Nature Positive Design

Examples of how to retrofit cities and buildings to address multiple sustainability issues and achieve net-positive social and ecological outcomes

Prof. Janis Birkeland

netpositivedesign@gmail.com

Some examples may not suit all climates, contexts, conditions or circumstances.

ABCs of how nature-based design and development can address basic sustainability issues

A. Climate mitigation
1. Sequestration
2. Sea level retrofits
3. Street havens
4. Shade trees
5. Urban cooling

See biodiversity and climate at end

B. Energy/heat
6. Urban wind
7. Algaetecture
8. Solar windows
9. Solar (salt) ponds
10. Trombe walls

C. Energy saving
11. Passive Solar homes
12. Passive solar retrofits
13. Passive lighting
14. Optical fibers
15. Curtain wall retrofits

D. Floods and waves
16. Shoreline restoration
17. Reef restoration
18. Rural floods
19. Urban floods

E. Natural disasters
20. Tornados
21. Earthquakes
22. Typhoons
23. Fires
24. Storms
25. Sinkholes

F. Urban food security
26. Food access
27. Crop rotation
28. Aquaponics
29. Community gardens

G. Soil production
30. Urban composting
31. Decontamination
32. Erosion control
33. Biochar

H. Material sources
34. Construction
35. New IFC materials
36. Bio-based products
37. CO2 absorbing products

I. Land regeneration
38. Desert restoration
39. Urban forests
40. Land rewilding
41. Off-ground buildings

J. Human health
42. Furnishings
43. Living walls
44. Combined systems
45. Organic interiors

K. Urban biodiversity
46. Nature retrofits
47. Retrofit scaffolding
48. Structural scaffolding
49. Ecological space
50. Nature corridors

L. Infrastructure
51. Sewage
52. Sewerage
53. Road and rail
54. Street retrofits
55. Fuel Cells

M. Consumables
56. Fabrics
57. Food waste
58. Mining
59. Luxury goods
60. Packaging

N. Urban air
61. Urban air cleaning
62. Bio-facades
63. Urban scaffolding
64. Pollution filtration

O. Urban water
65. Water remediation
66. Water security
66. Bioretention
67. Daylighting streams

P. Socio-economic
68. Recreation
69. Sense of Community
70. Stability
71. Employment

Q. Plastic pollution
72. Cigarettes
73. Mushroom leather
74. Fire toxin removal
75. Plastics and climate

R. New food sources
76. Insects
77. Algae or seaweed
78. Fungi foods
79. Mushroom and health

S. Drought
81. Individual water
82. Water for crops
83. Buidling water conservation
84. Microbial desalination

T. Refugee camps
84. Employment
85. Food sources
86. Emergency shelter
87. Community water

U. Democracy
88. Access to needs
89. Real choices
90. Education
91. Politics

V. Industrial toxins
92. Design for decomposition
93. Green solvents
94. Green adhesives
95. Forever chemicals

W. Housing
96. Double-decker burbs
96. Temporary housing
97. Affordable housing
98. Homeless shelters

X. Mental health
99. Biophilia
100. Negative ions
101. Pet therapy
102. Nature therapy

Y. Over-population
103. Economic design
104. Doing nothing
105. Inequitable design
106. Gender inequality

Z. Concrete
107. Cement substitutes
108. Self-healing bacteria
109. Self-healing fungi
110. Hempcrete

Biodiversity and Climate
111. Ocean sinks
112. Soil sinks
113. Grassland sinks
114. Forest sinks
114. Wetland sinks

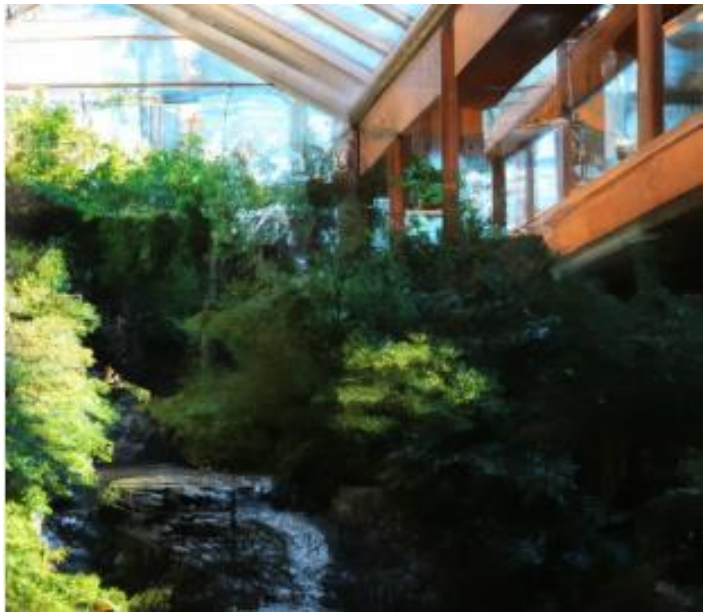
More to come

Suggestions or corrections are welcome

A. Climate mitigation

1. Carbon sequestration: With net-positive design, buildings can sequester more carbon than they emit over their lifecycle using permanent, building-integrated vegetation (shown quantitatively). For example, multi-purpose PD 'Green Scaffolding' systems can produce ecosystem services and increase nature.

https://www.tandfonline.com/doi/abs/10.1080/09613218.2015.961001



Birkeland, Structural green scaffolding

A. Climate mitigation

2. Sea level retrofits: Sea water can infiltrate freshwater aquafers through rocks and dirt below sea walls.

Abandoned flooded cities will contaminate the oceans, so retrofitting is absolutely necessary.

Lower levels of coastal buildings could be sealed with non-toxic waterproof materials, and streets and walkways could be constructed at higher levels.

https://www.insurancejournal.com/news/national/2020/07/30/577498.htm

https://www.weforum.org/agenda/2019/06/how-china-s-sponge-cities-are-preparing-for-sea-level-rise/

https://earth.google.com/web/@34.7325599,-94.20828246,31753.68522125a,12000000d,35y,0h,0t,0r/data=CjASLhIgNzJlM2QwZWU3NGMyMTFlODhjMWNiZjg2OTQ1ZTVlZWMiCnZveV9zcGxhc2g

A. Climate mitigation

3. Street havens: Buildings and spaces can use durable exterior shading and structures with integrated solar cells, etc. In hot regions, urban gardens can benefit from shading and power generation.

Cities are incorporating shade structures that support solar panels and reduce the city's reliance on fossil fuels. (France has mandated solar cells on all parking lots by 2028.)

https://www.governing.com/next/transforming-farms-food-production-with-solar-panels.html

This 'chill out' seating combines charging stations, solar power, sensors, lighting, public WiFi, greenery, smart fountains and smart bins.

https://streetfurniture.com/world-first-smart-chillout-hubs-designed-and-built-in-australia/

https://www.forbes.com/sites/carltonreid/2022/11/09/solar-panels-must-cover-large-parking-lots-rules-french-senate/

A. Climate mitigation

4. Shade trees: Trees and vegetation can shape public spaces and parklets that channel breezes as needed to prevent stagnant ground level pollution (ozone, etc.) using, for instance, the Venturi Effect.

Trees reduce the 'UHI effect' - amount of heat absorbed by pavement and buildings that radiate heat back when the urban air cools.

https://www.architecturendesign.net/45-of-the-worlds-most-magical-streets-shaded-by-flowers-and-trees/

https://twistedsifter.com/2013/02/wisteria-flower-tunnel-kawachi-fuji-garden-kitakyushu-japan/

A. Climate mitigation

5. Urban cooling: Solar-powered water sprays, fountains, drip wire over screens. (Even roof water tanks that heat up in the sun can be designed to release heat to the interior at night).

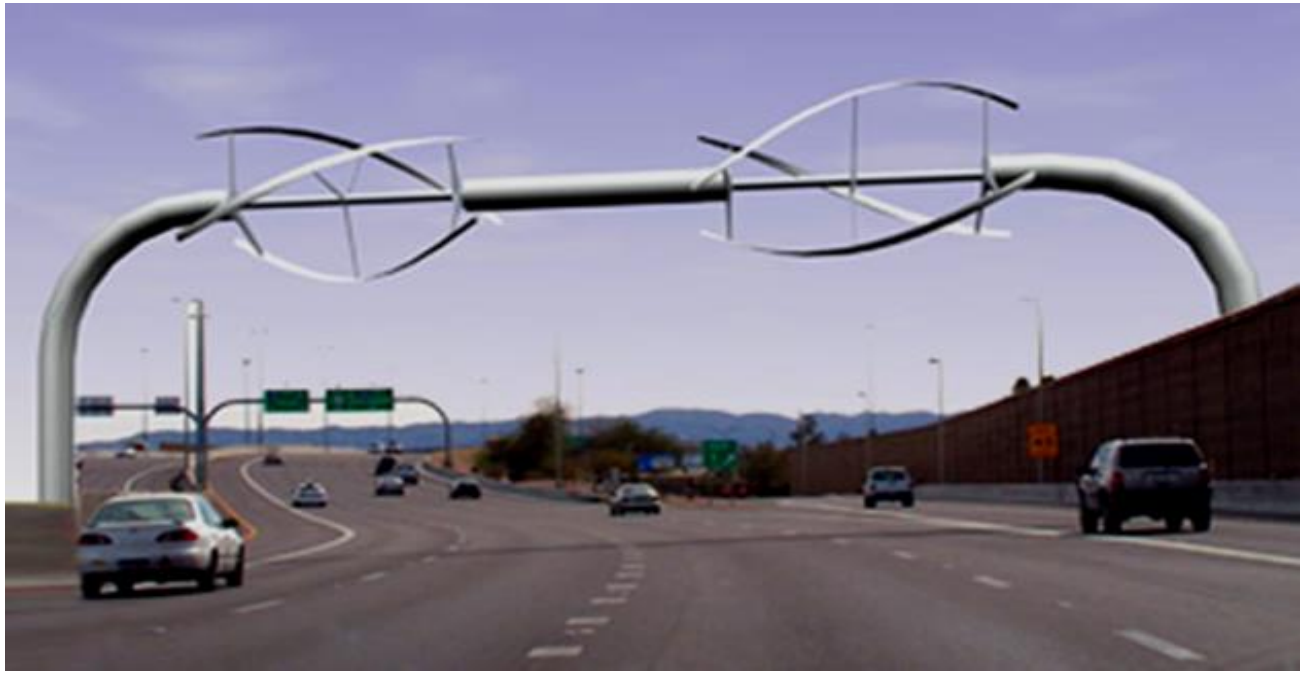
Sprays enable more outdoor social activity and amenity in hot urban centers (urban ponds have little cooling effect - but provide amenity along with water storage for sprays and social activity).

