-28	4
>28	2

Potential areas of agrivoltaic system



Priority	Area (Sq. Km)
Very Low	200342
Low	1084960
Moderate	1516780
High	271708



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Potential areas of agrivoltaic system-AER wise

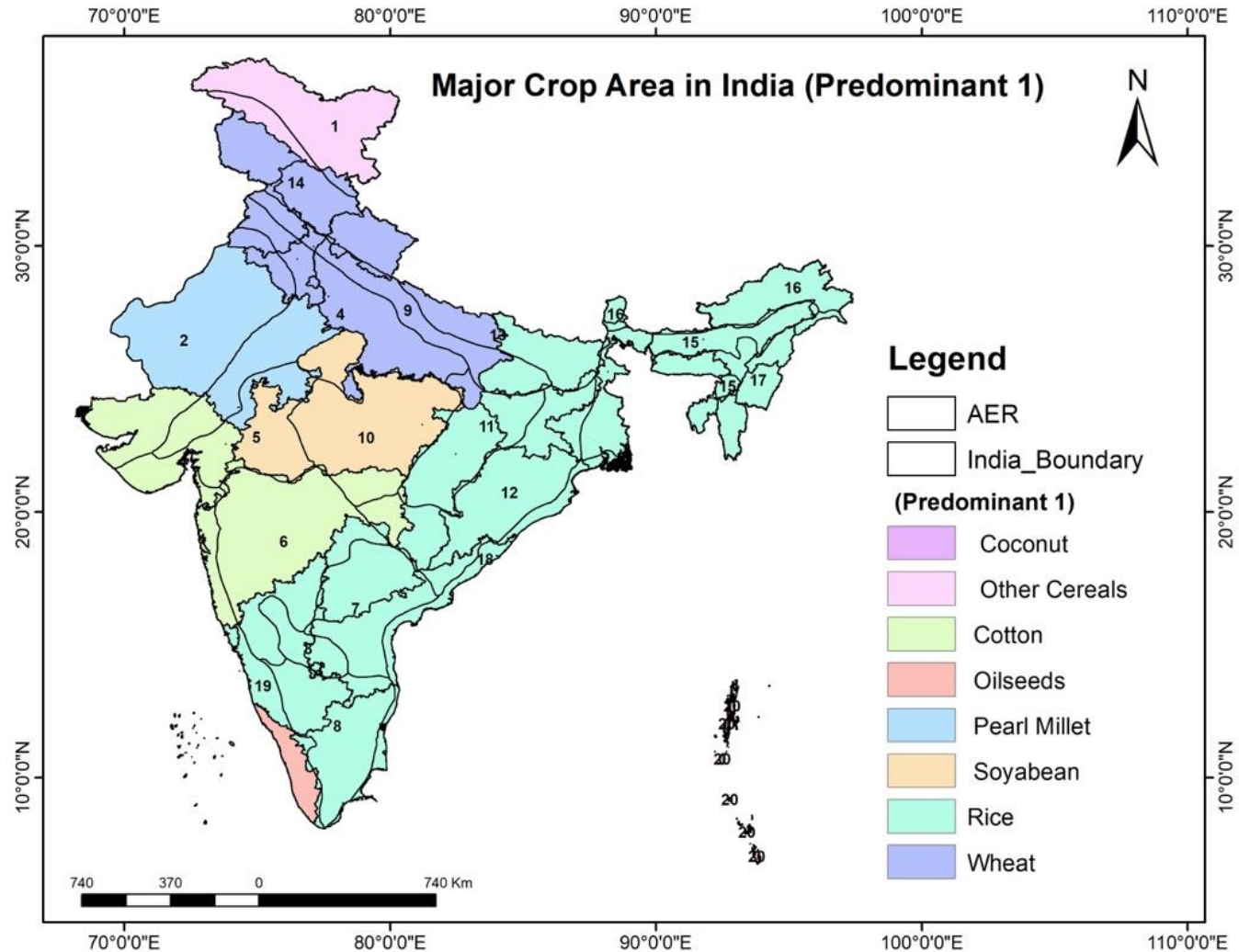
Agro-ecological Regions	Very Low	Low	Moderate	High	Grand Total (Million Hac.)
1. Western Himalayas (Cold Arid)	5.48	3.58	3.67	1.25	13.98
2. Western Plain, Kachchh, and part of Kathiawar Peninsula	0.05	10.93	10.17	8.50	29.65
3. Deccan Plateau	-	0.07	4.32	0.42	4.81
4. Northern Plain and Central Highlands including Aravallis	0.03	21.15	7.96	1.95	31.08
5. Central Malwa Highlands, Gujarat Plains, and Kathiawar Peninsula	-	0.85	14.49	1.28	16.63
6. Deccan Plateau, hot semi-arid ecoregion	-	0.65	28.38	0.73	29.76
7. Deccan (Telengana) Plateau and Eastern Ghats	-	0.16	15.18	0.79	16.14
