DIGEST

BIODIVERSITY AND PHOTOVOLTAICS

Impacts of Photovoltaic Installations on Biodiversity

To address the climate crisis and replace fossil fuels, solar energy is developing rapidly. However, unlike wind power or hydropower, its impacts on biodiversity remain poorly understood. Photovoltaic installations and panels can alter ecosystems and their functioning through habitat loss, species mortality or destruction, pollution, or the spread of invasive alien species. Animals may alter their behaviour, while vegetation beneath the panels may also be affected by the creation of new microclimates. Despite progress, solar energy still requires large areas of land, creating a potential conflict between environmental protection, electricity generation and other land uses. In this context, it is necessary to better document the pressures exerted by photovoltaic installations on biodiversity, in order to ensure that they are better taken into account in the development, construction and management of projects.

This document aims to summarise known impacts and to complement them with recent research on less-studied or more overlooked aspects that nevertheless deserve the attention of stakeholders in the sector.

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Photovoltaic impacts : what are we talking about?

Like most human infrastructure, renewable energy generation facilities can directly and indirectly harm biodiversity. Ecosystems may be disturbed during the extraction of the resources required for their production, installation and decommissioning, as well as during their operational phase. These infrastructures contribute to the decline of local biodiversity and, consequently, to the global biodiversity crisis.

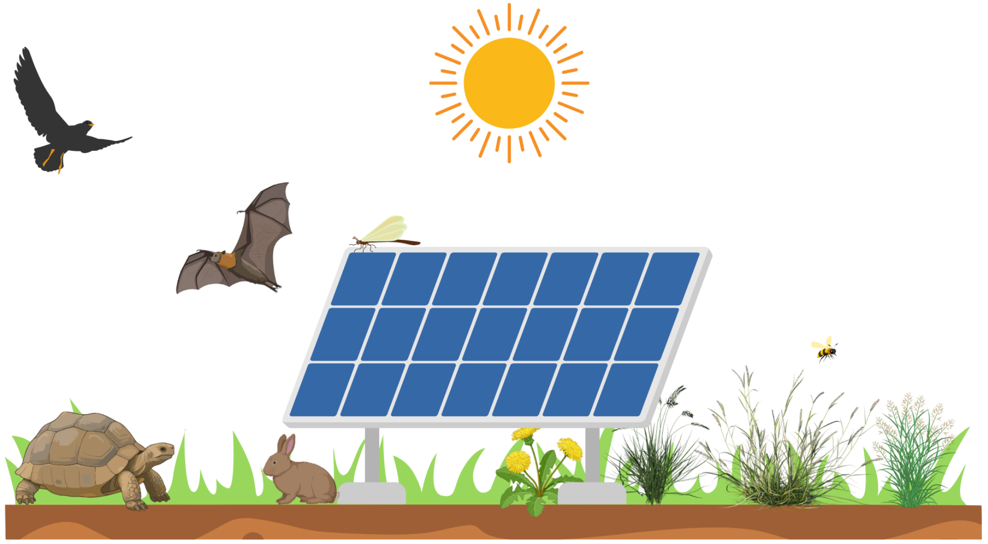
Graphical summary of the impacts of photovoltaic installations on fauna, microclimates and soils, and vegetation. Red boxes indicate negative effects, green boxes positive effects, and blue boxes neutral, undetermined or context-dependent effects. Potential impacts identified in the literature but not yet consolidated are shown in italics.

Impacts on fauna

- Habitat loss and fragmentation
- Disruption of migratory routes and population dynamics
- Changes in bird and arthropod communities
- Direct mortality caused by associated infrastructure (roads, fences, power lines)
- "Lake effect" for waterbirds and insects

- Shade zones in semi-arid climates
- Refuges, feeding sites and breeding sites for pollinators
- Food and perches for generalist passerines

- *Refuges for predators*



Impacts on microclimates and soils

- Increased soil compaction, leaching and erosion
- Obstruction of drainage-channel aeration
- Changes in CO_2 fluxes, litter decomposition and nutrient cycles
- Changes in biomass and microbial activity
- *Contamination by chemicals contained in panel washing water*