B. Energy/heat Production

6. Urban wind: Single-function structures used for radio towers, bridges, overpasses, signs for roads or buildings can pay back their costs by producing energy.

They can be designed or modified to support plants and/or urban-integrated wind generators that power signs, nearby buildings, streetlights, etc. They feed back into the grid and provide electricity in black-outs.

https://www.sciencedirect.com/science/article/pii/S2666165920300296



B. Energy/heat production

7. Algaetecture: Buildings can be retrofitted with 'bio-reactive facades' to supply hot water and space heating. The algae panels shade the building while growing biomass and generating heat. The biomass is harvested via floatation, and the heat is used via a heat exchanger. The algae eat carbon from nearby combustion processes to reduce urban waste and pollution.

The panels shade the building where needed. Excess heat is stored.

https://www.morethangreen.es/en/solarleaf-solar-leaf-algae-bio-reactive-facade/

https://www.actu-environnement.com/ae/news/performance-energetique-batiments-biofacade-cstb-microalgues-31966.php4

B. Energy/heat production

8. Solar windows: Building-integrated photovoltaics mean that solar cells are embedded in façade, roofing and shading materials or in interior ‘solar blinds’. Windows with embedded solar cells can be responsive to changing sunlight and provide sun screening. They are becoming more widely available.

https://solarmagazine.com/solar-roofs/solar-shingles/

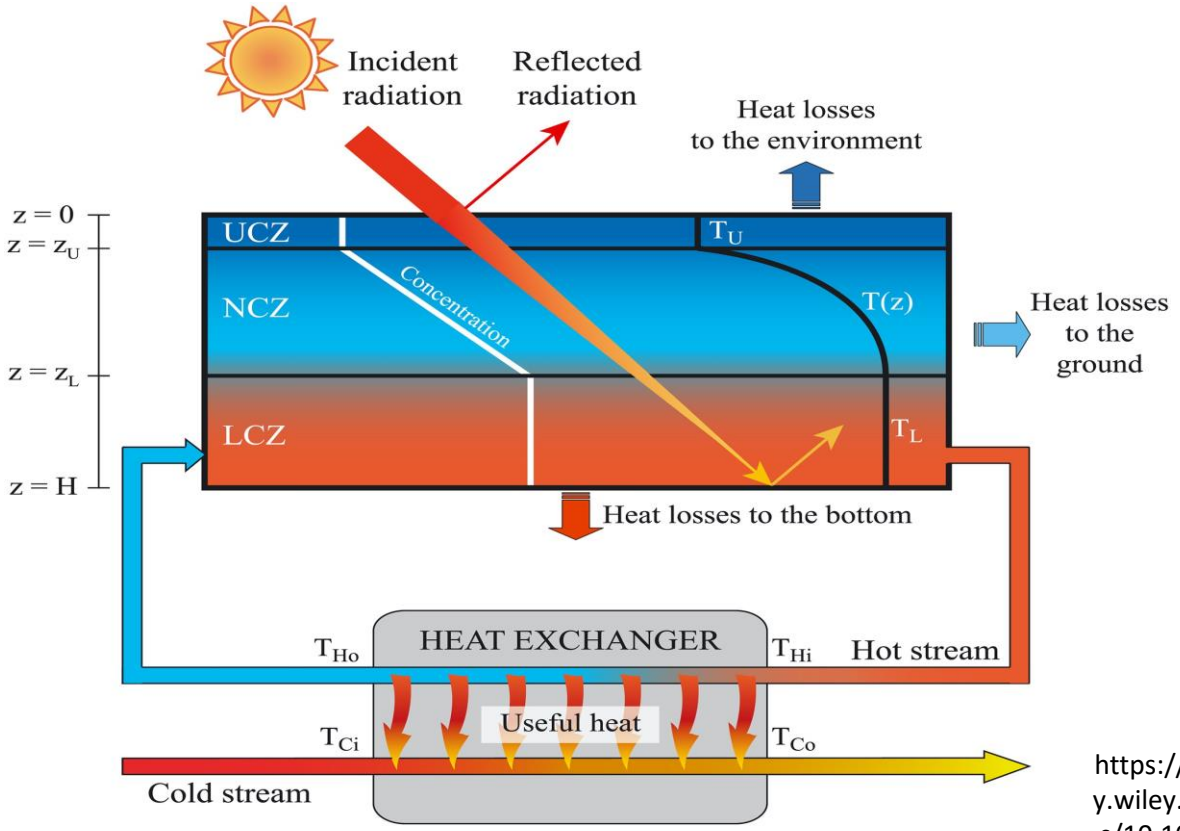
https://news.energysage.com/solar-panel-windows-solar-blinds/

https://www.solarreviews.com/blog/what-are-solar-windows

B. Energy/heat production

9. Solar (salt) ponds: Solar ponds produce and store heat and salt, usually for industrial purposes. For instance, they have been used for heating industrial buildings, brining shrimp and producing salt. They can be used to desalinate land. They can provide resting areas and food sources for waterbirds that must travel over arid regions.

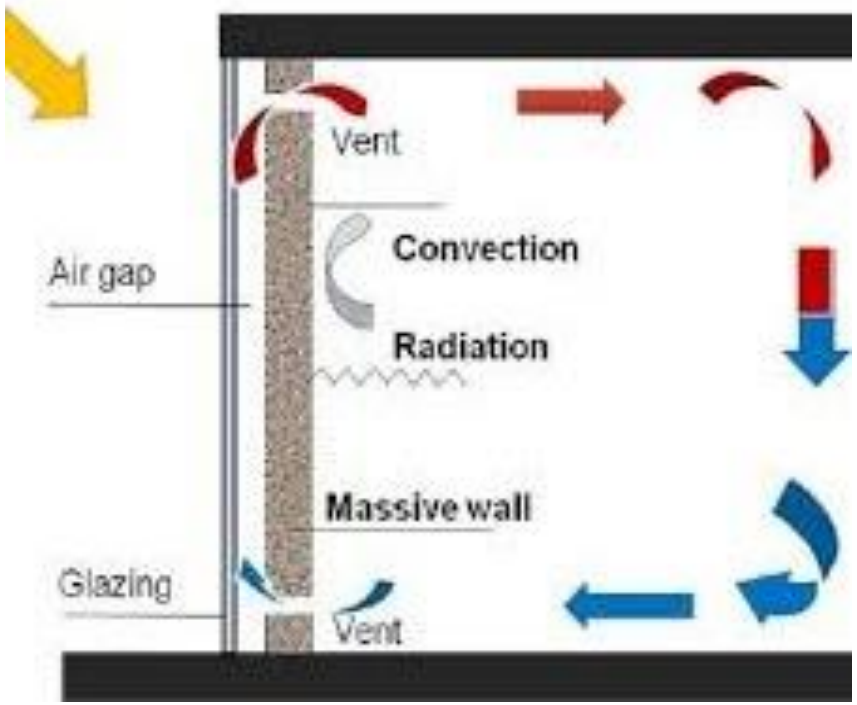
CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=423014



https://onlinelibrary.wiley.com/doi/abs/10.1002/er.3539

C. Energy/heat production

10. Trombe walls: These are common passive systems that can be added to windowless, sun facing walls to generate passive cooling, heating and ventilation. They can also be installed behind windows that lack a view. They have been used in many large buildings as well as homes.



https://www.researchgate.net/publication/228678835_Heat_gain_through_Trombe_wall_using_solar_energy_in_a_cold_region_of_Turkey

https://www.treehugger.com/

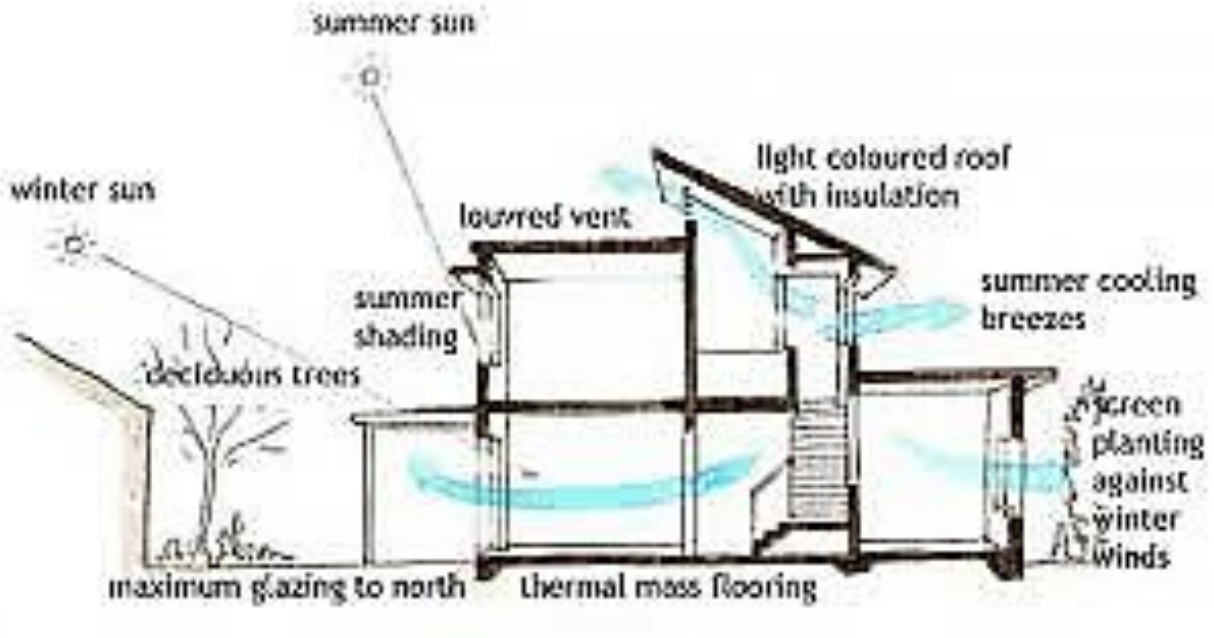
http://www.designbuildbluff.org/

https://en.wikipedia.org/wiki/Trombe_wall

https://www.researchgate.net/publication/275213123_Performance_amelioration_of_a_Trombe_wall_by_using_Phase_Change_Material_PCM/figures?lo=1