8. Eastern Ghats, Tamil Nadu Plateau and Deccan (Karnataka)	0.03	0.74	14.33	3.13	18.22
9. Northern Plain, hot sub-humid (dry) ecoregion	-	11.46	0.07	0.09	11.62
10. Central Highlands (Malwas, Budelkhand, and Eastern Satpura)	-	2.82	18.42	1.09	22.32
11. Eastern Plateau (Chattisgarh), hot sub-humid ecoregion	-	6.90	6.31	0.63	13.84
12. Eastern (Chotanagpur) Plateau and Eastern Ghats	-	14.06	11.41	1.06	26.53
13. Eastern Plain	-	6.65	2.69	0.13	9.47
14. Western Himalayas (Warm Sub-humid to humid)	6.16	9.41	1.06	0.38	17.02
15. Bengal and Assam plains	0.60	8.94	1.45	0.10	11.09
16. Eastern Himalayas	6.29	0.89	0.05	0.01	7.24
17. North Eastern Hills (Purvanchal)	1.25	6.00	2.73	0.00	9.98
18. Eastern Coastal Plain	-	1.34	4.69	0.49	6.52
19. Western Ghats and Coastal Plain	0.11	1.47	3.98	5.06	10.61
20. Island of Andaman Nicobar and Lakshadweep	-	0.12	-	-	0.12
Grand Total (Million Hac.)	19.98	108.18	151.37	27.09	306.63