- Changes in airflows, wind speeds and turbulence
- Lower temperatures, daily temperature range, net radiation and PAR beneath the panels
- Higher humidity beneath the panels
- Degraded soil chemical and physical properties compared with semi-natural habitats
- Soil pH depends on the habitat

Impacts on vegetation

- Shift in plant communities towards shade-tolerant species
- Habitat loss and fragmentation
- Ruderalisation of vegetation
- Changes in species richness, abundance and biomass
- Vegetation growth control operations
- *Barrier to seed dispersal*

- Lower risk of frost and damage from heavy rain and hail beneath the panels

- Increased growth beneath the panels
- Delayed growth, flowering and fruit ripening beneath the panels
- Alternative habitats for generalist or pioneer species

PRESSURE–IMPACT RELATIONSHIPS

Pressure Impacts

LAND-USE CHANGE

The main pressure exerted by solar installations on biodiversity is land-use change, resulting in habitat loss and fragmentation, as well as physical barriers (fences, buildings).

In animals :
- mortality or injury,
- disruption of species migration,
- limitations on movement,
- avoidance behaviour,

In plants :
- depletion of the soil seed bank
- inhibition of reproduction
- adverse effects associated with herbicide use, reducing essential functions such as plant growth or plant–pollinator interactions.

On soils :
- degradation of soil physical and chemical quality

Installations can also positively influence several soil properties :
- increased aggregate stability,
- larger microbial communities,
- higher organic matter content.

BIOMASS « REMOVAL »

The loss of ponds or specific wetlands through conversion into solar production sites leads to alterations in migratory routes or breeding patterns.

These installations can act as ecological traps for certain species, attracting them into a hazardous environment where they are exposed to a higher risk of predation or injury through collisions with structures.

Bird species are disproportionately affected by mortality compared with other taxa. Indeed, waterbirds and other wetland-dependent species, which are nocturnal migrants, account for almost half of avian deaths at solar installations.

CHEMICAL POLLUTION

The construction and operation of photovoltaic farms are sources of pollution. Toxic substances involved include accidental releases of fuels, oils and lubricants during construction and maintenance operations, as well as the use of pesticides and herbicides to control vegetation.

The impacts include direct and indirect mortality of living organisms, poisoning and avoidance behaviour.

LIGHT POLLUTION

Light pollution from photovoltaic power plants can be problematic at certain times (night-time lighting), due to its intensity (glare) and its nature (polarised light). Impacts include direct and indirect mortality of living organisms, poisoning and avoidance behaviour.

Artificial light disrupts nocturnal animals, including their movements and behaviour. Reflections from solar panels can cause glare and disorientation, particularly among migrating birds. Polarised light attracts certain species that mistake these surfaces for water, turning them into ecological traps that can lead to breeding failure and mortality through collision, predation or futile reproductive efforts.

NOISE POLLUTION

The installation phase, which can last two to three years, generates noise.

This pressure results in :
- habitat loss,
- exclusion of native species,
- creation of unsuitable environments for migratory species .

LIGHT POLLUTION

These installations generate electromagnetic fields that can affect wildlife.

Impacts include disruption of the nervous system, circadian rhythms, cardiac functions, immune response and fertility in wild mammals, as well as changes in behaviour and pollination efficiency in bees.

MODIFICATION DU MICROCLIMAT

The construction of photovoltaic power plants modifies the microclimate (reduced evapotranspiration, heat-island effect). This may favour shade-tolerant species and exclude species that prefer light. This modified environment could create refuges for rare species, potentially mitigating some impacts of climate change and contributing to soil restoration.

Photovoltaic panels create an uneven distribution of rainfall. They increase fluctuations in soil water, reduce drought stress and increase soil water availability.

Changes to the local microclimate may have positive impacts on certain species, including some invasive alien species.

Plant flowering may be delayed beneath panels, while floral abundance may increase. Pollinators are also less abundant and less diverse in the shade of photovoltaic panels. There is a link between these effects on plant and pollinator communities and changes in microclimatic conditions beneath photovoltaic panels. In arid environments, shading from photovoltaic panels can create a cool island that may extend to the outer perimeter of the power plant, thereby providing a potential thermal refuge.

INVASIVE ALIEN SPECIES

Disturbances caused by the installation and operation of large solar farms can create ecological niches that allow opportunistic exotic plant species to colonise the area before native vegetation can recover.

