KEY WORDS:
Dhule Fridge, Ecological Landscape Planning, Energy Landscape, Land Degradation, Wind Farms

Wind Farm: Siting the New Energy Landscape in Dhule Fringe

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ABSTRACT

Globally wind power is the fastest growing sectors and holds highest potential among the top renewable energy sources. Wind farms are the most invested renewable energy sources and alternative energy supply to fossil fuels in terms of preventing climate change. There is lack of planning and strategic development guidelines leaving large part of wind farm site as unutilized resulting in land degradation and exploitation of resources. Such large-scale development activity and ignorance related other natural resources, aims only at tapping wind energy, affecting the ecological stability and landscape character. Thus, it is a collaborative work in planning for wind farms sites making the role of landscape architects valuable. This research study is intended to provide qualitative solutions for devising integrated ecological management and planning approach for on shore wind farm sites. The methodology applied is studying the current practices for wind farm sitting and operation along with comparative analysis of case studies and focused interviews with experts both in global and Indian context. The research is focused to analyze the existing condition of third largest Indian wind farm at Brahmanvel, Tal. Sakri, Dist. Dhule. This paper concludes that by ecological means one can achieve the sustainable way of siting the wind energy landscape.

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Introduction

Renewable energy sector has become an intrinsic source of energy production in many countries for securing sustainable energy with least emissions (Kale, 2017). Growing concern for environmental degradation and increasing dependence of fossil fuels the energy sector is shifting to renewable sources at global scale. While world energy demand continues to increase at an average annual rate of about 2%, most of that demand (around 80%) is being met by fossil fuels (IEA 2018), with the well-known negative impacts on the environment and climate. Solar radiations, winds, tides, geothermal energy, hydroelectricity are in no danger of long-term availability (A. Chel, 2011). Globally wind energy is one of the fastest growing sectors and holds the second largest potential after solar power among renewable energy sources (Renewable Energy Policy Network for 21st Century, 2019). Though renewable energy has been widely seen as a positive developmental approach of nation within the context of the climate crises, some conservationists fear that many wind farms are poorly sited and will produce long-term landscape-scale changes (Kaldellis, 2005).

Under the current energy policies that encourage low or zero greenhouse gas emissions, wind power has become one of the fastest growing energy sources. Top wind power producing countries in 2021 (**Figure 1**).India stands fourth globally in renewable energy installed capacity as well as wind power capacity. Wind power costs in India are decreasing rapidly. Wind power capacity is mainly spread across the Southern, Western, and North-western states of India (**Figure 2**). The total installed wind power capacity currently is 41.93 GW mainly spread across states of Tamil Nadu, Gujarat, Maharashtra, Karnataka, Rajasthan and others. Wind power accounts nearly 8.5% of India's total

Wind Farm Size	Nos.	Capacity	Distance c/c	
Small	1-3	Per turbine as per model	--	
Medium	3-20	120 KW	X-250m	Y-500
Large	20-50	300 MW to 500 MW	X-4Dm	Y-6D
Very Large	50+	500 MW and above	X-5D	Y-10D

***Table 1**: Wind farm size and capacity (NS Energy, 2020)*

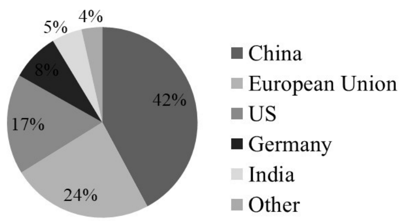


Figure 1 : *Global wind energy (Source: Portal, 2021)*

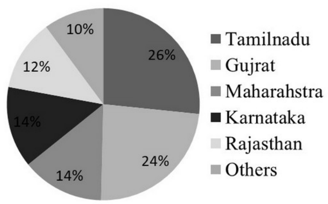


Figure 2: *National wind energy (Source: Energy, 2022)*

installed power generation capacity, and it generates 1.6% of the country's power (Ministry of New Energy and Renewable Energy, 2022). Wind farm (often called a wind park) is a cluster of wind turbines that acts and is connected to the power system as a single electricity producing power station (F. Ashby, 2016). Wind farms are areas where many large wind turbines have been grouped together. They “harvest” the power of the wind.

Environmental Degradation and Wind farm development

The Wind farm development is one of the key steps towards addressing the global climate change. This results in land-use change resulting from the loss of forests and pastures can lead to significant carbon emissions that cause the greenhouse effect. Therefore, it should be taken into consideration that besides many other negative effects (effects on human health, effects on the ecosystem, effects on animals, etc.), land cover changes caused by wind farms may indirectly cause important problems such as climate change (Pekkan, 2021).

Environmental degradation, in most of the developing countries, is becoming a major constraint on future growth and development. The impact is widespread and conspicuous in land-hungry agrarian economies like India. In several regions of India, especially the arid and semi-arid regions, environmental degradation is nearing irreversible levels even as replacement costs continue to rise. In the Indian context, the costs of environmental degradation were estimated at 4.5 per cent of the GDP in 1992 (TERI, 1998). Similarly, the soil types (black and red) appear to be more susceptible to degradation (Abrol, 1994). Agriculture extension in India poorly compares with other Asian countries like China. It is likely that the process of liberalization would dilute it further. Therefore, strengthening the extension network is very much needed in order to alleviate the problems of land degradation (Reddy, 2015).