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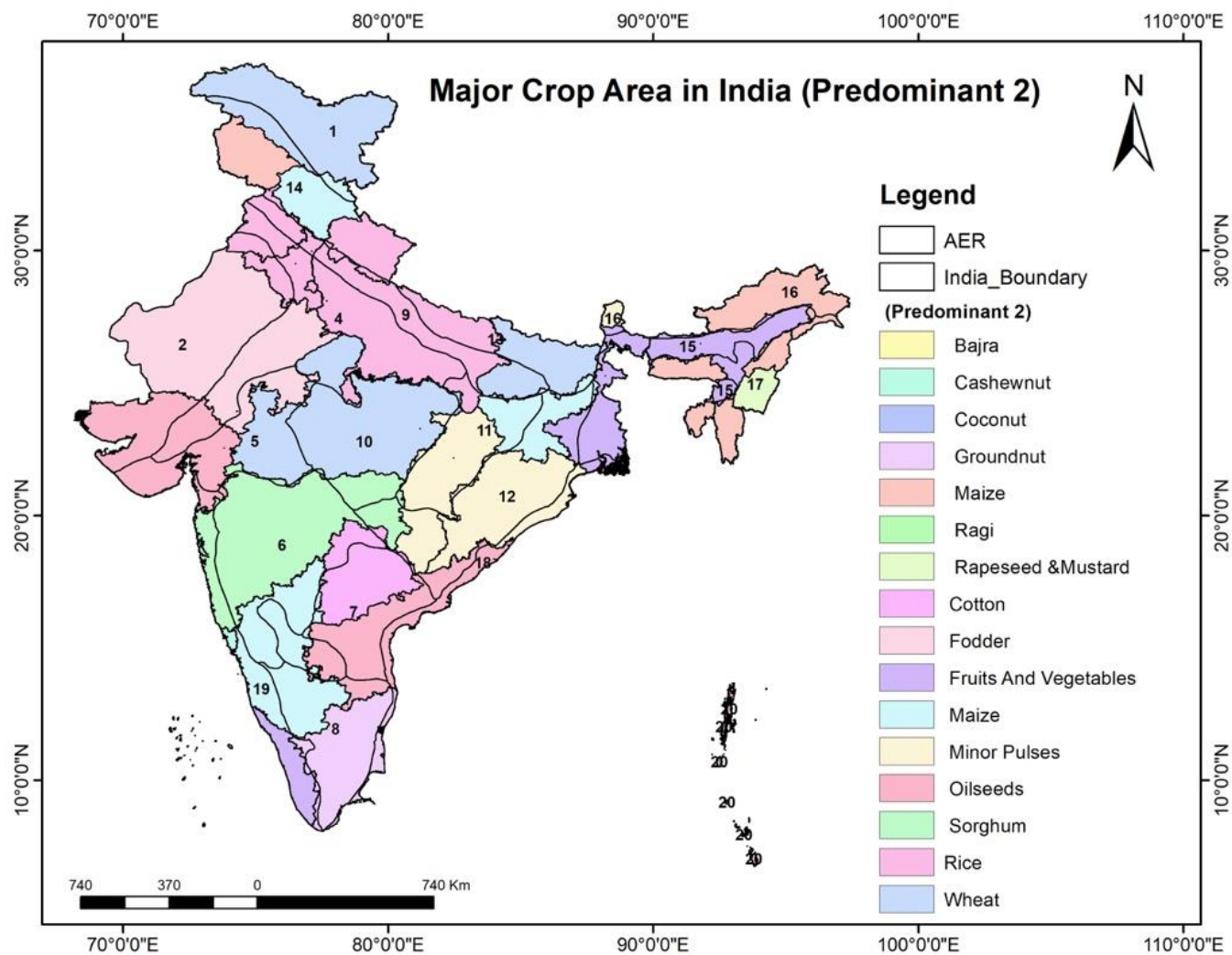