These changes result in the disappearance of certain plant species and the animal species associated with them.

SPOTLIGHT ON AGRIVOLTAICS

Studies have shown that photovoltaic panels installed over agricultural land affect the local microclimate differently from panels installed over bare soil. Air temperatures are generally lower. Relative humidity also tends to be higher beneath agrivoltaic panels than in open fields.

Solar structures also act as windbreaks, limiting soil erosion. Some are equipped with systems that collect rainwater from the panels and redistribute it for irrigating crops located below, optimising water use.

However, they can delay crop development and affect yields to varying degrees.

Agrivoltaic systems represent a promising solution to the “food-energy-environment” nexus, but their impacts on biodiversity are complex, multidimensional and largely hypothetical at this stage.

AN APPROACH BASED ON IMPACTS ON ECOSYSTEM SERVICES

A systematic review documents the impacts of solar production systems on 11 ecosystem services. It shows contrasting results: some ecosystem services clearly benefit from solar installations, while others decline.

HABITAT AND BIODIVERSITY MAINTENANCE SERVICE

Negative impacts	Description
Habitat loss and fragmentation	•Actual or potential habitat loss due to the expansion of solar parks •Fragmentation of ecological corridors and obstacles to animal movement •Overlap with conservation areas and habitats of rare species
Changes in the composition of communities	•Decrease in species diversity and abundance beneath the panels
Mortality and welfare of species	•Mortality due to collision, accidents, burns, etc. •High uncertainty due to the difficulty of assigning a precise cause to these mortalities •Increased mortality of waterbirds and insects associated with polarised light •Concerns about potential future impacts during panel disposal in the decommissioning phase
Effects on photosynthesis and productivity	•Reduced photosynthetically active radiation beneath the panels •Reduced productivity, biomass production and vegetation cover

Positive impacts	Description
Improvement in diversity and species richness	Improvement, protection and creation of habitats through: •Proximity to vegetation •Wildflower planting •Creation of beneficial shade •Integration into the local landscape
Species survival and wellbeing	•Birds using infrastructure for shelter, perching, feeding and nesting

FOOD PRODUCTION SERVICE

Negative impacts	Description
Reduced yields	•Crops sensitive to reduced radiation: wheat, maize, soybeans •Delayed growth and maturation
Land-use changes	•Trade-off between energy and food production •Potential risks to food security
Positive impacts	**Description**
Improved growth and yields	•Benefits strongly influenced by climate, crop choice and system design •Significant benefits have been documented in climates with high solar radiation through: •Increased shading •Higher soil moisture •Improved water-use efficiency •In temperate climates, yields are favoured in drier years
Systemic benefits of agrivoltaics	•Improved food-system resilience •Increased crop diversity •Pollination benefits for surrounding crops •Improved overall land-use efficiency
Livestock welfare	•Lower body temperatures in cows beneath the panels, with reduced heat stress. •Lamb live weight beneath panels comparable to that under open-field grazing, despite higher stocking density

CLIMATE REGULATION

Negative impacts	Description
Increase in air temperature	•Mainly in warmer and drier regions •Above the panels or in exposed areas: increased heat transfer •Higher temperatures within the panel array leading to heat dissipation through convection •At night or in winter: panels retain heat, increasing temperatures beneath them •Modelling predicts localised increases in air temperature •Nearly one quarter of the data show a reduction in albedo associated with solar panels
Reduction in soil carbon	•Due to reduced plant growth beneath the panels, decreased soil moisture, or increased salinity and pH. •Negative consequences for climate regulation
Other negative impacts	•Reduction in precipitation following the hypothetical construction of large solar parks •Speculation about an overall deterioration in climate regulation

Positive impacts	Description
Reduction in air temperature	•Climate-change mitigation when generated energy substitutes for fossil-fuel use •During the day, directly beneath the panels: reduced temperature due to shading and reduced solar radiation •Cool-island effect: panels capture incident solar energy as electricity •At night: temperatures beneath the panels may remain lower than ambient temperatures •Grasslands vs. deserts: system-level cooling where the albedo difference is less pronounced •Additional benefits: creation of wetlands and planting of vegetation that reduce temperatures
Systemic benefits of agri-photovoltaics	•Improved food-system resilience •Increased crop diversity •Pollination benefits for surrounding crops •Improved overall land-use efficiency