C. Energy saving

11. Passive solar homes: Buildings can provide all their own heating, cooling and ventilating needs (at least in moderate climates) with passive solar energy retrofits. In very cold climates, basement rock storage containers can store heat for many days during snowstorms. These were used in some homes constructed over 60 years ago.



https://360building.com.au/passive-solar-building-design/

C. Energy saving

12. Passive solar retrofits: Urban retrofitting for resource autonomy, efficiency and other benefits can ‘blend in' with any constraints, such as sites with poor solar access, restrictions on changing historic buildings, or local cultures and aesthetics, as has been demonstrated many times. They can support biodiversity (eg. green roofs).

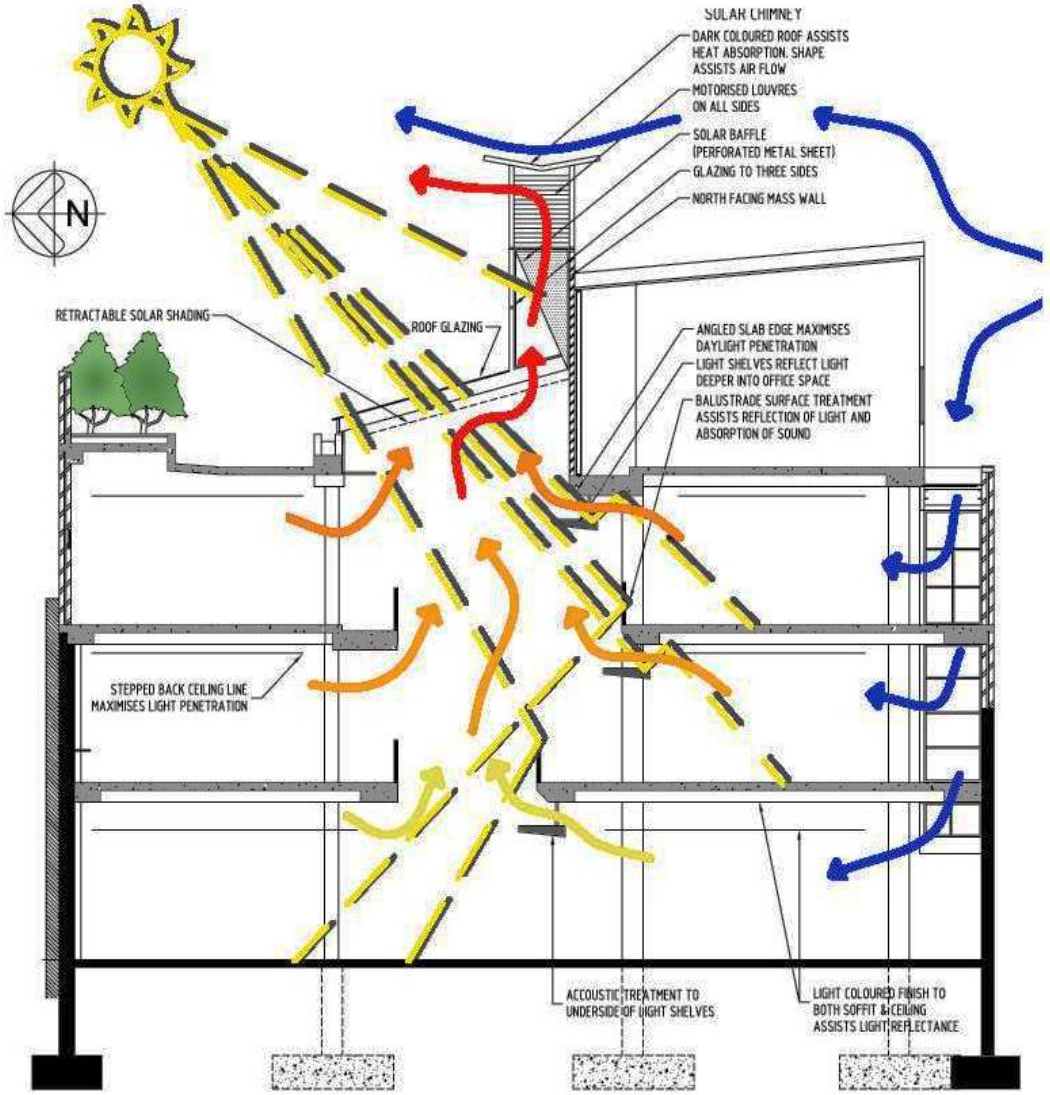
wbdg.org

Construction21.org

C. Energy saving

13. Passive lighting: Daylighting and views been proven to increase worker health and productivity. Retrofitting with clerestory windows, skylights, light shelves, mirrors, light wells can reduce lighting costs and grow interior gardens. Lighting costs are still substantial in most office buildings despite energy-efficient bulbs and renewable energy.

https://www.c-sgroup.com/sun-controls/daylight-systems



C. Energy saving

14. Optical fibres: In addition to daylighting methods, indoor urban farms can use optical fibres to send light into the building via collectors on the roof. (Optical fibers transmit light pulses along glass 'hairs' or plastic fibers bundles.)

Planting walls behind curtain glass windows can also reduce indoor glare and heat gain.

https://balconygardenweb.com/green-plants-as-a-curtain-living/#google_vignette

C. Energy saving

https://www.glassonweb.com/article/evaluating-use-double-skin-facade-systems-sustainable-development

15. Curtain wall retrofits: Covering old curtain glass windows with films, double glazing, or 'window walls', can reduce heating and cooling loads. If replace by embedded solar cells windows they can provide renewable energy.

Many of the panels could be covered with outdoor planting boxes if accessible from inside for maintenance.

A window wall is another option for improving acoustics and ventilation.

https://www.constructioncanada.net/glazing-performance-and-sustainable-design/

D. Floods and waves

16. Shore restoration: Shorelines are eroding from waves and storms caused by climate change. Although concrete bollards are often used which can support some marine life, more eco-logical options are available, such as discarded oyster shells in cages.

These support nurseries for marine biodiversity and fish production.

https://www.tfhmagazine.com/Reef restoration projects

D. Flood and wave mitigation

17. Reef restoration: Scrap metal (even clean car bodies) are increasingly used to create substrates for reefs to grow and provide baby fish nurseries.

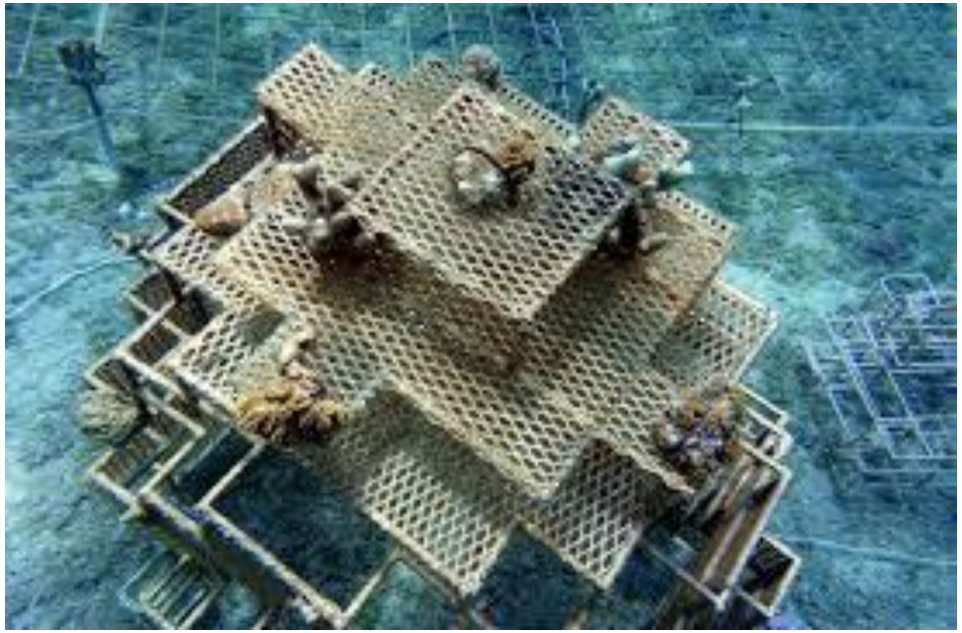
Artificial structures not only grow reefs to support marine life but help to protect coastlines and coastal cities from storms and surges.

https://www.nature.org/en-us/

https://wildnet.org/regenerating-the-great-barrier-reef-one-coral-at-a-time/

https://www.tfhmagazine.com/Reef restoration projects

https://www.globalcoral.org/new-cozumel-coral-restoration-project/



D. Flood and wave mitigation

18. Rural floods: Dams poison rivers when they cover mines and agricultural lands, and they often produce methane. Floods that break flood barriers and dams do far more damage than natural flood cycles.

