Nature-based Solutions Bio-inspired Design in Green Technology for Resilience

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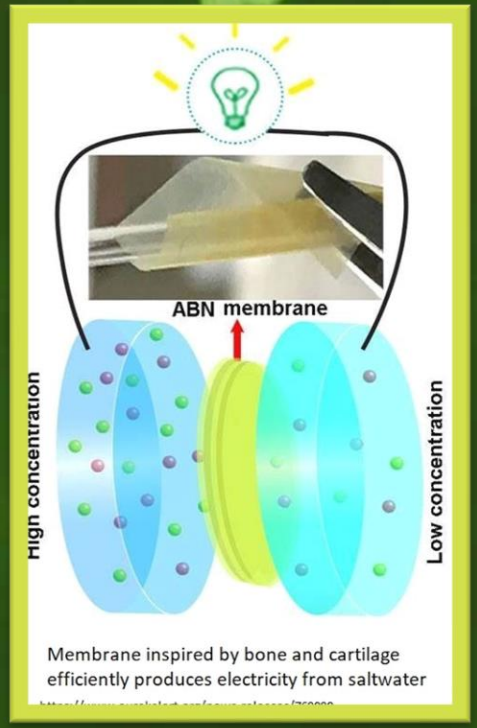
Anvar Shalmashi(PhD)

shalmashi@irost.ir

General Director
International Scientific Cooperation
Iranian Research Organization for Science and Technology
Ministry of Science, Research and Technology



Membrane inspired by bone and cartilage efficiently produces electricity from saltwater

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Nature-based solutions (NbS) and bio-inspired design are innovative approaches that :

- draw inspiration from nature's strategies
- forms, and processes to address various societal challenges related to the natural environment
- built environment,and human resources or health.

These solutions aim to provide sustainable, efficient, and resilient responses to pressing global issues.

Introduction

Nature based Solutions

According to the European Commission (EC, 2015):

1. cost effective
2. simultaneously provide environmental, social and economic benefits
3. help build resilience

Such solutions bring more, and more diverse, nature and natural features and processes into cities, landscapes and seascapes, through locally adapted, resource-efficient and systemic interventions.
Nature-based solutions must therefore benefit biodiversity and support the delivery of a range of ecosystem services.

(NBS) involve:

The sustainable management and use of natural features and processes to address various socio-environmental issues, such as ***climate change, water security, water pollution, food security, human health, and biodiversity loss.***

These solutions are inspired and supported by ***nature***, providing environmental, social, and economic benefits while helping build resilience.

NBS bring more nature and natural features into cities, landscapes, and seascapes through locally adapted, resource-efficient, and systemic interventions.

They include actions like the protection, restoration, or management of natural ecosystems, sustainable management of aquatic systems and working lands, and the integration of nature in and around cities.

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Nature-based solutions, bio-inspired design, and green technology are interconnected concepts that aim to address environmental challenges, improve sustainability, and enhance resilience through the sustainable management of natural resources and the development of innovative technologies inspired by nature.

Benefits of NbS:

1 Flood protection

- NbS can help protect coastal areas from flooding by utilizing ecosystem services such as mangroves .
- which reduce the impact of storms on human lives and economic assets.

2 Urban heat reduction

- NbS can help reduce urban heat effects by increasing green spaces.
- and incorporating vegetation in urban areas.

3 Carbon sequestration

- NbS can contribute to decreasing greenhouse gas emissions by preserving ecosystem services.
- and promoting carbon sequestration in natural systems.

4 Habitat and biodiversity benefits

- NbS can support habitat and biodiversity conservation by protecting.
- and restoring natural ecosystems, which provide essential habitats for various species.

Benefits of NbS:

5

Green space and human well-being benefits

- NbS can improve air and water quality, buffer natural disasters
- control flooding, and increase green space, contributing to human well-being and quality of life.

6

Air, soil, and water quality improvements

- NbS can enhance air, soil, and water quality by promoting sustainable land use practices and preserving ecosystem services.

7

Cost-effectiveness and resilience

- NbS are often cost-effective and resilient approaches to environmental challenges providing multiple benefits compared to traditional gray infrastructure.

8

Disaster risk reduction

- NbS can help manage disaster risk and reduce the incidence and impact of flooding, mudslides, and other disasters.

9

Climate change adaptation and building resilience

- NbS play a key role in climate change adaptation and building resilience in landscapes and communities.

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How Nature Designs and Implements NBS

1. Conduct a vulnerability assessment

Identify the climate impacts that NbS for adaptation might address.

2. Identify possible actions

Determine the actions that can address the adaptation needs in a specific region and population.