Wind energy, together with other renewable energy sources, is expected to grow substantially in the coming decades and will play a key role in mitigating climate change and achieving energy sustainability (Porte-Agel, 2019). One of the main challenges in optimizing the design, operation, control, and grid integration of wind farms is the prediction of their performance, owing to the mitigation for land degradation, loss of biodiversity etc. To achieve a sustainable ecological planning of wind farm it is necessary to understand the concept of wind farm and siting criteria along with the challenges in the wind power generation. Further, to avoid the land degradation, the wind farm area shall be utilized with various applications and sustainable and productive activities. Hence it is important to analyze the intended development of sustainable energy landscape by comparing global and Indian case studies based on various parameters and strategies. Further, rating the case studies based on various aspects of the project gives the framework for the research study. The investigation through focused interviews reveals challenges faced by experts. All these collective key findings lead to the applicability of these strategies in Dhule fringe context. This will be an opportunity to catch/harness renewable energy from site while creating interesting spaces which will benefit citizens.

Landscape and wind energy

The landscape is a powerful, diverse and dynamic cultural resource for mankind. In many ways it is as much part of our culture as literature, art and language. In these multi-disciplinary and trans disciplinary research can reveal the power of landscape to assist in managing inherited landscapes, and in planning and designing “sustainable landscape” (Blaschke, 2013).

Wind turbines can be prominent landscape features, with some standing tall over 50 m or above and remaining visible from far away. Blooming of wind energy is widely accepted as having a vital impact on landscape affecting sensory experiences, perceptions and sense of place. In comparison between wind farm developments, it is intended that wind turbines were seen as disciplined as and less disruptive than other industrial or infrastructure constructions. Now the question would be what are the criteria for siting the onshore wind farms? What kind of practices are required for implementation of wind farms? What practical solutions are available for challenges in policy and management regarding wind farms? These questions are in essence core of this research study.

The scope of study points to the possibility of conjunctive land use; lack of planning and strategic development guidelines leaves large parts of the wind farm sites unutilized resulting in land degradation and exploitation of resources. Such large-scale development activity and ignorance related to other natural resources, aims only at tapping wind energy, affecting the ecological stability and landscape character.

More wind farms will be needed to meet renewable energy targets and the challenge is to make sure these are sited and designed well in landscapes without ignoring natural resources. Varied combinations for installation of different size, model, and color of wind turbine can add a visual-element into the energy landscape. This approach can be taken as a sustainable adaptation to remote waste land. Renewable energy generation systems can be integrated into the landscape while enhancing the surrounding environment. Thus, it is the collaborative work in planning for wind farms sites hence the role of landscape architects is important.

Wind Power Plant	Megawatt (MW)	Location
Muppandal Wind Farm	1500	Tamil Nadu, Kanyakumari
Jaisalmer wind Park	1064	Rajasthan, Jaisalmer
Brahmanvel Wind Farm	528	Maharashtra, Dhule
Dhalgaon Wind Farm	278	Maharashtra, Sangali
Venkusawade Wind Farm	269	Maharashtra, Satara District
Vaspel Wind Farm	114	Maharashtra, Vaspet
Tuljapur Wind Farm	126	Maharashtra, Osmanabad
Beluguppa Wind Park	100.8	Beluguppa, Andhra Pradesh
Mamatkheda Wind Park	100.5	Madhya Pradesh, Mamatkheda
Anantapur wind Park	100	Andhra Pradesh, Nimbagallu

Table 2: *Largest wind farm projects in India (Source: NS Energy, 2020)*

"Renewable energy Park": A blue print for locally produced clean energy

This renewable infrastructure can serve as smart and sustainable asset for areas with surplus industrial property. Renewable Energy Park has not only provided a source of reliable, locally produced clean energy but also have contributed to eco-tourism with a new type of energy tourism. It has also served as an educational resource to local school, universities and business groups. In past, energy sites have been one dimensional with coal or gas plant producing electricity whereas energy parks today can incorporate an assortment of technologies and purposes. For instance solar, wind, biomass, geothermal, nuclear, clean fossil or hydrogen generation (Harmes, 2013).

This study is about onshore wind farm development only. This does not cover the offshore wind farms. Brahmanvel Wind farm located in Dhule; Maharashtra is studied for the purpose of this research with the identified parameters. The popular model of horizontal axis three bladed wind turbines have been considered. The study does not highlight any kind of socio-economic impacts of wind energy.

Site Context and Location

Dhule is a city located in the Dhule District in the North-Western part of Maharashtra state, India known as West Khandesh. Brahmanvel Wind Farm was initially started with 40MW as onshore wind power project in 2016 and currently 528 MW energy is being generated. It is located in Sakri taluka of Dhule district. It has been developed in multiple phases. Bramhanwel is established in 2005-2006. Post completion of construction, the project got commissioned in August 2007 (Power plant profile: Dhule Wind Farm, 2023).