A movement to 'unplug' old dams has gradually gained scientific endorsement in recent years.

https://thehound2.files.wordpress.com/2015/05/glines-removal.jpg

The USA has removed over 1,000 dams. Mini-hydro is far less harmful.

D. Flood and wave mitigation

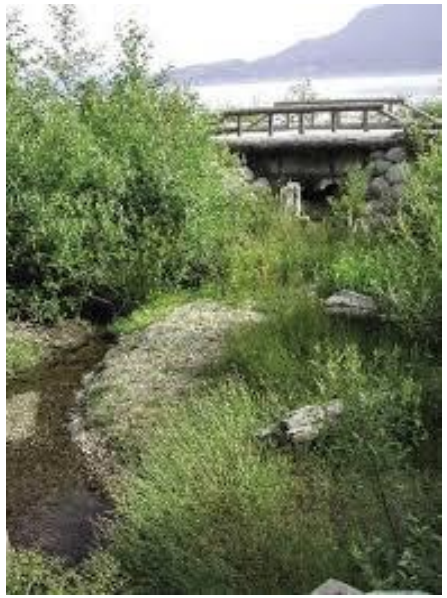
19. Urban floods: Although conventional urban infrastructure has exacerbated flood impacts, there are many landscaping solutions. These include diverting excess urban water into reservoirs in parks, and ‘daylighting’ or exposing buried streams to manage flood waters.

Flood-prone land can be converted to recreational uses which allow for quick evacuation in unusually bad floods.

http://nrcsolutions.org/daylighting-rivers/

https://www.wikiwand.com/en/ Daylighting

https://www.psands.com/saw-mill-river



https://chesapeakestormwater.net/events/webcast-urban-stream-restoration/

E. Natural disasters

20. Tornados: Community facilities can serve as refuges in fires (CFRs), cyclones or other crises where evacuation may be difficult. They can store emergency firefighting and medical equipment while serving multiple public functions at other times. Semi-underground shelters under new public parks or playgardens are good locations.

Albert France-Lanord Architects

Archimania

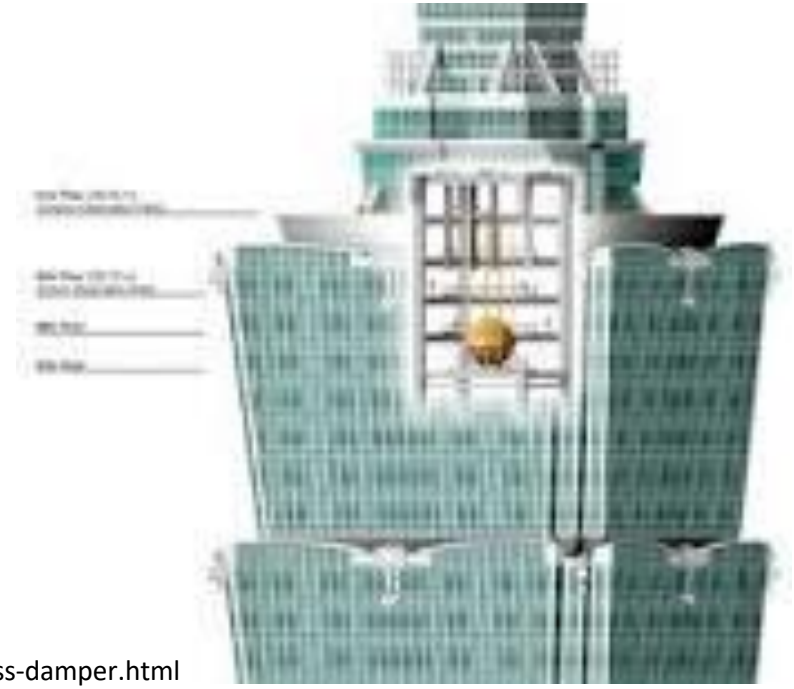
E. Natural disasters

21. Earthquakes: Buildings can be designed or retrofitted to be more tornado-resistant with more aerodynamic shapes that reduce wind drag.

Tornado-safe rooms or shelters within buildings, combined with early warning systems, should be built into new projects and undertaken in retrofits where other options would not be better.

The Taipei 101 tower is aerodynamic to minimize its movement during storms or earthquakes and has a 'seismic damper', a large pendulum located near the top of the tower to reduce vibrations and counteract wind-induced movements.

https://www.civilengineeringweb.com/2021/04/what-is-tuned-mass-damper.html



Taipei 101 tower was tallest tower in 2019

https://en.wikipedia.org/wiki/Taipei_101

E. Natural disasters

22. Typhoons: Homes can use passive design such as curved or sloping roofs to reduce the amount of wind pressure on the structure or risk of damage from high winds.

Windows and vents at the top and bottom of a building's walls can help to equalize pressure inside and outside the building.

https://www.theplancollection.com/blog/designing-homes-to-withstand-wind-water-and-fire

https://www.topsiderhomes.com/hurricane-proof-homes.php

Typhoon-resistant homes usually use sloped roofs. A 30-degree roof slope for wind deflection is generally recommended.

Steel trusses or cables can keep the roof attached to the walls.

Impact-resistant laminated glass windows or shutters can withstand more debris.

Exterior walls reinforced with structural foam can help absorb and distribute the wind. Round structures reduce wind impact.

Green concrete and concrete substitutes can provide structural strength.

E. Natural disasters

23. Fires: Water pipes can fail in earthquakes that cause urban fires. Buildings should provide integrated rainwater storage tanks linked to irrigation systems for landscaping. In case of fires or extreme heat waves or heat inversions, they can be used to spray mists on the building roofs, facades and surrounding streets.
They were recently used to protect sequoias.

https://completepumpsandfire.com. au/what-are-esfr-sprinkler-systems/

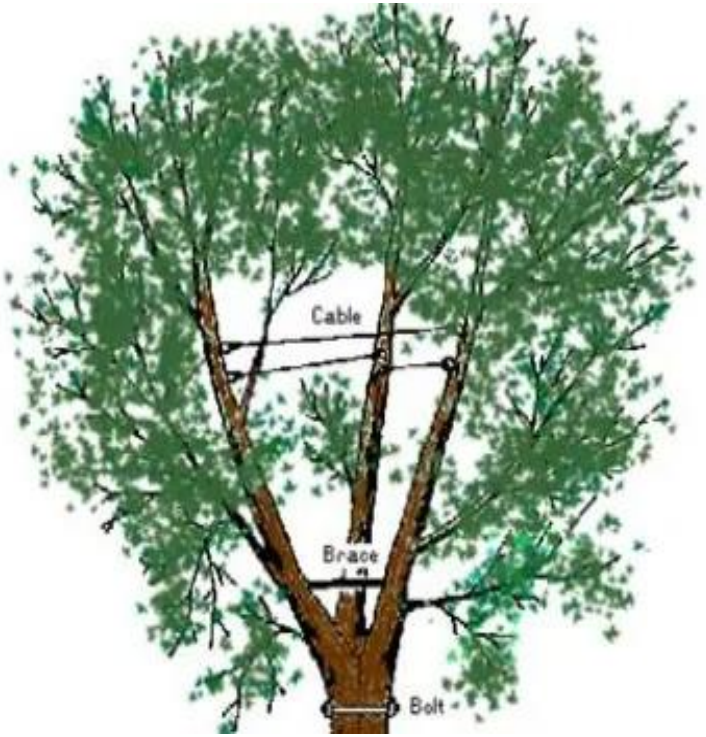
E. Natural disasters

24. Storms: To reduce demolition impacts, old buildings or unstable trees can be strengthened or storm-proofed with low-cost internal or external cables (or Green Scaffolding that supports multiple additional functions).

Cables are far more adaptable than heavy machinery and industrial materials.

Impoverished regions could use bamboo or wire to similar effect.

https://link.springer.com/article/10.1007/s10518-020-00875-3



https://www.soundarbor.com/cable-and-bracing

https://www.carlstahl-architektur.com/en/applications/facades/

Icoxindia.weebly.com/blog/different-types-of-large-span-structure-and-their-advantages-and-disadvantages

E. Natural disasters

25. Sink holes: Sinkholes can occur where ‘dissolvable’ underground materials like gypsum, salt, and limestone are eroded by water that does not drain well. Earthquakes, slides and sinkholes also increasingly occur due to cumulative oil, water or resource extraction. Some so-called 'sponge cities' are filling such gaps with water that drains when full.

Lynbrook Estate stormwater wetland, Melbourne

https://www.independent.co.uk/

https://www.cbsnews.com/pictures/giant-sinkholes/

https://www.cbsnews.com/pictures/giant-sinkholes/

F. Urban food security

26. Food access: Urban farms reduce transport impacts and can prevent food shortages in economic or civil crises.

Some apartment houses, restaurants and grocery stores use their own roofs or rent roofs to grow their produce, or to create attractive outdoor dining areas and so on.

These can revitalize urban districts and build community.

https://saigoneer.com/saigon-health/2430-rooftop-vegetable-gardens-catching-on-in-hanoi

https://www.weforum.org/agenda/2014/11/how-rooftop-gardens-can-help-combat-flooding/

ouzz.com.au/photos/rooftop-garden-design-ideas

These gardens also provide relief from the concrete jungle.

F. Urban food security

27. Crop 'rotation': Industrial-scale vertical agriculture has been established in old abandoned warehouses as well as new urban greenhouses. These are relatively free of pests and disease.