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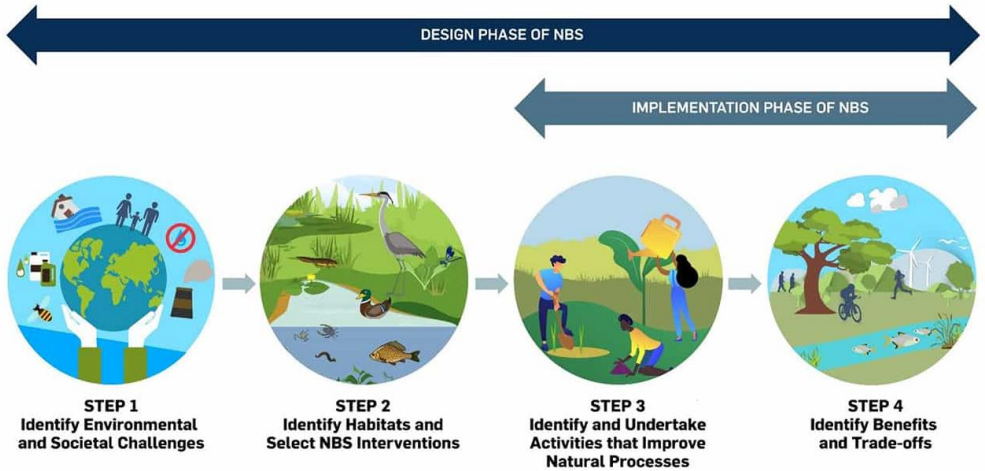
3. Assess the need for transformative change

Evaluate whether the NbS needs to be transformative to achieve the desired outcome.



Proposed steps to follow for benefit identification across the design and implementation phases of NBS.

https://limno.com/wp-content/uploads/2022/11/402_nbs-guide-march-2021-design-implementation-phases.jpg

4. Select and design the NbS action

Choose the appropriate NbS action to be implemented, considering the specific context and challenges.

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5. Monitor and evaluate the effectiveness

Track the progress of the NbS in achieving adaptation goals and assess its overall effectiveness.

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Some Key Activities and Best Practices in designing, implementing, and monitoring NbS include:

1. Engaging stakeholders to ensure the visions of local communities, governments, and other partners are integrated into all stages of a project.

2. Co-defining the setting and understanding the challenges

3. **Employing ecosystem process utilization, which involves the use of ecological actions and events that link organisms and their environment.**

4. **NbS can address various challenges, such as biodiversity conservation**
   - **climate mitigation and adaptation**
   - **coastal protection and disaster risk reduction**
   - **Urbanization**

   The degree of human intervention involved in NbS can range from artificial solutions like biomimicry to hybrid solutions and the protection of existing ecosystems. Planning NbS requires a framework that considers the specific context and challenges, and it is essential to involve stakeholders throughout the process to ensure the success of the project.

Some examples of Bio-inspired Design in Green Technology (part 1)

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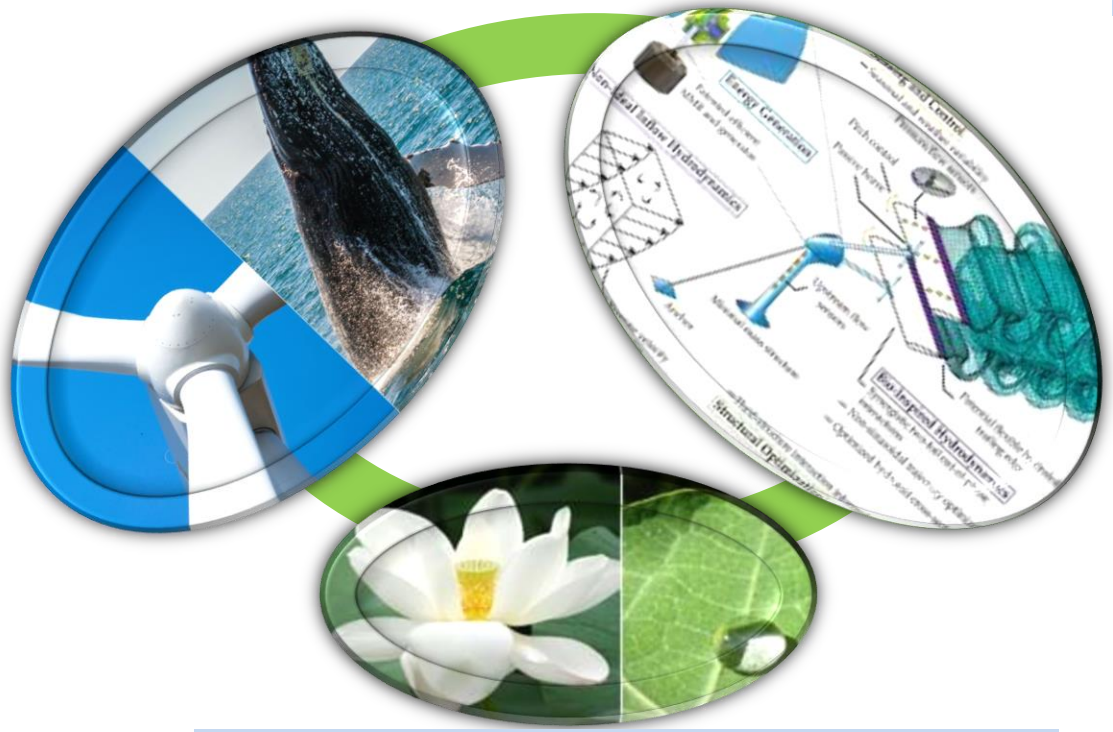
1. Whale wind turbines

Researchers have found that the bumpy protrusions on the front of a humpback whale's fins, called tubercles, contribute to its aerodynamic abilities. This discovery has inspired the design of wind turbines with similar bumps, which are more efficient and quieter than traditional wind turbines.