Built as per EIA Guidelines (2013) for wind power developed by Center for Science and Environment, New Delhi; Brahmanwel wind farm is a project which has undergone Environmental Impact Assessment. Most the previous wind projects in India have not been accessed similarly. This gave it an added benefit of receiving funding from an international development finance institution like the Asian Development Bank (ADB) or the World Bank.

Research Methodology

Methodology chart

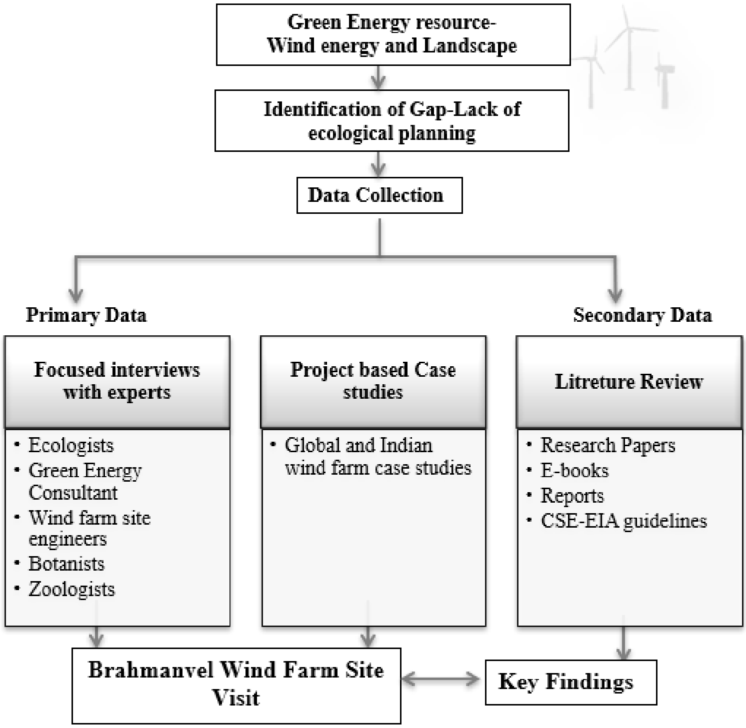


Figure 3: *Methodology chart adopted for the research (Source: Author)*

Dhule Fringe: Site Context of Brahmanvel Wind Farm

Site Study at Wind Farm: The 3rd largest farm is sited with total capacity of 528 MW. It is located in Brahmanwel. The project has got an EIA/EMP report done because the project was funded by Asian Development Bank (Source: EIA-Guideline 2013). Since the site is located on Deccan plateau which is a semi arid region having a black cotton soil type highly prone to land degradation.

Brahmanwel Potential:

Mean annual speed 6.42 M/S.
The site does not lie in the vicinity of any eco-sensitive areas.
Mean annual wind power density 278 w/m to 324 w/m.
The land topography is undulating which is most ideal for siting of wind farms.

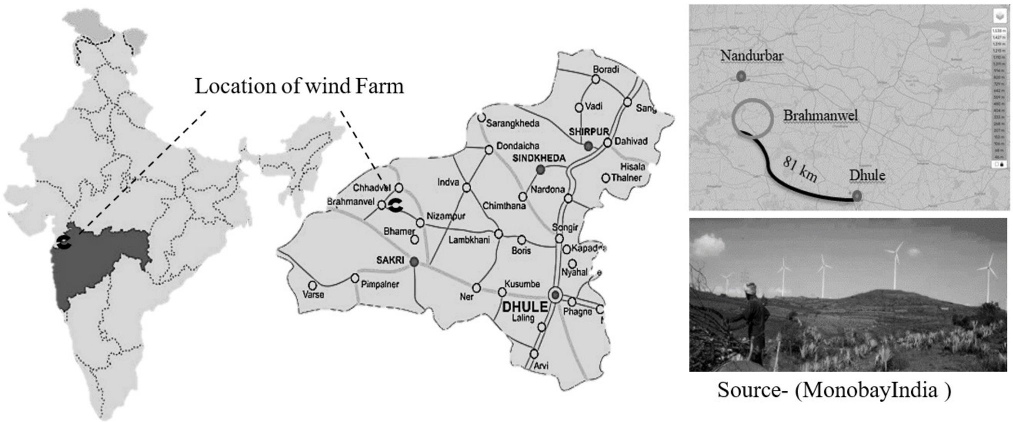


Figure 4: *Location of Bhrahmanvel wind Farm, Taluka-Sakri, District-Dhule*

Figure 5: *Site Topography and current site conditions of wind farm (Source: Author)*