Predominant cropping map in India



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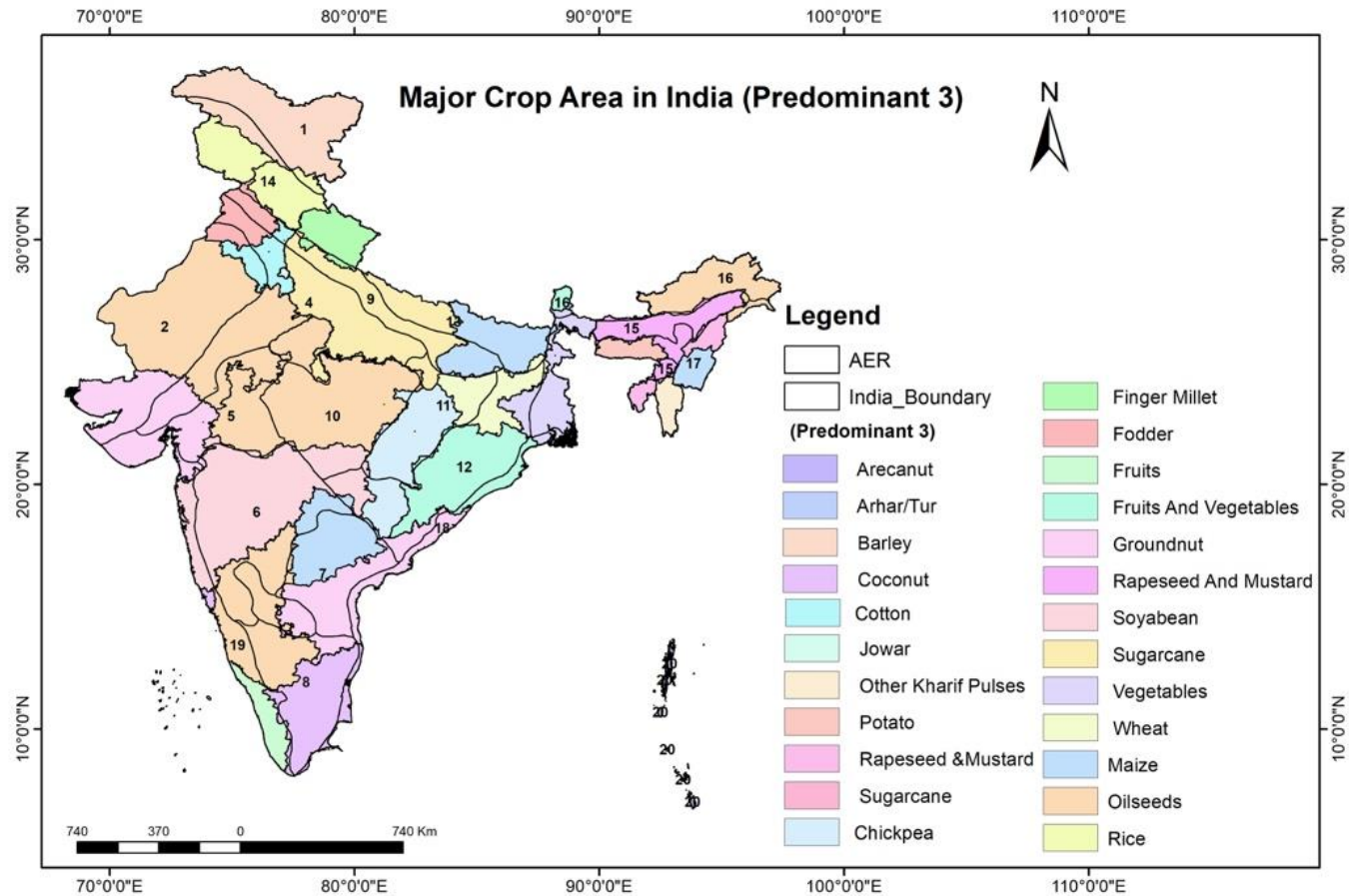
Predominant cropping map in India