2. Bio-Inspired Renewable Energy (BIRE)

BIRE is a system that generates power from riverine environments using pairs of out-of-phase oscillating hydrofoils placed into oncoming flow. The energy is harvested with a power conversion mechanism that converts the oscillatory pitch and heave motion of the foils to unidirectional rotary motion with high efficiency and minimal mass.

3. Lotus-inspired hydrophobia

The lotus plant has a unique ability to repel water, which has inspired the development of hydrophobic coatings for buildings and other structures. These coatings can help to reduce water damage and improve energy efficiency by reducing the need for air conditioning.

Some examples of Bio-inspired Design in Green Technology (part 2)

Biomimicry in solar design

Researchers have developed techniques to increase the efficiency and efficacy of solar panels by observing and reproducing the complex structures and processes seen in nature. For example, mimicking the structure of a leaf can improve the absorption of sunlight, while mimicking the wings of a butterfly can improve the efficiency of solar cells.

Bioinspired building materials

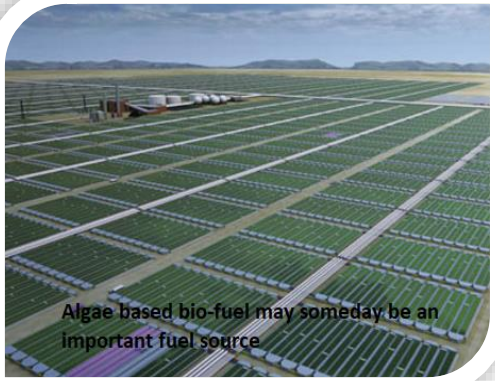
Scientists and researchers are using biomimicry to develop new building materials that are more sustainable and environmentally friendly. For example, researchers have developed a concrete that is inspired by the structure of coral, which is stronger and more durable than traditional concrete.

Termite-inspired architecture

The Eastgate Centre in Zimbabwe is a building that is designed to regulate its temperature using a system that is inspired by the ventilation system of a termite mound. The building uses 90% less energy for cooling and heating than a conventional building of its size

Biofuels

They are derived from plant, algal, or animal biomass, making them renewable energy sources.



different generations of biofuels

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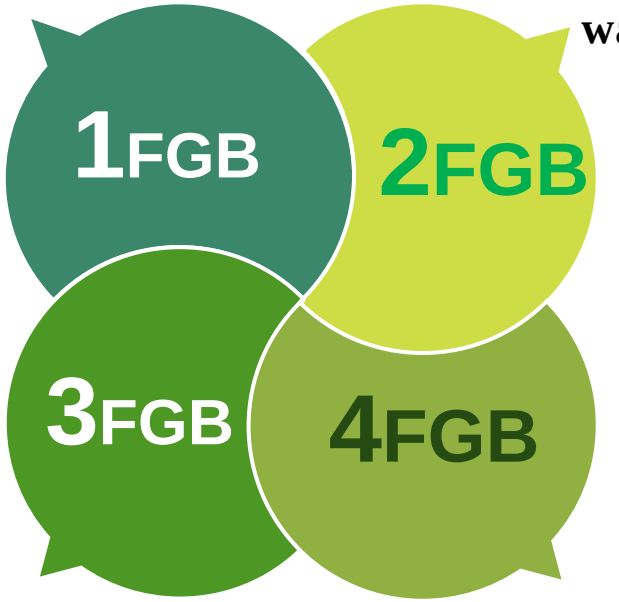
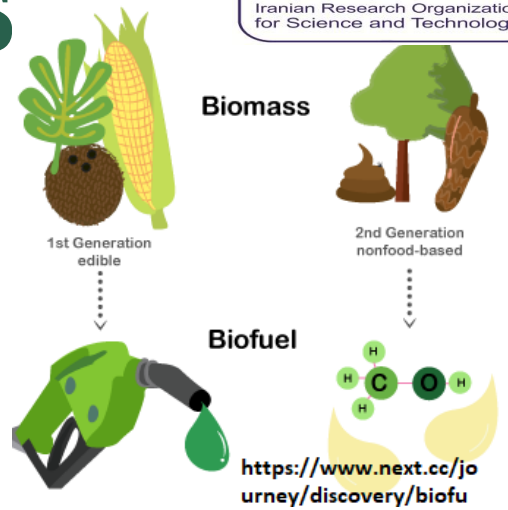
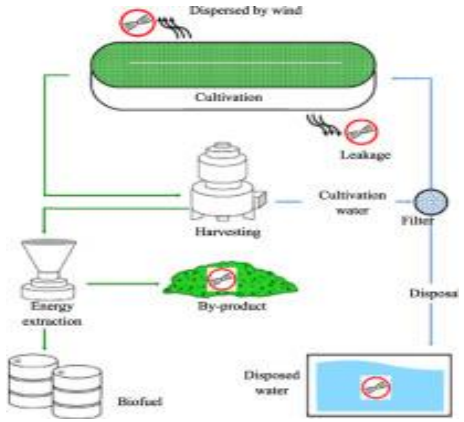
first-generation (1FGB), such as biodiesel and bioethanol, are produced from food crops like soybean, corn, and rapeseed.