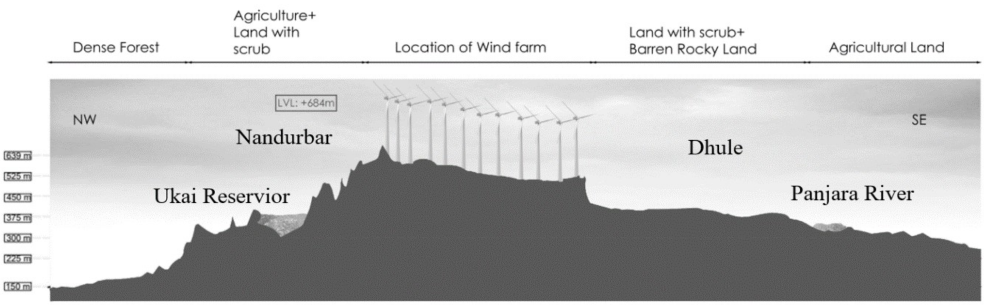


Figure 6: *Section showing location of Brahmanvel wind farm (Source-Author)*

Project Based Case Studies

Several case studies with similar parameters were identified at global and national level considering developing countries similar to India having following criteria:

- Tropical countries similar to India
- Developing countries to understand various challenges.
- Topography
- Ecological values

	Parameters	Global Context	Indian Context
A)	Wind farm planned with for productive purpose	Wind Stalks, Abu Dhabi	Bhīma Shankar wind power project
B)	On the periphery of city	Whittle wind farms, Scotland	Muppandal Wind Farm, Kanyakumari district, Tamil Nadu
C)	Sited within the city	Lamma Winds, Hongkong	Jaisalmer Wind Park, Rajasthan
D)	Community Wind farm	Kansas Community Wind Farms	Odanthurai village near Coimbatore
E)	Theme Park for recreational purpose	Qurrent, the Dutch-Energy Theme Park	Energy Park, Raipur, Chhattisgarh

Table 3: *Identifying Global and Indian case studies (Source: Author)*

Focused Interview with Experts

Interviews were carried out with experts such as ecologists, green energy researchers, and wind farm engineers. The questionnaire focused on various parameters like identifying important factors for siting and selection criteria for wind farms, ecology, fauna, grid connectivity, road network, land degradation, decentralization, maintenance and recommended re-utilization of wind farm.

	Wind Energy Expert	Green Energy expert	Ecologists
Important Factor	Global wind pattern	Wind velocity and power density	Combination of wind pattern and local available resources
Siting & Selection criteria	Easy for transportation, therefore flat is accessible.	Wind power/air density important factor in case of high hilly regions.	Easy for transportation, therefore flat is accessible.

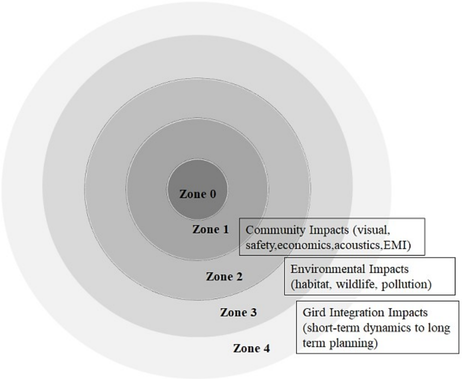
	100kms away from community habitats, GPS system for siting turbines		
Ecology		Avoid in vicinity of Eco-sensitive zones ecologically restore and reducing footfall/ intervention	Avoid in vicinity of Eco-sensitive zones
Fauna	Avifauna fatalities negligible	Avifauna fatalities negligible	May lie in the migratory path ways of fauna.
Grid connectivity	overhead connected to MSEB substation	with existing National Grid network	With existing Grid network
Road Network	For maintenance of wind turbines	For maintenance of wind turbines	Reducing footprints with the ecology
Land degradation	NA land converted into industrial land.		Soil erosion control Land restoration after installation is mandatory
Decentralization	No long-distance transmission	Decentralization provides stable grid and better energy output	Good In production is ecologically benefited
Maintenance	Half yearly and yearly pattern-to check all components, greasing, oiling.		No littering of oils and grease, leading to soil pollution
Recommended Re-utilization of land	Continuation with agricultural activities is the best suited.	Continuation with agricultural activities is the best suited.	Can propose Agriculture, tourism, research, restoration, educational purpose kind of activities.

Table 4: *Focused interviews with experts*

Data analysis

Siting of wind Farm

Ecological approach in siting of wind farms suggest that they should be sited 10kms away from ecologically sensitive areas like wetlands, forest reserves, and migratory paths of wildlife. Bipolar opinion should be taken for visual and noise impact. Bipolar opinion should also be taken for vegetation and agricultural production, but no scientific evidence has been proved yet for such a action. Installation of axillary structure causes negative impacts on land.