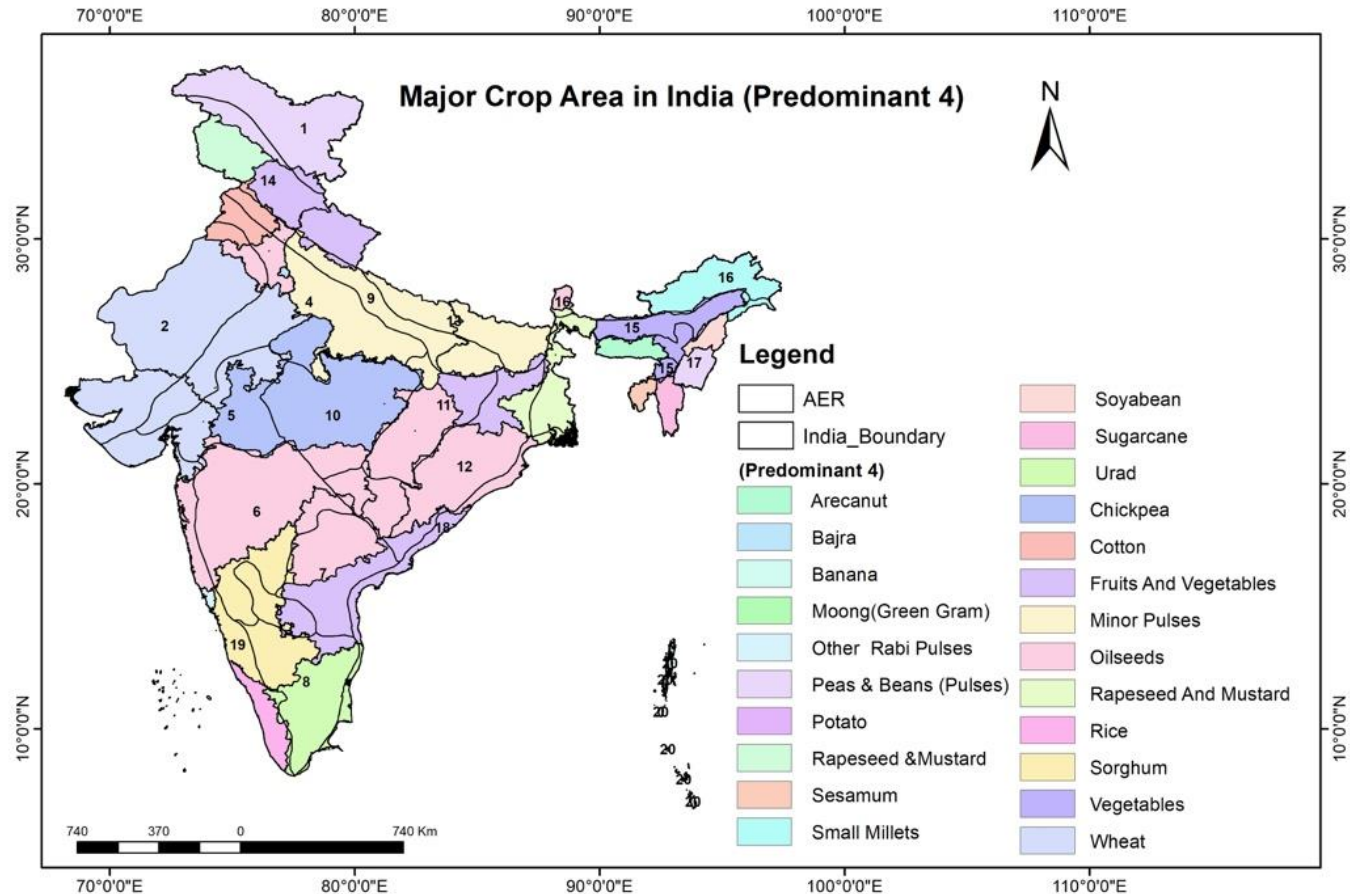
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Predominant cropping map in India



Predominant cropping map in India



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Benefits and drawbacks of Agrivoltaic system