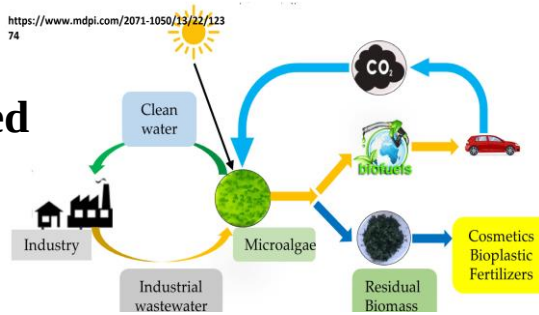
Second-generation biofuels use non-food lignocellulosic materials, such as perennial grasses, woodchips, agricultural and forest residues, and municipal and industrial solid wastes as raw materials



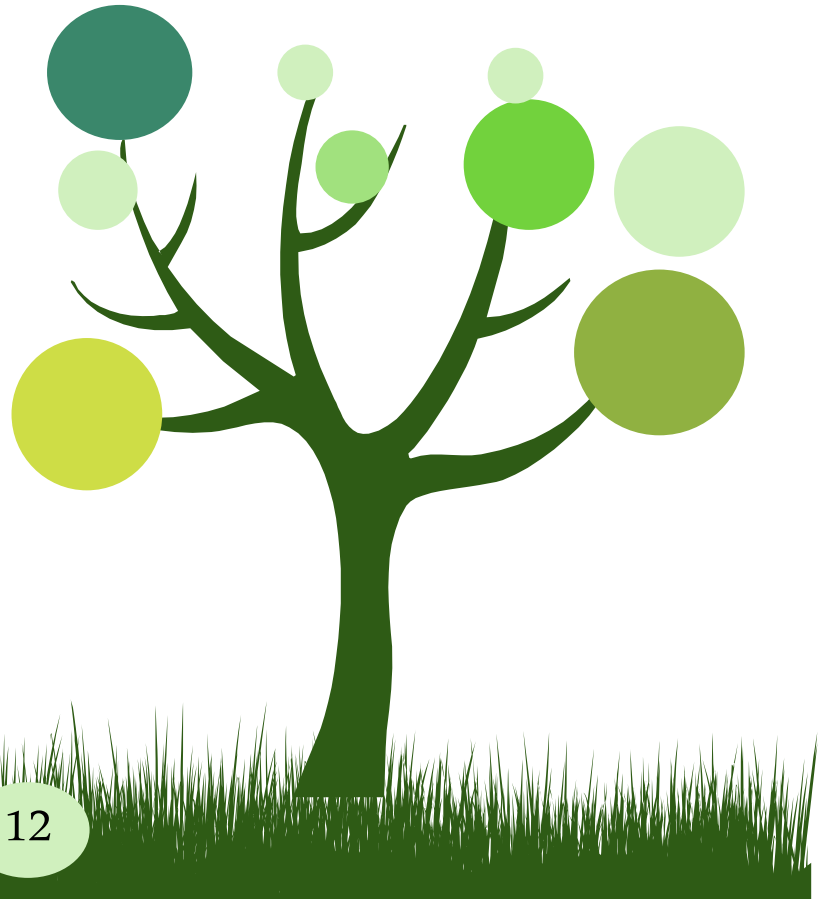


Third generation biofuels are also known as “algae fuel” or “oilage” since they are produced from the algae.

fourth-generation uses genetically modified (GM) algae to enhance biofuel production.



Bio-Inspired Renewable Energy: biodiesel in Green Technology



Bio-inspired renewable energy, particularly biodiesel,

is a clean-burning, renewable substitute

for petroleum diesel that can be produced from vegetable oils, animal fats, or recycled restaurant grease.

Biodiesel production involves a process called trans esterification, which converts fats and oils into biodiesel and glycerin (a co-product).