Zone 0	0	Siting of wind farm
Zone 1	2 km	Noise level (high decibels)
Zone 2	0.5 km	Losses and stress for long period
Zone 3	10 km	Eco sensitive zone
Zone 4	Beyond 10 km	To be Connected with National Grid

Figure 7: *Ecological Approach in siting wind farms (Source:Author)*

Parameters	Positive Impacts	Negative Impacts
Land	Very less generation of solid waste adding to land degradation	May degrade the land if not carefully planned
Water		The ground water may get disturb if the foundation is in path of the aquifer
Vegetation	Remaining land can be used for plantation.	Negligible or no impact
Air Pollution	No pollution produced.	
Biodiversity	Woodland planting can sometimes be used to screen infrastructure, whilst contributing to biodiversity and woodland enhancement objectives.	Fragmentation and habitat loss, An increasing risk of collision and habitat loss of flying fauna (especially birds and bats)
Energy and Environment	Replace fossil fuels with wind energy	
Socio-economic (Rural /Urban)	Social acceptance increases with increased distance from urban areas and places of interest. Maintaining rural cohesion, including tourism Provides Financial support	
Installation of wind turbines		Impact decreases on residential well-being after the construction of wind turbines over a period of five years

Table 5: *Impact of wind farm on various landscape design parameters (Source: Author)*

Proposed process for siting of wind farm as an energy landscape

Sustainable development is critically linked with land degradation, especially in agrarian economies like India. Judicious management of all these components is vital for achieving overall sustainable development. As far as land degradation is concerned, population pressure does not seem to exert any undue pressure. Interestingly the major interventions in all the problem regions relate to water and land management.

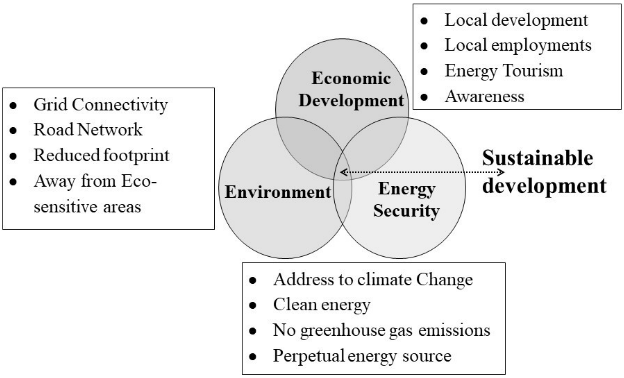


Figure 8: *Proposed Process for sitting of wind farm as an energy landscape (Source-Author)*

Comparative Case studies analysis of wind farm sites:

Global Wind Farm Case studies	Wind Stalks, Abu Dhabi	Whittle wind Farms, Scotland	Lamma winds, Hongkong	Kansas Community wind	From wind farm to theme park, Qurrent, Netherland
Type	Tourism	Futuristic Landscape	Awareness	Community	Recreational (8,000sq.m.)
Purpose	F, E, R	F, E, R	F, E	F	F, E, R
Topography	Undulating	Flat	Hilly land	Undulating	Flat
Capacity	117MW	539 MW	800 KW	112 MW	120 MW

Context and siting	Outskirts	Within the city	Periphery of city	Rural peripheral area	In the outskirts of the community area
Surrounding area land use	Entrances, wind turbines, exploration trails	Entire area	Rural community usage	Agricultural land and partial residential	Recreational and roller coaster rides
Circulation	Defined movement-walking, cycling, horse riding	Movement in random manner	Pedestrian friendly	As per orientation of community residences	A previous wind farm into a sustainable theme park.
Visual quality	Environmental leads to aesthetic appearance.	Green cover	Dominant focal point	Dominant focal point	Specially designed wind turbines with roller coaster rides
Passive and active activities	Trail, treks, walking	Trails, educational, recreational etc.	Since its an island Well known as tourist destination	Agricultural land and residential activities. Grind grains, pump water and generate electricity.	Beaufort buster, a water slide with a spiral slide
Biodiversity		Local fauna is well protected	AVI-fauna is well protected	Varied reptiles species are observed	Proper management for local fauna
Environmental Impact	Not sited within biodiversity area	Well management of wind farm and resources	Well management of wind farm and resources	Mitigation policies applied	Well management of wind farm and resources
Landscape Approach	Green cover, minimum intervened retaining natural look	Awareness through recreation	Dominant focal point	Development by design approach to landscape scale	World’s 1st wind farm converted into a sustainable theme park.

Table 6*: Case study Analysis for Global Context. F-Functional, E-Economical, R-Recreational (Source-Author)*

Indian Wind Farm Case studies	**Muppandal Wind Farm, Kanyakumari district, Tamil Nadu**	**Jaisalmer Wind Park, Rajasthan**	**Odanthurai village near Coimbatore**	**Energy Park, Raipur, Chhattisgarh**	**Bhima Shankar wind Power Project**
Type	Commercial	Commercial	Energy production for the whole village energy demands	Tourism, Community leisure	Commercial
Purpose	F, E	F, E	F, E	F, E, R	F, E
Topography	Undulating	Flat	Hilly Land	Flat	Hilly areas of western ghats
Capacity	1500 MW	1064 MW	350 KW	112 MW	75 MW
Context and siting	Around the settlement	In vicinity to Jaisalmer fort	Periphery of city	8km from the main city area	3.5 km from forest area (Eco sensitive zone)
Surrounding land use purpose	Mixed	Entire area	Residential, Farm lands and allied activities	Agricultural land and partial recreational area	Forest zone utilized for commercial energy production
Circulation	Movement in random manner	Movement in random manner	Pedestrian friendly	As per orientation of natural sources-sun, wind	Random
Visual quality	Environmental leads to aesthetic appearance	Green cover due presence of vegetation	Dominant focal points	Boasts lush greenery, colorful flowers, playful fountains and waterfalls	Disturbing the natural forest instincts
Passive and active Activities	Trails, treks, walking	Trails, educational, recreational activities	Agricultural, daily livelihood activities for residential and commercial activities	Indoor and outdoor exhibits, working models, interactive games along with solar-powered toy cars for toddlers.	Wild life habitat and forest tribes' community
Biodiversity		Great Indian Bustards is a	well managed and yielding	Pollination manageme	• Skekaro(squirrel) is a