Benefits of Agri-voltaic system

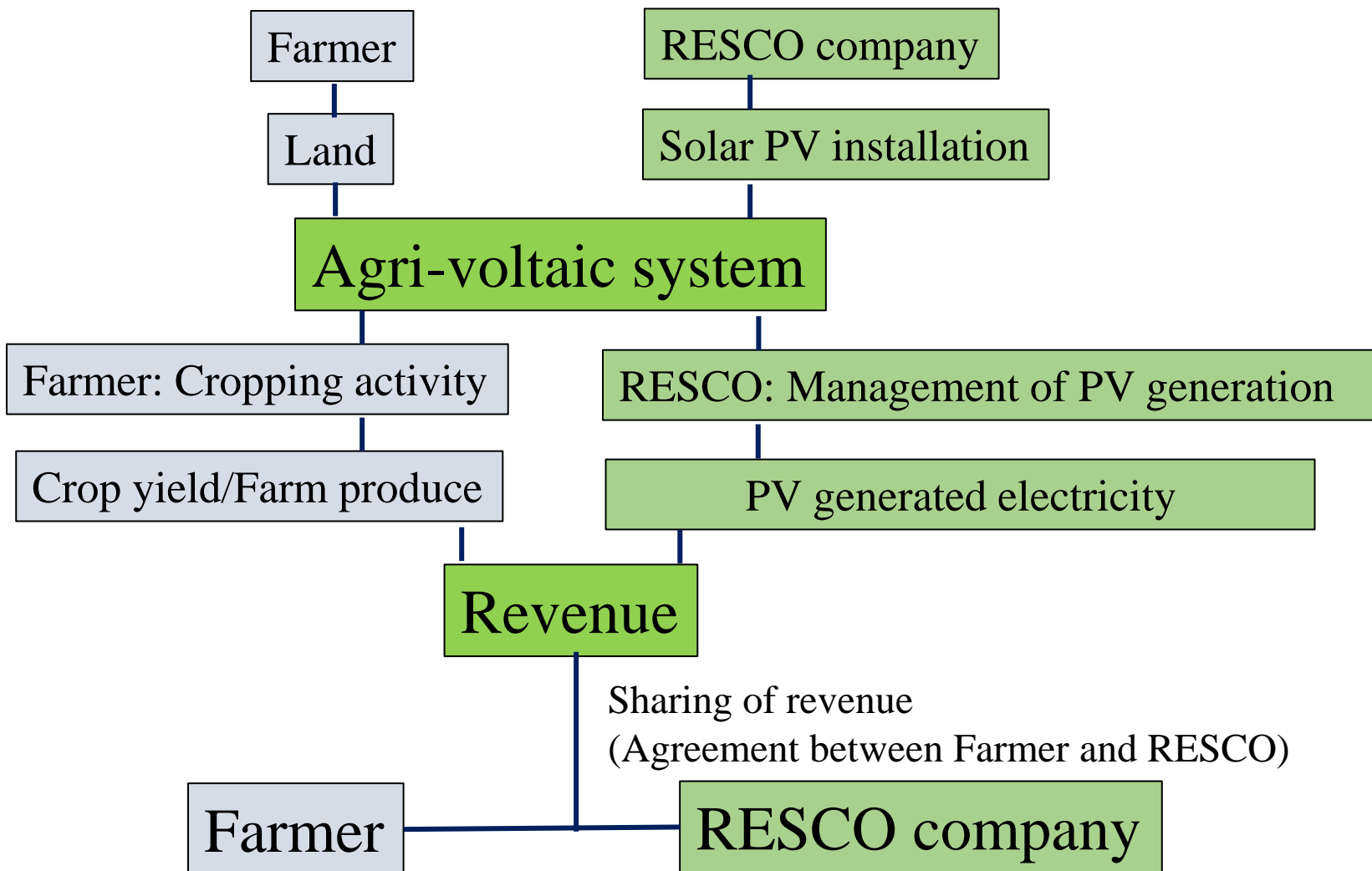
- Increased income from farm land
- Recycling of harvested rainwater for cleaning PV modules and irrigating crops (1.5 lakh litre per acre and can provide 40 mm irrigation in 1 acre land)
- Improvement in microclimate for crop cultivation and optimum PV generation
- Reduction in soil erosion by wind
- Reduction in dust load on PV panel
- Improvement in land equivalent ratio (LER ~1.41)
- Soil moisture conservation by reducing the wind speed on ground surface
- Reduction in GHG emission (598.6 tons of CO₂ savings/year/ha)

Few perceived drawbacks

- Safety of field workers engaged in agricultural activity
- Managerial complexity: additional load on plant manager for agricultural activity
- Ownership issue: Farmer and solar power plant functionary
- Sharing of benefits in case of joint venture
- High capital investment during initial establishment



Agrivoltaic system in Farmer's field-KUSUM scheme (option)



Future of agrivoltaics in India

Win-Win model

Farmers with large hand holding/
Farmers' cooperative/
FPOs

Farmers

Purchaser



Policy makers/
Finance sector

PV owner

RESCO/
Private PV power plant etc

Mandi/
Agro-
processing
Industry/
DISCOM/
Renewable
energy
departments

ICAR (CAZRI)
MNRE (NISE)
NSEFI
IGEF
GIZ
IWMI
CII
IFC, FAO
NABARD



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Possible Convergence of Govt policies

- **National mission of Sustainable Agriculture (NMSA)**
- **Pradhan Mantri Krishi Sinchai Yojana (PMKSY)**
- **Kisan Urja Suraksha Utthan evam Mahaabhiyann (KUSUM)**
- **National Solar Mission (NSM)**
- **National Initiative on Climate Resilient Agriculture (NICRA)**
- **Doubling farmers' income**
- **Sustainable development goals (SDGs)-Land degradation neutrality (LDN)**



Thank you

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