SOIL QUALITY REGULATION

Negative impacts	Description
Degradation of soil physical quality	•Compaction caused by construction machinery: •Anaerobiosis, waterlogging, nutrient depletion and reduced fertility •Changes in soil temperature affecting growth, development and nutrient uptake, and influencing microbial community composition and organic matter decomposition
Soil chemistry	• Reduced nutrient levels, particularly nitrogen, affected by topsoil stripping and removal of vegetation cover. Low nitrogen concentrations limit organic matter accumulation •Observed increase in salinity with adverse effects on plant growth •High concentrations of toxic substances (lead, chlorine), potentially due to panel leaks •Contamination by transformer oil during construction
Soil biological quality	•Substantial reductions in soil microbial biomass and in the abundance of mites, springtails, fungi and Gram-negative bacteria

Positive impacts	Description
Reduction in soil temperature	•In solar parks located in arid regions or areas experiencing increased drought •Mitigates the effects of climate change when temperatures are close to critical thresholds for certain vital processes: productivity, decomposition and seed germination
Improvement in soil chemical and biological quality	• Increase in nitrogen and organic matter •Management favouring the formation of biological soil crusts (a key element of pedogenesis in desert ecosystems) •Potential restoration of degraded arid ecosystems
General improvement in fertility and pedogenesis	•Improved soil health in certain contexts

WATER CYCLE MAINTENANCE SERVICE

Negative impacts	Description
Increased water scarcity	•Use for panel washing • Particularly critical in dry climates
Reduced soil moisture beneath panels	•Mainly due to diversion of rainwater by solar infrastructure •Consistent effect across climate types and ecosystems
Positive impacts	**Description**
Increased soil moisture	•Shading from solar panels reduces evaporation and allows rainfall to accumulate along the edges of the frames
Future opportunities	•Potential to improve the water cycle by reducing water consumption for panel washing and reusing wash water for agrivoltaic irrigation •Rainwater collection

BIOMASS PRODUCTION SERVICE

Negative impacts	Description
Reduced plant productivity	•Panel shading reduces above-ground net primary productivity and the biomass of forage grasslands •There are substantial variations depending on installation design, soil moisture, and seasonal/diurnal variations in light and temperature
Reduced supply of raw materials	•Magnitude varies according to location, construction methods and management practices
Positive impacts	**Description**
Increased biomass quantity and quality	•Improved forage quality and digestibility
Management adaptation to improve supply	•Cultivation of biofuel plants in kitchen gardens; rainwater collection

SOIL EROSION REGULATION SERVICE

Negative impacts	Description
Increased erosion through water channelling	•Formation of rills and gullies beneath panels
Soil disturbance	• Topsoil stripping •Impact on vegetation and soil properties, particularly its susceptibility to erosion
Positive impacts	**Description**
Overall reduction in erosion	•Demonstrated across various climates and ecosystems, although the effect is probably more pronounced in arid regions through ground vegetation cover (rooting), which reduces wind and water erosion
Rainwater collection	•Rainwater interception and reduced runoff •Panels intercept rainwater and reduce splash erosion.

SPOTLIGHT ON FLOATING PHOTOVOLTAIC SYSTEMS

Few studies have examined the ecological impacts of floating photovoltaic systems on aquatic ecosystems. Nevertheless, a literature review was published in 2025. Its findings are summarised below.

The organisms studied most extensively are algae and photosynthetic bacteria. The general trend observed is a decrease in primary production. Studies show a reduction in biomass and a decrease in growth rates for algae.

Impacts on fish and crustaceans are variable: they may be negative, by disrupting feeding patterns, or positive, by reducing thermal stress.

For waterbirds, they result in reduced diversity and increased abundance, suggesting that the panels may favour certain species at the expense of others.

These structures can provide a substrate for various organisms, with a potential risk of dispersal of non-native species.