Some use rotating container systems for easy accessibility for planting and harvesting the crops. These expose plants to skylights to provide the ideal amounts of sunlight.

https://ourworld.unu.edu/en/farming-in-the-sky-in-Singapore. Photo: Kalinga Seneviratne/IPS.

F. Urban food security

28. Aquaponics: Urban aquaponics can address overfishing. It is a closed-loop system where fish produce the nutrients that grow vegetables. The fish make fertilizer for the plants to grow that in turn feeds the fish, and both can be harvested. It can work at the domestic or commercial scale and can utilize kitchen food waste.

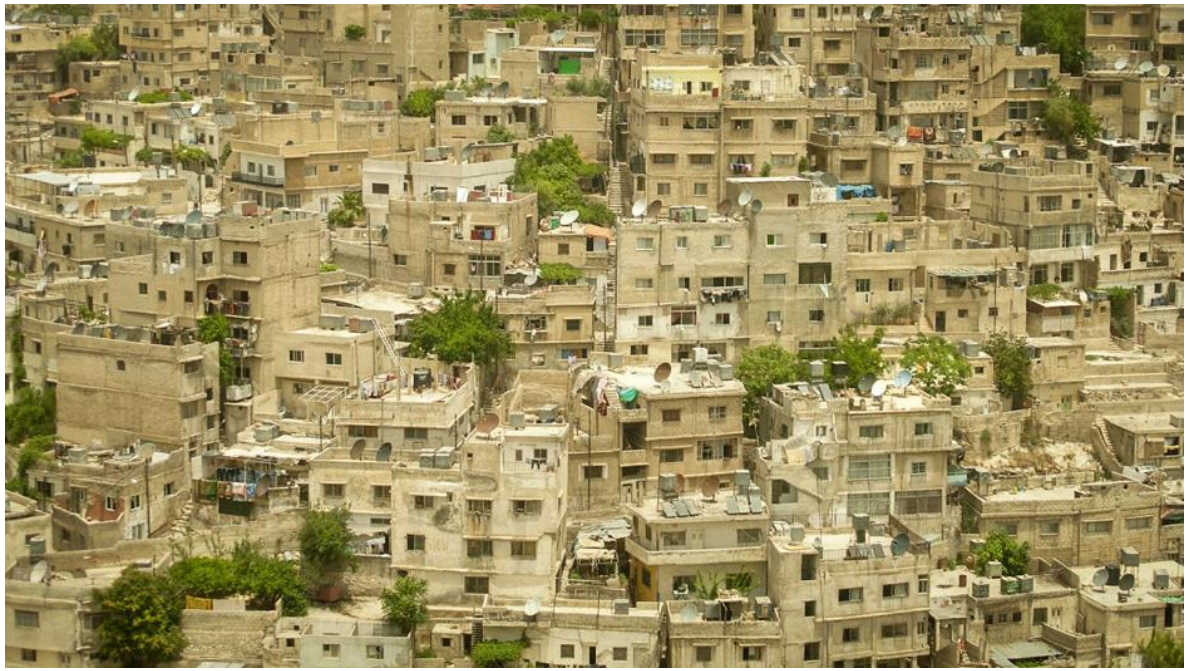
F. Urban food security

29. Community gardens: Urban food deserts are common in disadvantaged areas of cities. These self- managed food gardens can be established on vacant lots, abandoned buildings or unused spaces in the area.

http://vpuu.org.za/safe-node-area/community-urban-gardening/

https://use.metropolis.org/case-studies/brasil-sao-paulo-community-gardens

- The **People's Grocery** in Oakland *also* offers nutrition education and job training programs.
- **La Finca del Sur** in the South Bronx *also* offers job training and educational programs for youth.
- The **Edible Schoolyard** in New Orleans *also* educates students about healthy eating and environmental sustainability.
- **Growing Power** in Milwaukee *also* offers educational programs and job training opportunities for residents.
- **City Blossoms** in Washington D.C *also* offers educational programs for youth and adults.



https://ourworld.unu.edu/en/in-home-gardens-income-and-food-for-urban-poor

G. Soil production

30. Urban composting: Silent, non-odorous, vertical processors in urban areas can treat organic waste from the surrounding district to produce soil for urban landscapes or public gardens and provide fuel.

A variety of systems have been used at the individual building scale as well, such as systems in basements.

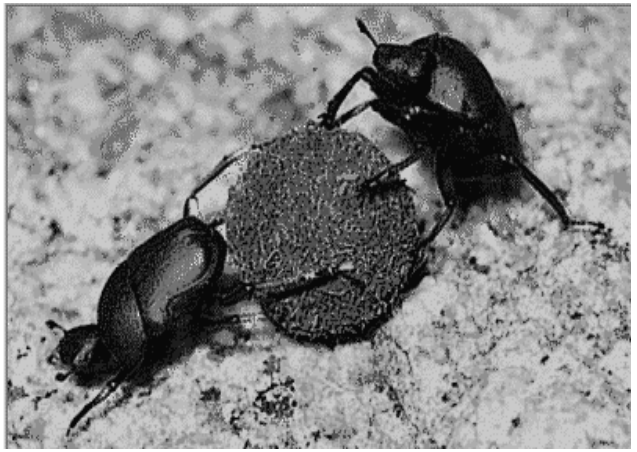
https://theconversation.com/city-compost-programs-turn-garbage-into-black-gold-that-boosts-food-security-and-social-justice-136169

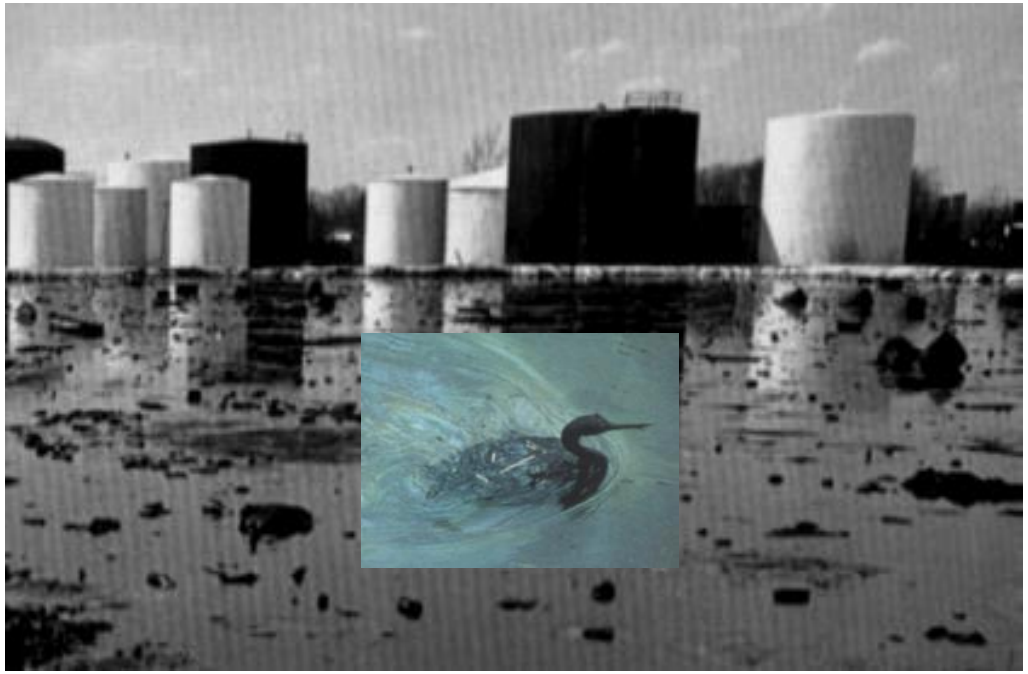
https://www.darpro-solutions.com/industries-served/industrial-service

Urban composters treat urban waste to reduce transport impacts and support urban parks and gardens.

G. Soil production

31. Decontamination: Some remediation companies have long used microbes to decontaminate soil. Soil can also be effectively regenerated by earthworms and detoxified by mushrooms. While earthworms turn waste into resources, mushrooms can process pollution and remain edible. This is net positive.





https://www.yesmagazine.org/environment/2019/03/05/mushrooms-clean-up-toxic-mess-including-plastic-why-arent-they-used-more

G. Soil production

32. Erosion: Urban stormwater systems channel rain runoff in ways that cause erosion, water and soil pollution and sedimentation. Many 'water-sensitive landscape' strategies slow down, filter and store excess runoff or release it slowly.

However, retaining walls could also provide biodiversity habitats (unlike typical engineering).

G. Soil production

33. Biochar: Biochar is a form of charcoal that is produced by heating organic materials in the absence of oxygen (pyrolysis). It releases CO_2 during pyrolysis, so it must be produced with renewable energy sources and waste.

https://www.biochar-industry.com/biochar/

Biochar improves:

- **Soil moisture**: It's porous structure holds onto water longer and reduces water stress on plants.
- **Nutrient availability**: It's high surface area and ability to attract nutrients provides the nutrients to plants (eg. nitrogen, phosphorus, potassium).
- **Soil structure**: It promotes the growth of microorganisms that break down organic matter and create channels for water and air in the soil.
- **Carbon sequestration**: It is carbon and can sequester carbon in the earth for thousands of years.
- **Reduces fertilizer use**: Synthetic fertilizer have more impacts on climate change, energy consumption and water pollution.
- **Roads and buildings**: Biochar improves the durability of concrete and asphalt as well as sequestering carbon.