		threatened species due to confined resources within the area	agricultural production bananas, coconut, mustard etc	nt is in practised	threatened species • Loss of wild life and agro diversity
Environmental impact	• Well-developed grid infrastructure • Degradation in surface and ground water resources,	• Land-Deforestation and waste overflow, soil erosion • Vegetation-Loss of vegetation cover • Water-surface water pollution/decreasing water (physical-chemical, biological quality)	• well management of wind energy along with biomass energy achieving the energy demands of whole village		• Land-Deforestation and waste overflow, soil erosion • Vegetation-Loss of vegetation cover • Water-Ground water pollution/decreasing water (physical-chemical, biological quality)
Socio-economic impacts		• About 2 kilometers from the main town, bear the high decibel levels of the noise • stress over a long period, locals	• community participation • well management if green energy along with surplus energy sold to surrounding 14 villages generating economic benefits		• Visible loss of livelihood, • Loss of traditional knowledge/practices/cultures, land dispossession etc.
Landscape Approach	• Green cover, minimum intervened retaining natural look	• distraction in heritage skyline by placing it in vicinity to heritage structures • Sited in bio diversity rich zone of great Indian Bustard. Which endangered the state bird of Rajasthan • Since it has completed its LCA tenure, re-powering it must consider the underground electric cables	Generates a surplus energy along with economic benefits to community	• Generate awareness about sources of renewable energy	• Substantial Forest destruction and triggered large scale soil erosion. • Disturbed ecology/wild life zone • Environmental impacts-biodiversity loss, deforestation, soil erosion etc.

Table 7*: Case study Analysis for Indian Context. F-Functional, E-Economical, R-Recreational (Source-Author)*

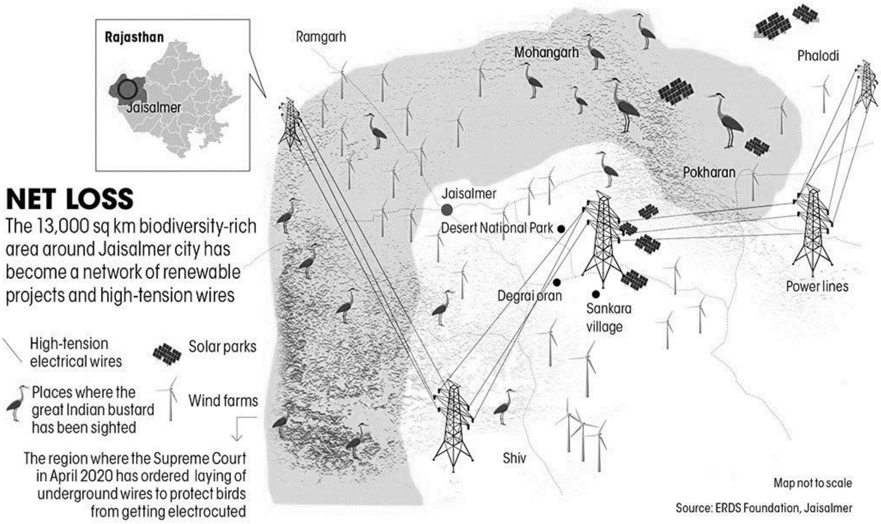


Figure 9. *Great Indian Bustard loss due to high tension transmission lines in Jaisalmer (ERDS Foundation 2022)*

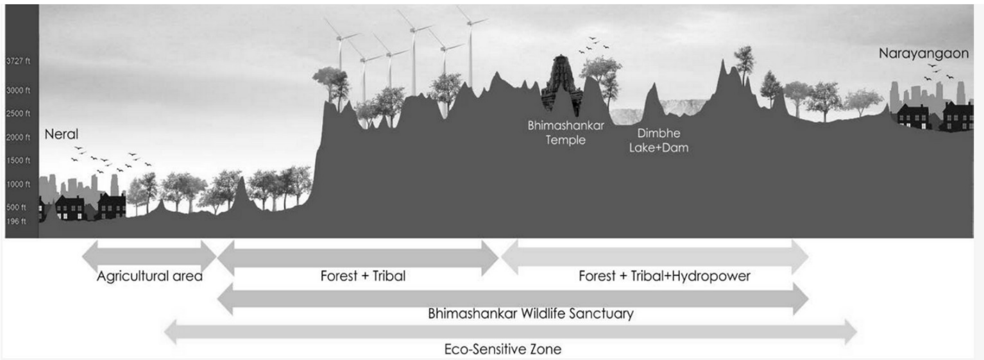


Figure 10: *Bhimashankar wind farms sitted in Forest-Eco sensitive zone (Source-Author)*

The Wind Farm Design and Optimization Problem Definition

The WFDO problem is defined as the set of advanced planning actions needed to enhance the performance of wind farms, while satisfying all constraints, given partial or complete information regarding advance planning actions needed to enhance the performance of wind farms.