CULTURAL, RECREATIONAL AND AESTHETIC SERVICE

Negative impacts	Description
Visual impacts and landscape perception	• Mainly in natural areas •This impact reduces the perceived well-being of local populations, lowers acceptance of the solution and may affect tourism

Positive impacts	Description
Potential for improvement	•Where vegetation is managed to improve aesthetics or where solar parks provide benefits to local populations: •Recreational activities •Community gatherings •Scenic viewpoints

POLLINATION SERVICE

Negative impacts	Description
Pollinator habitat loss	•Changes in community composition due to: •Expansion of solar parks •Potential impacts on pollinator survival and movement

Positive impacts	Description
Improvement through management decisions and practices	•Plots managed with native vegetation and wildflowers •Increased floral resources for pollinators •Improved habitats compared with the previous land use
Future opportunities	•Potential to improve the water cycle by reducing water consumption for panel washing and reusing wash water for agrivoltaic irrigation •Rainwater collection

PEST AND DISEASE REGULATION SERVICE

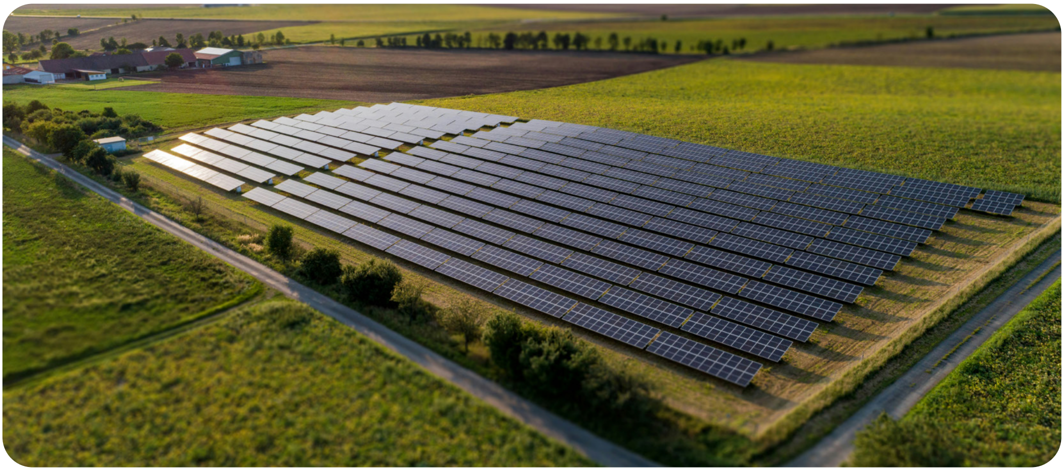
Negative impacts	Description
Increase in invasive species and pests	•Impacts mainly associated with construction work and the management phase
Effects on human health	•Risks of disease and exposure to electric and magnetic fields

Positive impacts	Description
Hypothetical improvement in biological control	•Two-thirds of publications refer generally to the potential improvement of biological control, human health and predation of crop pests. •The level of evidence is low and associated with proximity to vegetation or long-term integration into the landscape

FLOOD REGULATION SERVICE

Negative impacts	Description
Increased runoff	•Rainwater interception by impermeable solar panels

Positive impacts	Description
Potential improvement in flood regulation	•In cases where arable land is converted to grassland with vegetation cover: •Improved soil stability •Increased vegetation cover •More effective infiltration
Creation of pollinator habitats	•In cases where an unsuitable environment (intensively cultivated field) is converted into grassland with natural vegetation or nectar-rich plantings.



When it contributes to reducing the use of fossil fuels, solar photovoltaic power generation is a promising alternative for addressing the climate crisis. However, **it is essential to consider its impacts on biodiversity**. This booklet therefore highlights both the positive and negative effects of these installations on ecosystems.

Nevertheless, significant knowledge gaps remain. These concern both the temporal scale, due to a lack of long-term studies, and the spatial scale, as research has predominantly focused on arid regions and on the installation scale.

Furthermore, **taxonomic and ecological coverage remains limited** : studies on fauna focus mainly on birds and pollinators, while other animal groups remain poorly studied.

Thus, **a substantial knowledge gap remains to be addressed**, particularly as many existing studies still present limitations in terms of experimental rigor.

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See the full synthesis :

Reference : Soubelet, H., Goffaux, R.& Salomon, C. (2026). The impacts of photovoltaic installations on biodiversity. Knowledge synthesis. Paris, France : Fondation pour la recherche sur la biodiversité
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