Clean-burning,

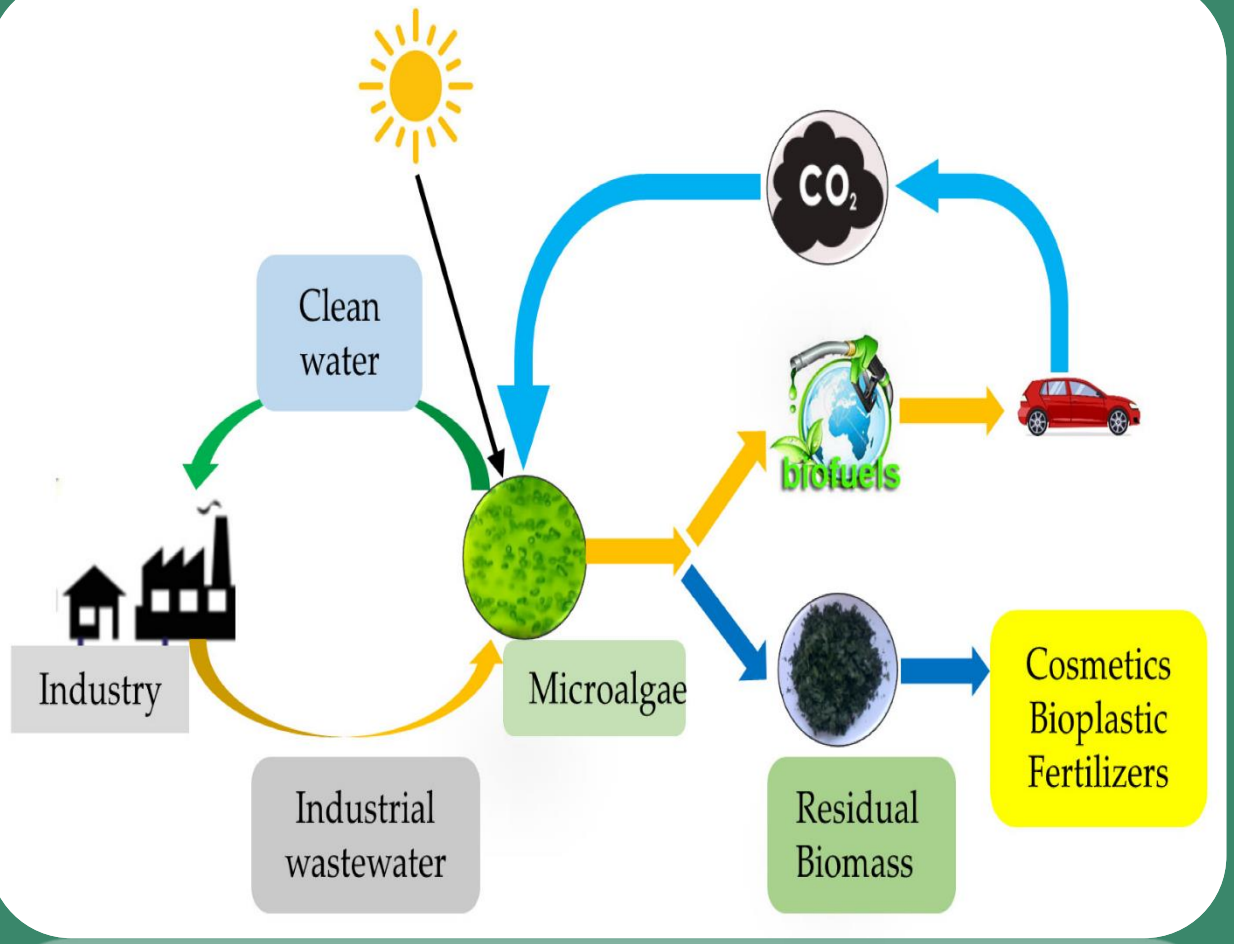
Renewable substitute

Biodiesel can be used in conventional diesel engines, directly substituting for or extending supplies of traditional petroleum diesel.

Biodiesel reduces life cycle emissions, as carbon dioxide released from biodiesel combustion is offset by the carbon dioxide absorbed from growing soybeans or other feedstocks used to produce the fuel.

Biodiesel improves fuel lubricity and raises the cetane number of the fuel, which helps keep moving parts from wearing prematurely.

Biodiesel advantages



Case Study: IROST Microalgae Project

One example of bio-inspired green technology is the use of microalgae biomass as biofuel. Microalgae have the potential to capture and utilize CO2 for bioenergy feedstock production, offering a greener approach for environmental protection.

The most productive source of 'fresh' oil is green algae, microscopic water living organisms, which capture sunlight and store it as oil.

Organisms use the solar energy to bind atmospheric carbon dioxide into organic matter .

One ton biomass of microalgae sequestered 1.8 ton CO_2.