	Advanced planning actions
1.	The wind farm location, the wind farm size, the topography complexity and land-use
2.	The short and long-term, meso and micro-climate and wind resource
3.	The available infrastructure (e.g., electrical, civil engineering and telecommunication infrastructure);
4.	The available technologies (e.g., WT type, size, efficiency and cost);
5.	The local environment (e.g., wildlife, bird migration paths, closeness to human settlements, etc.);
6.	The national and international regulations, directives and conventions on energetic resources (e.g., government and private sector agreements, historical energy pricing, main electric system condition and capacity);
7.	The potential issues (e.g., cyclic weather phenomena and/or adverse natural phenomena).

Table 8: *Advanced planning actions needed to enhance the performance of wind farms (Herbert-Acero 2014)*

Finding and Discussion

1. Finding form focused interviews

Guidelines and key features for wind farm site selection before Siting wind Farm:

The site selected for wind farm development need to have many positive attributes including geographical location, road and grid network, community support, minimum risk for biodiversity etc. The geographical attributes should avail superior wind speed, suitable terrain and geology for on site access. Road and grid network should be well connected and aligned with electrical grid, industrial support should be acquired for construction and on-going operations. It is not possible without the Community people with Supportive land holders with privately owned free hold land. The site must be located away from wetlands and forest zones for minimum risk to biodiversity of agriculture and forestry operations.

The potential effects of the proposed increase in wind energy developments on birds are explored using information from studies of existing wind farms. Evidence of the four main effects are observed: collision, displacement due to disturbance, barrier effects and habitat loss. No significant impacts on birds have been recorded at any of these wind farms to date (L. Drewitt, 2006).

Impact on wildlife and biodiversity caused by wind farms may produce side effects during their construction and in operation:

(1) Impact on local vegetation, by inducing local micro-climate changes.

(2) Impact on local wildlife, with special emphasis on the short and long-term loss, degradation and fragmentation of birds/bats. Most of the potential impacts of wind farms on migrating birds/bats can be reduced to acceptable levels through a smart micro-siting design (e.g., bird electrocution fatalities can be dramatically reduced by burying internal wind farm power lines underground while bird-WT collision fatalities can be reduced by properly separating WTs from sensitive zones such as migration corridors) and by performing site-specific mitigation processes.

(3) Identifying zones (e.g., natural protected areas) of possible concern should be done as early as possible in the wind farm planning stage. In high-risk zones the ultimate mitigation solution could be to implement control strategies on selected WTs during bird or bat migration (Herbert-Acero, 2014).

2. Compare-Analyze-Rating (based on case study)

Rating the case studies as per analysis of various parameters:

Score: ○ 1 point ● 2 points					
Global Case studies	Wind Stalks,Abu Dhabi	Whittle wind farms,Scotland	Lamma Winds,Hongkong	Kansas Community wind farm	Qurrent the Dutch energy theme park
Type	●●○●	●●●○	●●●	●●●●	●●●
Purpose	●●●●○	●●●●○	●●●	●●○	●●●●○
Topography	●●	●	●○	●●●	●●●●
capacity	●●●○	●●●●○	●●○	●●●	●●●●
Context	●●●○	●●●●	●●○	●●●○	●●●●
Siting and context	●●●○	●●	●●○	●●●	●●●●
Land use	●●●○	●●	●●●○	●●●●	●●●●○
Circulation	●●●○	●●	●●●	●●●○	●●●○
Visual	●●●●	●●●○	●●	●●○	●●●
Activities	●●●	●●●	●	●●●●	●●●○
Biodiversity	-	●●●	●●●	●●●○	●●●○
Environmental	●●●	●●●○	●●○	●●●○	●●●○

Impact					
Landscape Approach	●●●●	●●●	●●	●●●○	●●●○
Total	**83**	**79**	**62**	**87**	**97**
Range	Min 62 max 97		**Average Score- 82**		

Table 9: *Ratings For Case studies at global Context (Source-Author)*

Score: ○ 1 point	● 2 points				
Indian Case studies	Muppandal Wind Farm, Kanyakumari district, Tamil Nadu	Jaisalmer Wind Park, Rajastha n	Odanthurai village near Coimbatore	Energy Park, Raipur,Chattisgarh	Bhīma Shankar wind power project
Type	●●●	●●○	●●●●	●●●○	●○
Purpose	●●●	●●●	●●●●	●●●●○	●●○
Topography	●	●	●●●○	●●●○	●●○
capacity	●●●●	●●●●	●●	●●	●
Context	●●	●	●●●○	●●●○	●
Siting and context	●●	●	●●●○	●●●○	●
Land use	●		●●●○	●	●○
Circulation	●○	●○	●●●	●●●●	○
Visual	●●	●	●●	●●●●	●
Activities	●	●	●●●○	●○	●●●○
Biodiversity	-	○	●●○	●○	○
Environmental Impact	●●	○	●●●●	-	○
Socio-economic impact	-	○	●●●○	-	○
Landscape Approach	●	●	●●	●	●●●
Total	**49**	**37**	**89**	**67**	**41**
Range	Min 37 max 89		**Average Score- 57**		