H. Material sources

34. Construction: Hempcrete can sequester carbon and can be poured like concrete or used as boards or soft insulation.

Robotically-printed buildings are rapidly advancing and could soon print out bio-based materials like hempcrete in lieu of ecologically harmful concrete. Some technical issues remain to be resolved.

https://alternativehousingoptions.com/what-is-a-hempcrete-or-hemp-block-house/

https://www.treehugger.com/hempcrete-house-5113218

https://www.isohemp.com/en/building-hemp-blocks-insulating-and-efficient-envelope

hemptoday.net

H. Material sources

35. New IFC materials: Mycelium (mushrooms) could replace Styrofoam in the efficient ICF process (insulated concrete formwork) system, which could then be filled with hempcrete.

Harmful Styrofoam and concrete could be avoided without have to change conventional construction practices or consumer tastes..

https://www.icfblocksolutions.com/

https://www.octaform.com/blog/news/icf-vs-octaform/

https://buildblock.com/how-to-build-an-icf-home/

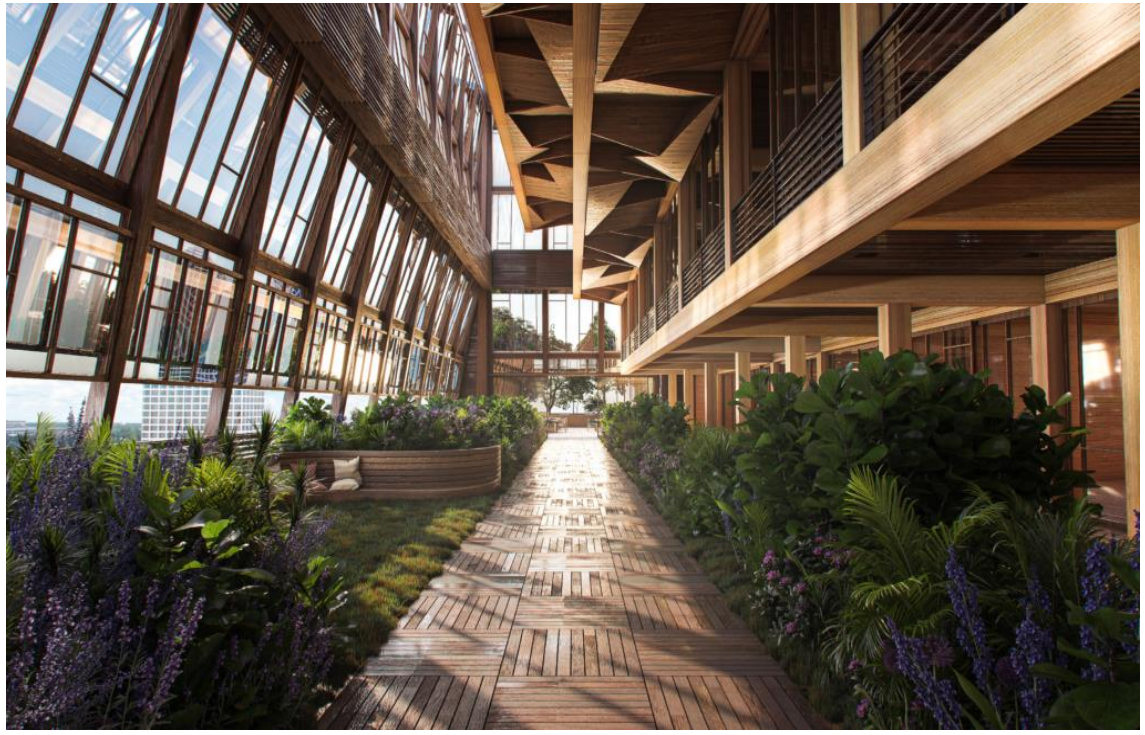
https://thermohouse.ie/blog/pros-cons-icf/

H. Material sources

36. Bio-based products: There are many building products from agri-waste (strawboard, strawbale, etc.) or crops (bamboo, hemp, etc.) or dirt (mud bricks, pressed earth, etc.). Straw, bamboo, and hemp can also be pressed into boards.

Bamboo has been used in architecture as a structural material in its natural form with stunning designs.

https://materialspalette.org/straw-bale/



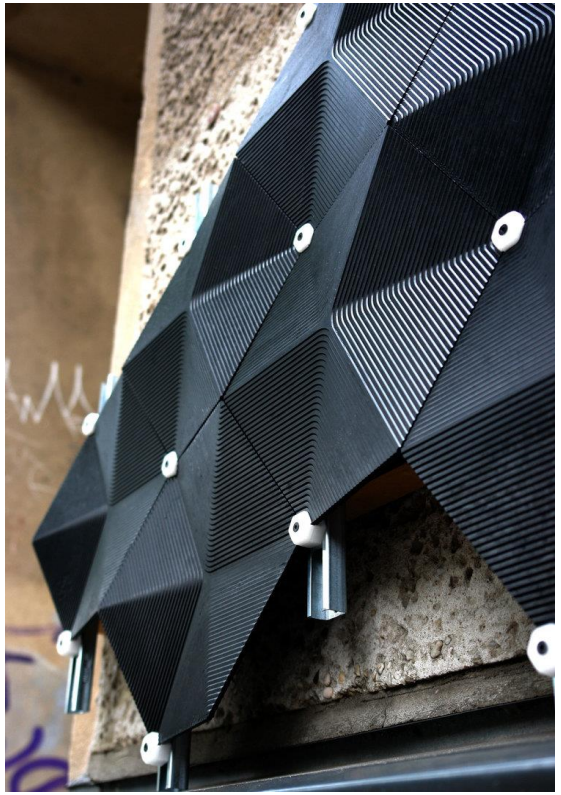
https://4returns.commonland.com/organisations/rizome-bamboo-climate-positive-building/

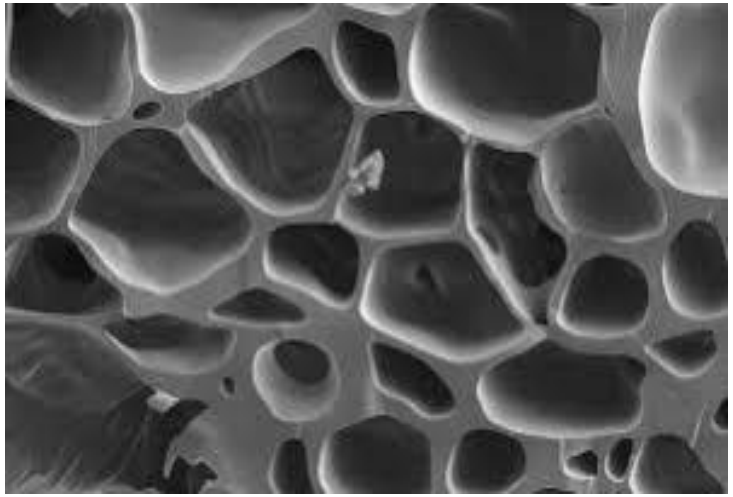
https://www.sumatranorangutan.org/our-work/creating-new-wild-populations/orangutanhaven/

H. Material sources

37. CO_2 absorbing materials: Certain concrete and mortar products claim to absorb CO_2.

Building materials such as mortar, bricks, concrete or plaster can contain biochar (biomass burnt in oxygen-free chambers). New materials can be moulded from it. However, it could lead to harmful plantations for growing biochar and involves pyrolysis.





https://char-grow.com/

Note: Claims that such products sequester net carbon may leave pyrolysis out of the calculations.

https://www.materialdriven.com/blog/2018/12/3/a-case-for-carbonnegative-materials-made-of-air

I. Land regeneration

38. Desert restoration: Deserts have delicate ecosystems, but developed areas that have degraded into deserts may be suitable locations for new cities or industries, assuming population growth is not reduced.

Such developments could fund the regeneration of nearby deserts and halt further desertification of fertile land.

https://pitchstonewaters.com/drought-busters-restoring-desertified-desert-grasslands/

https://sand-boarding.com/desert-cities/

I. Land regeneration

39. Urban forests: Trees have been used to decontaminate urban industrial areas while providing recreational uses until the land is safe for direct contact by humans. The trees can be harvested for materials or remain as a parkland.

Since contact with nature is becoming more highly valued, there has been growing public pressure for the preservation of treed areas near cities.

https://www.nature.org/en-us/newsroom/ny-forest-for-all-nyc-urban-forest-agenda/

https://archello.com/de/project/forest-park-bridges

https://www.weforum.org/agenda/2017/07/welcome-to-china-s-urban-forest/

I. Land regeneration

40. Land rewilding: Mycelium-based bricks, boards and insulation can be grown in vertical spaces. This means that agricultural, mining, and forest lands that are currently used for producing building furnishings and materials could gradually be rewilded - or at least reclaimed for public purposes such as outdoor education and recreation.

https://www.buildwithrise.com/stories/mycelium-fungi-as-a-building-material

https://www.buildwithrise.com/stories/mycelium-fungi-as-a-building-material

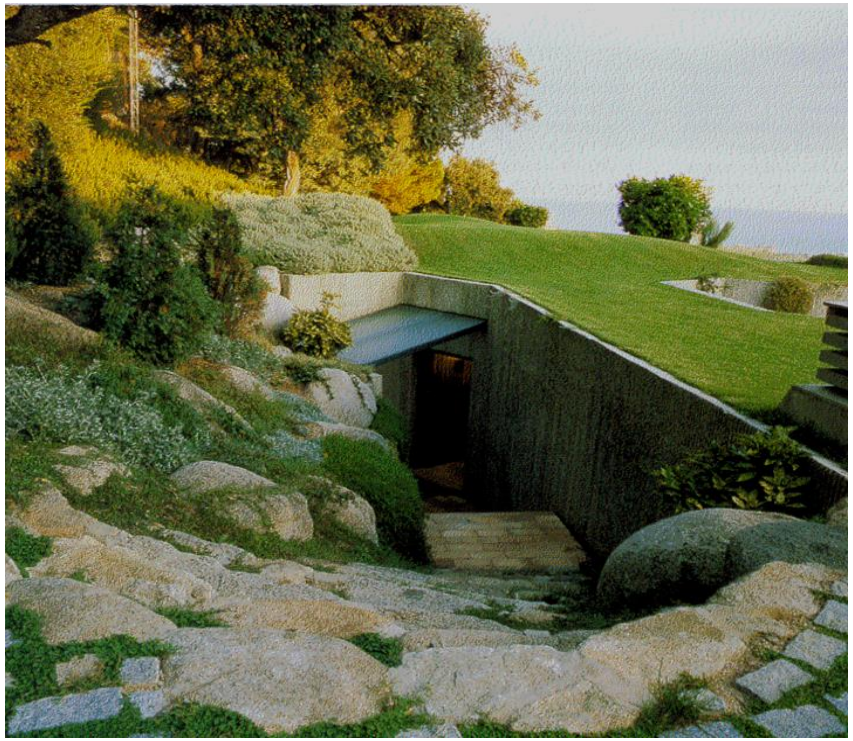
I. Land regeneration

David Baggs
architect

41. Off-ground buildings: There are many reasons for elevated buildings, as traditionally used in tropical climates for ventilation, or for underground buildings that increase fire protection, insulation, etc.