Microalgae Products

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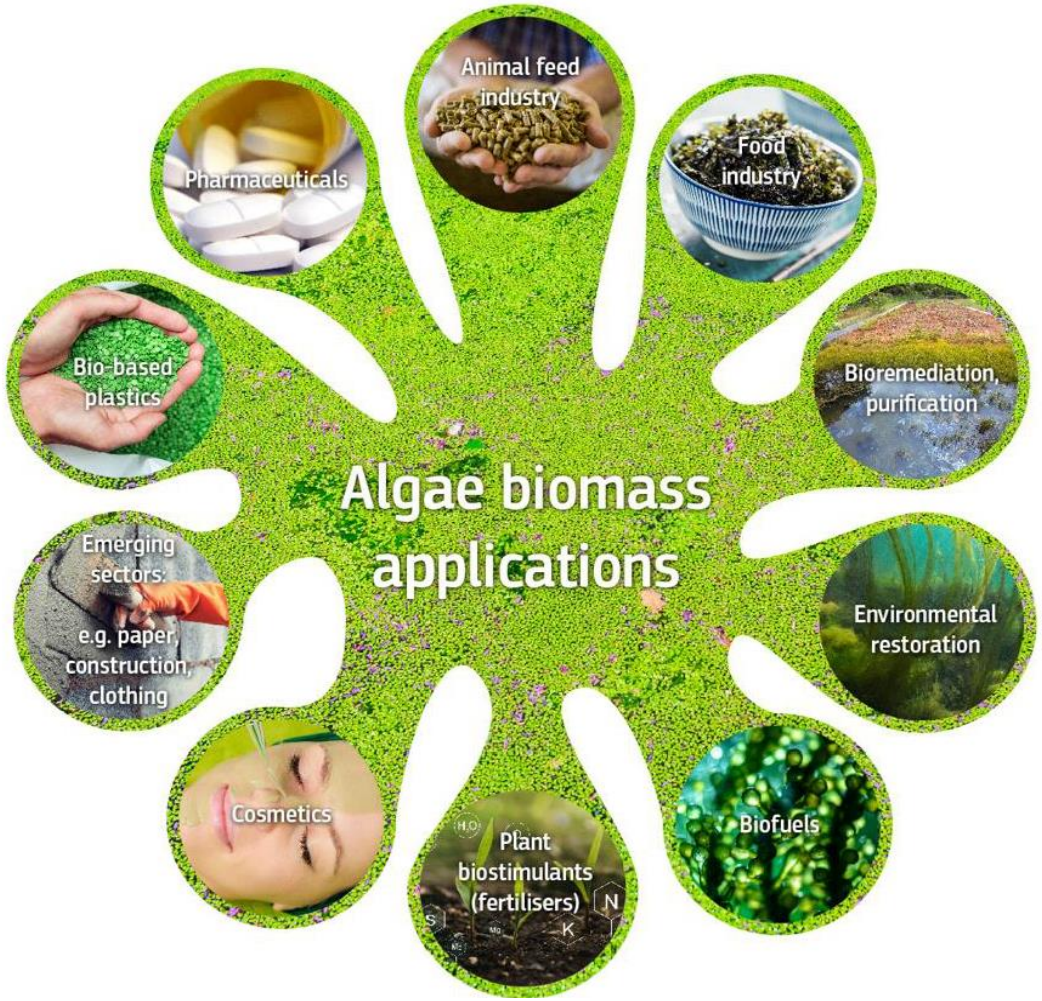
used to
bio-fuels

power jet aircraft
trucks, cars, ships and railway locomotives.

used to
manufacture

- biopharmaceuticals
- fertilizers
- chemicals
- textiles
- biodegradable plastics
- paper and

other industries



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Pilot plant with:
Flat photo-bioreactors (10-25 Li)
Open pond raceway (2*250 Li)

Project Background

In-door open ponds (4*2500 Li)
Out-door ponds (2*2500 Li,3*25000 Li)

Project Background

Microalgae Pilot plant IROST, 2009

Microalgae Pilot plant Queshm Island,2002

Project Background

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In-door open ponds (4*2500 Li)

Out-door ponds (2*2500 Li, 3*25000 Li)

2500 L. Indoor Open Pond

Qeshm Micro Algae Biorefinery

QMAB

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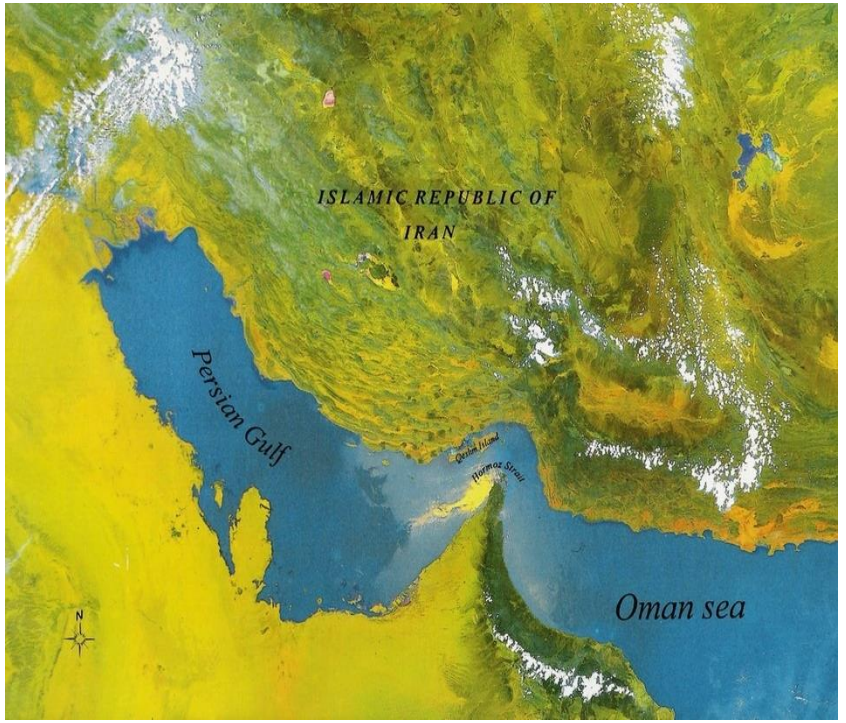
QMAB Company established in April 2014 in Queshm Island, Persian Gulf, IRAN.