Table 10: *Ratings For Case studies at Indian Context (Source-Author)*

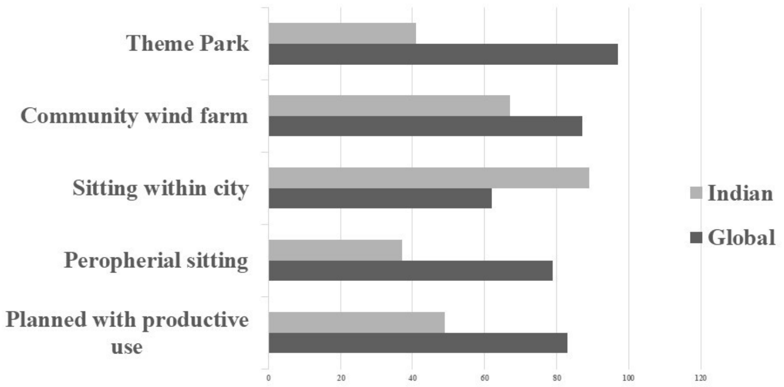


Figure. 11.- Bar chart for Comparative case studies Global and National context (Source-Author)

Comparing the case studies ratings in global and Indian Context

As seen in **Figure 11** the global wind farm ratings are higher with respect to Indian wind farm ratings in all respect in terms of planning, siting, adaptive reuse, landscape approach towards wind farm sites. Thus, further aid is needed for planning intervention for wind farms in Indian context. Proper wind farm planning has major positive economic impacts for both wind farm investors and developers. Environmental impacts can be defined as the potential impacts the wind farm will produce in the environment of the site during its construction and while in operation (Herbert-Acero, 2014).

Role of landscape architect (based on literature review on current practices)

Landscape architect plays a major role in the revival of degraded landscapes by providing a positive impact to ecology and bio-diversity. The regenerative design approach will not only restore habitat and ecosystem as a resource but also treat air, soil quality and groundwater sources. In addition to it the suitable selection of plant palette has high potential for treatment of contaminated soil and reducing carbon footprint with affordable manner. Planning of active and passive recreation along with energy efficiency is vital. The profit generating renewable energy source with careful planning, management, conservation, implementation and design strategies together can play a vital role. If done collaboratively with allied experts it can generate measurable results. Reformation of wind farms as sustainable energy landscape spaces can be a boon in itself to tackle the global problem of climate change.

Conclusion

Guidelines for siting and operating of wind farms

The process of wind farm installation takes up to two to three years of development. Further, three to four years are required to bring the land back to its normal state or to merge the new elemental routine into the landscape by regenerative design approach.

Guidelines for mitigation measures to reduce impact of wind farm for wildlife and biodiversity

Siting of wind farm must be avoided in sensitive locations and at a distance of 5 km away from any sensitive location. The proper measures should be taken right from the stage of planning until the construction stage of the wind farm along with planning of expansion road and transmission grid infrastructure. Implementation of appropriate practices should be outlined during post construction i.e., operation period of wind farm. Siting of wind turbines and the service roads must be planned in order to have minimum footprints. Enhancing visibility of rotor blades and reduction of high contrast patterns or by UV painting of blades, marking of overhead cables using deflectors can reduce risk of collision for birds.

Guidelines for re-powering the wind farm

Wind farms have a life span of about 20-25 years. As existing wind farms near the end of their operating lives, re-powering will make an increasing contribution towards renewable electricity targets. This is important as it will become more difficult to find new sites as acceptable locations. In some cases, re-powering may provide an opportunity to increase strategic capacity by improving the land use pattern and design of wind farm development. In most cases, demand to install larger turbines when re-powering an existing site will be placed keeping the location same as to get the advantage of existing grid connectivity. The studies described above can help to addressing these issues for wind farms hence making them suitable for perpetual use.

Guidelines discarding the old turbines

The waste shall be disposed keenly by dismantling each part. Most of the times the parts have been reused with combination in case of wear and tear of wind turbine components, considering no compromise for energy generation. If the wind blades are made of FRP, the scrap has to be broken down in small pieces and shall be regenerated for various purposes like FRP sheets etc.

However, the fledging human explorations towards combating climate change and increasing energy efficiency also offer innovative opportunities for exploring new niches and opportunities around the theme of renewable and sustainable energy. Its use can combine environmental education and experience that attracts both technologically interested tourism segment and the family-oriented visitors.

An energy park is a separate area and planned for the purpose of clean energy development, like wind and solar generation facilities. Energy parks create many other economic developmental benefits along with green job creation, smart-grid connections, as well as new recreational, technology innovation and agricultural opportunities. Thus, planning and implementation of wind parks would create increased awareness for renewable source. It will also generate sustainable rural development along with the leisure and educational activities.

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