Both enable the preservation of more ground area for relatively natural land uses, vegetation and habitats (although access roads as still needed).

https://www.brisbanetimes.com.au/national/queensland/world-s-greenest-residential-building-slated-for-brisbane-20200706-p559ip.html



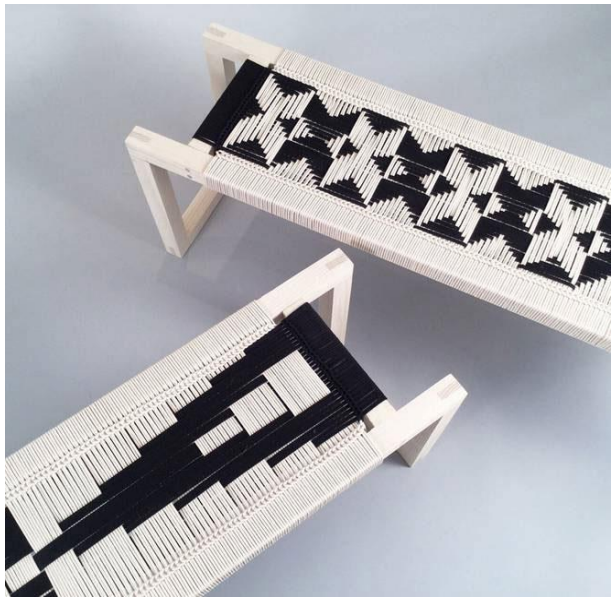
https://simple.wikipedia.org/wiki/Elevated_building_foundation#/media/File:Municipal_Services_Building-3s.jpg

J. Human health

42. Furnishings: Interior fabrics can be produced from low-impact materials like jute, cork, wool, hemp, bamboo, recycled plastic, eelgrass - and now even algae - that improve indoor air quality.

These reduce the huge cumulative, embodied energy caused by furniture due to real estate churn and continuous renovations to suit changing occupant preferences.

https://inhabitat.com/furniture-made-from-the-sea-plant-eelgrass/sdt_soeuld_10/ David Thulstrup



https://mindfuldesignconsulting.com/from-recycled-milk-jugs-to-woven-cotton-eco-friendly-furniture-ideas-for-your-interior-design/

https://m.facebook.com/Indonesia-Bamboo-Furniture-261139664547198/?_se_imp=1ibwj1ahMvSCii6Yq

J. Human health

43. Living walls: The benefits from regular exposure to greenery are now scientifically validated. Employees, commuters or students working in or around greenery are measurably healthier and more productive than their counterparts (even if facilities managers get annoyed). The additional oxygen and pollution absorption from plants are among many factors. This use of nature for human health is now commonly called 'biophilic design'.

J. Human health

44. Combined systems: Products are now available that combine technology that monitors air quality, microbial filters, hydroponic conditions, with provide specific plants that can absorb the problem toxins in the particular environment.

https://www.biome.us/taiga

https://www.freepik.com/premium-photo/vertical-green-wall-living-room-interior-3d-render_24038411.htm

J. Human health

45. Organic interiors: Modern furniture, cleaning products and building materials are well known for off-gassing toxins and have substantial embodied impacts in production as well.

'Organic' interior materials such as bamboo, hemp, mud bricks, earth, timber, etc., and green walls are far better for people than conventional indoor environments. s

Girbaud, New York

Al Patatrie Restaurant

Girbaud, Osaka

Omotesanto Gyre

K. Urban biodiversity

46. Nature retrofits: Every eco-positive retrofit could support biodiversity and create habitats, as well as collect, store and treat water, reduce the urban heat island and pollution, improve passive thermal performance, integrate renewable energy systems, increase human health, biophilic amenities, urban food security, urban air quality, and so on.

Birkeland examples of façade alterations 2007

Horizontal ducts transfer heat and coolness to Trombe walls and solar stacks

These conversions could support far more vegetation when fully grown

K. Urban biodiversity

47. Retrofit scaffolding: Green Scaffolding are space frames (Birkeland 2007) that support passive and natural systems, biodiversity habitats, etc. and can form the basic structure of the building itself or be used to retrofit all or part of a building envelop. Green Scaffolding could support up to two dozen ecosystem services in one building.

Birkeland examples 2007

K. Urban biodiversity

48. Structural Scaffolding: While retrofitting can support many building and environmental functions, it can also create more urban 'ecological space' to support specific bird species or ecological needs.

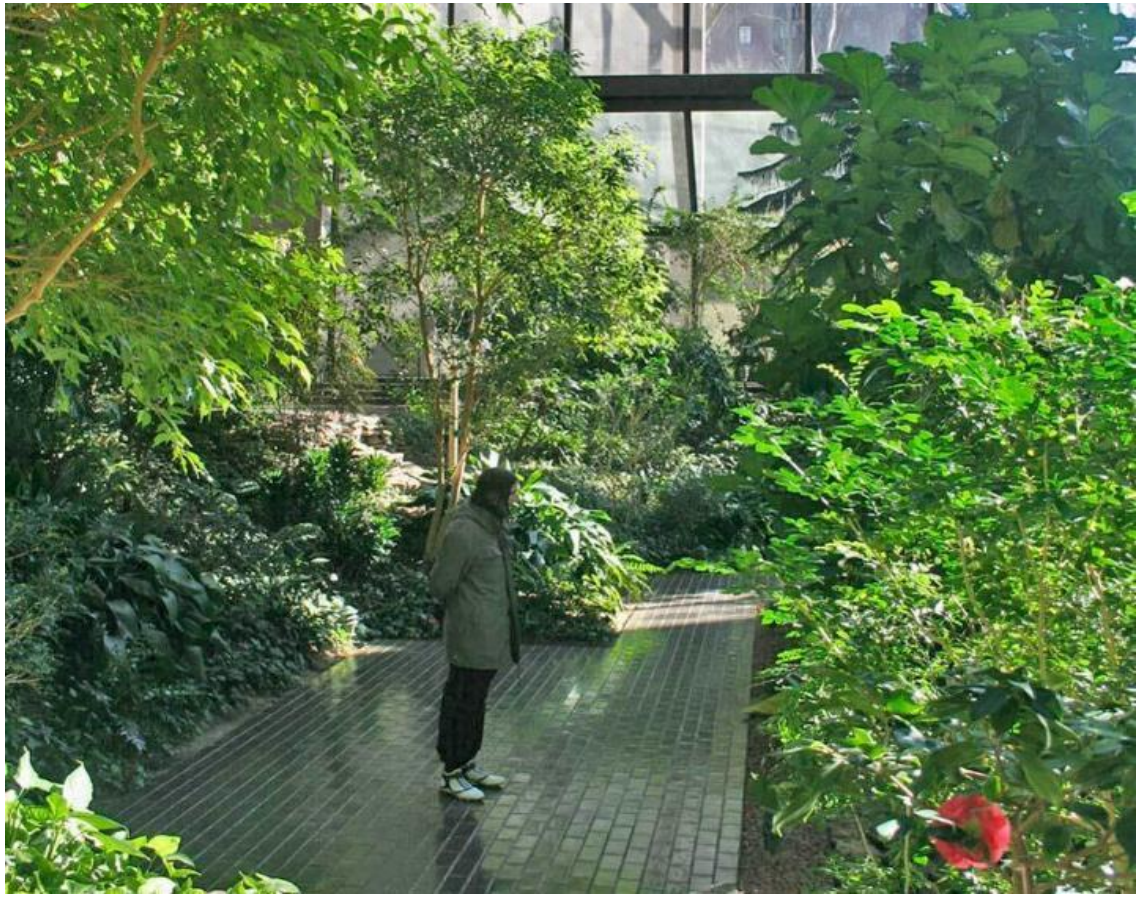
Such additions can be designed to improve aesthetic qualities or urban environments by mitigating the impacts of ‘brutalist’ building.

https://www.thenatureofcities.com/2021/04/30/what-actions-are-successful-in-activating-cities-to-implement-urban-biodiversity-conservation-policies-campaigns-and-projects/

Green Scaffolding building example: Birkeland

K. Urban biodiversity

49. Ecological space: Buildings can be retrofitted with biodiversity habitats in atriums, roofs, walls, or whole building floors dedicated to ecosystem enclaves while also supporting passive systems for thermal functions and compatible social activity to regenerate occupants.



K. Urban biodiversity

50. Nature corridors: Biodiversity passages throughout cities and regions are now essentil. As cities both densify and spread, the isolation of animals from prospective mates and lack of escape from feral predators is worsening.