QMAB is the first industrial scale of Microalgae and first Microalgae bio refinery in the Middle East.

Objective of QMAB is to develop knowledge, technology and process strategies for sustainable production of microalgae as feedstock for fuel, chemicals, food and feed at industrial scale.



Site of project

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Planned expanded of operation to 800 hectares open pond, in Queshm Island, scale system on the drawing board for 2016.

1800 km coastline of Persian Gulf and Oman Sea, ever sunny days, sea water, local utility, electricity, existing facilities for storage and distribution and access to ports of marine transport, are another advantages.

The previous experiment in 800 m^2 pilot scale suggests that approach could be successful at a commercial scale.

Site of project based in Queshm Island, has a goal to became the first Center in the country to economically produce biofuel from wild algae isolated from Persian Gulf.

Qeshm Micro Algae Biorefinery
QMAB

Open ponds design

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The cultivation process was done in an open pond, with Sea water and Direct Sunlight.

Cultivation processes are broken up into blocks called fields .

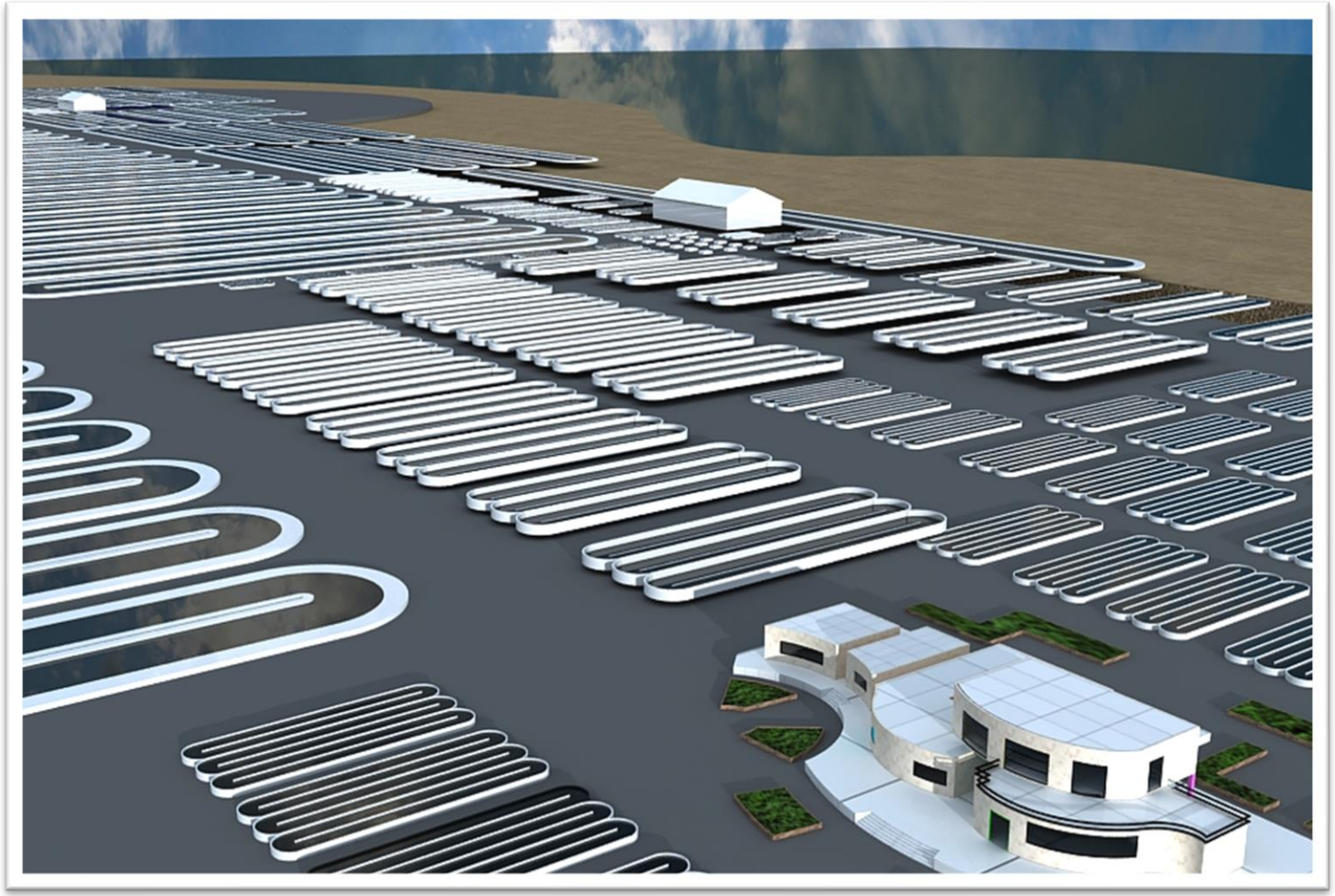
Each field is almost 100 hectare contains the reactor beds, algae inoculation and nutrient source, CO2 source, circulation pumps, and harvest sumps.

Each field contains 300 x 3000 m^2 reactor beds
Project design for expansion to 1000 hectares in three years.

Capacity production/T/y

T/h/y	Average productivity
240	Biomass
120	Oil
41	Carbohydrate in the rest of Biomass (40%)Ethanol
400	CO2 sequestration
48	Feed Additive

Project Perspective



Conclusion

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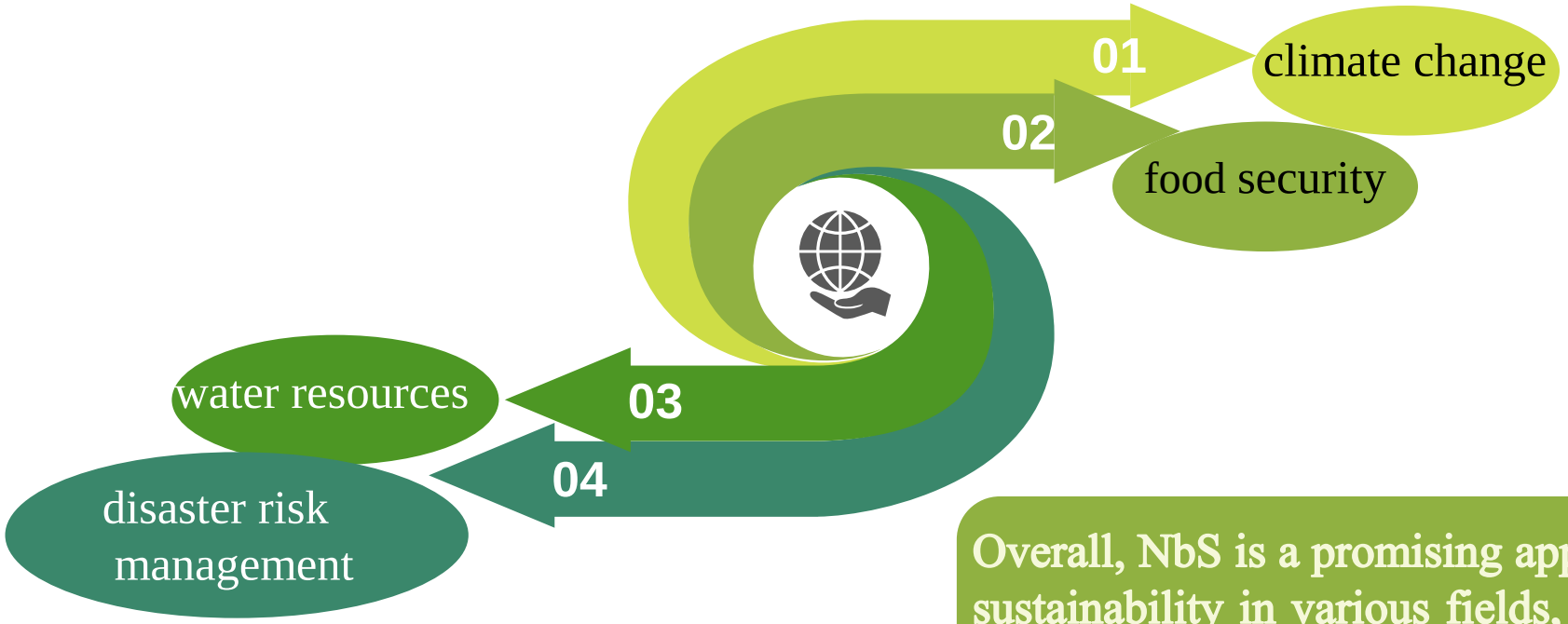
Nature-based solutions (NbS) aim to use nature to tackle challenges such as:



The concept has been adopted by the European Commission in its research program Horizon 2020 to promote its uptake in urban areas and establish Europe as a world leader of NbS.

Overall, NbS is a promising approach to enhance resilience and sustainability in various fields, but its implementation requires good practices and stronger evidence of its benefits.


Tank you for
your Kind
attention