Corridors as well as roofs, building floors, and facades dedicated to endangered species must also deter feral predators.

https://researchoutreach.org/articles/preserving-biodiverse-river-corridors-sustainable-city-development/

https://largelandscapenews.org/2021/07/02/invest-act/

https://conservationcorridor.org/digests/2012/11/australia-releases-national-wildlife-corridor-plan/

https://www.lifegate.com/trend/activism

L. Infrastructure

51. Sewage: ‘Living Machines’ (by J. & N. Todd) have been used to treat waste and pollution from buildings, industries and truck stops. They often use a series of vessels filled with water-based ecosystems to support selected microbes that eat certain toxins. This purifies the wastewater but can also support gardens, biodiversity habitats and social spaces (interior or exterior).

https://inhabitat.com/

L Infrastructure

52. Sewerage: Living Machines can be net positive in themselves because they can treat sewage and pollution in contained systems in low-impact greenhouses while contributing net public benefits and increasing nature. For example, they can replace sewerage systems and support native gardens or wetlands that include nurseries for endangered fish.

L. Infrastructure

53. Road and rail: Existing roads can be partly shaded with roofs supporting solar collectors or linear algae-based energy production systems for fuel production. Under-used roads have been converted into gardens, bicycles, pedestrian malls, and jogging paths.

There are now low-impact alternatives for road resurfacing and repair using waste products (eg. plastic).

https://www.theguardian.com/travel/2017/jun/07/paris-promenade-plantee-free-elevated-park-walkway-bastille-bois-de-vincennes

L. Infrastructure

54. Street retrofits: Urban streets and alleyways are being retrofitted to exclude cars (except for nighttime deliveries or emergencies) and include provision for segregated motorized wheelchairs, bicycle and pedestrian pathways.

These new spaces support social interaction, safety, recreation, gardens and a variety of seating for shaded outdoor eating and sunbathing

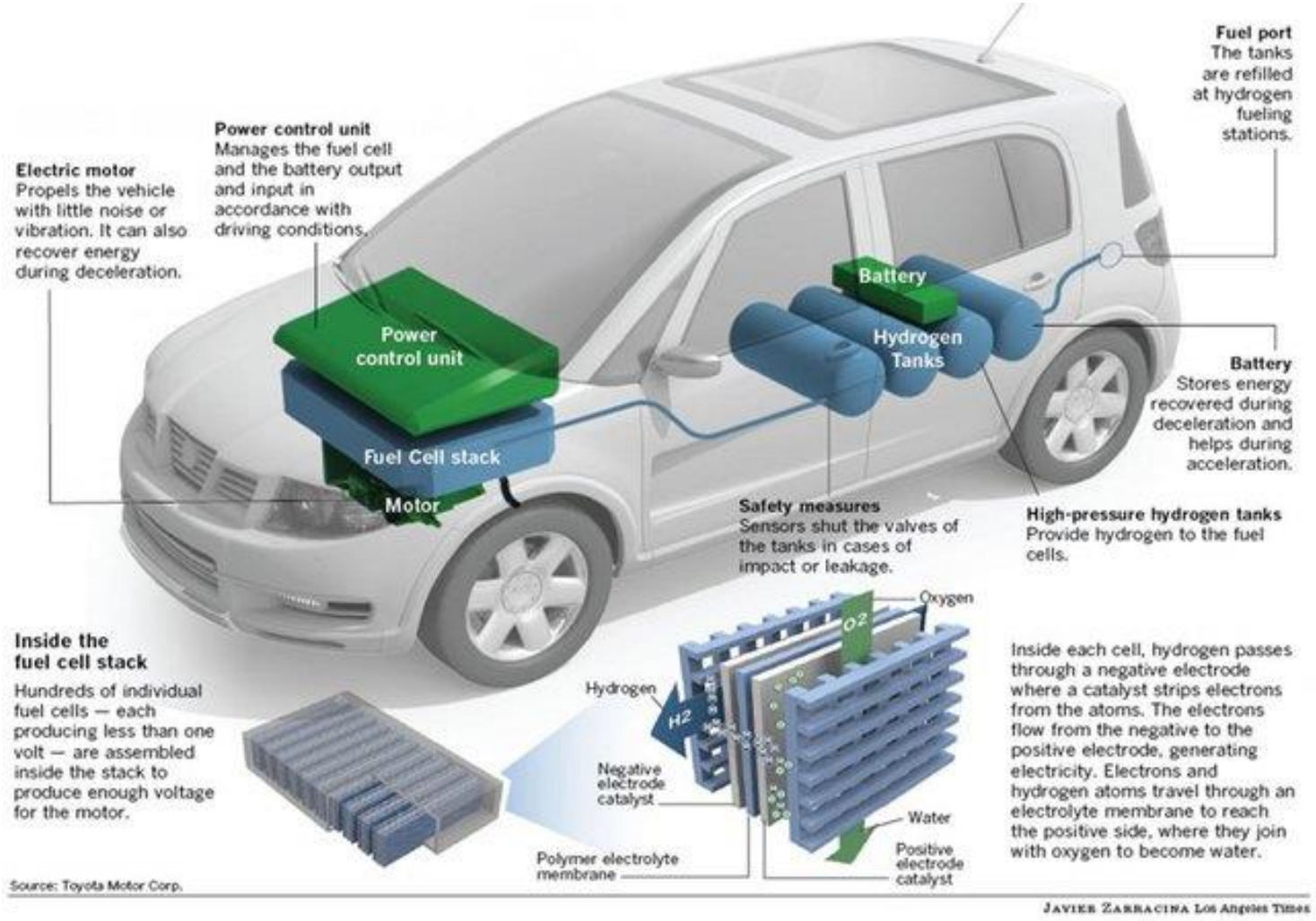
https://za.pinterest.com/managingproject/steel-cable-structures/

L. Infrastructure

55. Fuel Cells: It is now feasible to produce Hydrogen cheaply with renewable energy. Fuel cells create electricity in a chemical process to power machines - with water being the only waste product.

Since Hydrogen is a light-weight fuel, it allows for long distance travel, and may possibly prove more successful than electric cars.

https://www.wbdg.org/resources/fuel-cells-and-renewable-hydrogen



Hydrogen from renewable energy supplies fuel cells which have two plates separated by a membrane. The positive particles of the hydrogen pass through it to the air. The negative particles create a current that produces electricity. The outcome of the mostly passive system is power and water.

M. Consumables

56. Fabrics: Waste and toxins are a huge problem and microfibres from man-made materials (dislodged in washing machines) contaminate waterways and poison land and water species.

Natural materials support soil health, avoid toxins and require less water, pesticides or fertilisers. Leftovers can be used for compost, fertiliser or biomass.

Alternatives include:

- **Pinatex** is an upholstery material made from the leaves of pineapples.
- **Lyocell** is made from cellulose from wood pulp
- **Linen** is made from the fibres of the flax plant and is very durable.
- **Bamboo** sequesters more carbon dioxide and produces more oxygen than other plants.
- **Hemp** uses less water and fertiliser than cotton.

Furniture fabrics, carpets and curtains are changed almost every time a business or family moves, and is a huge part of a building's impacts.

https://thesocialoutfit.org/pages/impact

M. Consumables

57. Food waste: Food production needs to increase by 70% by 2050 to feed the world. Globally, about a third of food is thrown out. Food waste causes about 10% of GHGs. Food uses fuel in farming, processing, refrigerating and transporting. Up to 50% of food waste occurs at the consumer stage. In landfill it produces Methane, a highly potent greenhouse gas.

Reason.com

Moveforhunger.org

https://norwegianscitechnews.com/

Many restaurants, schools, residential buildings collect and compost waste onsite and use it in their gardens.

Multi-story buildings can have chutes on each floor to collect food waste in the basement or garden for composting.

Charities can remove and distribute excess food from restaurants while still safe for eating.

M. Consumables

58. Mining: Gold faucets and marble walls in buildings, like jewellery, are wasteful and unnecessary luxuries. They often come from far away. Few people can see the difference between real and substitute materials.

Good design can create a far greater wow factor than just advertising the cost of the materials.

Mining has huge impacts, such as cyanide and toxic heavy metals like mercury emissions. Mining generates 20 tons of toxic waste for every 0.333-ounce gold ring.

Maralagoclub.com

Worldatlas.com

https://greenliving.lovetoknow.com/

M. Consumables

59. Luxury goods: Fungi can replace petroleum-based plastics, textiles and wood coatings. For example, Chitin in cell walls of fungi can be extracted and processed into biodegradable plastics.

Some fungi can produce lipids, which can also be used to produce biodegradable plastics.

Coffins can be grown in 7 days

https://www.theguardian.com/society/2020/sep/15/first-funeral-living-coffin-made-mushroom-fibre-netherlands

Textile substitutes: The textile industry emits more GHG than shipping and aviation put together.

3 useful parts of mushrooms:

- The tough outer crust of mushrooms can make an impact-resistant coating for windshields, etc.
- The soft middle layer can replicate leather.
- The inner layer can be used to act like wood.

https://www.mycotex.nl/

M. Consumables

60. Packaging: Building materials involve excessive waste to landfill. For instance, the usable timber that ends up in the building after extraction, milling, transport and construction is made from a fraction of the original trees.

If transported long distances, the carbon emissions are huge.

In the past, only onsite construction waste was counted, not the full upstream and downstream impacts..

Renew.com.au

Most thief-proof packaging requires buying tools to open them. One cannot use scissors unless they already have scissors to open the package.

Materials libraries are emerging to allow samples to be borrowed (and returned) for free.

Larthur.com.au

Stryofoam packaging is environmentally harmful in production and disposal while mushrooms are compostable

https://www.ecovative.com/

N. Urban air

61. Urban air cleaning: Algae consume CO_2 to produce oxygen and can also absorb pollution - nitrogen oxides and particulate matter.

Cities cause up to 75% of global CO_2 emissions and the largest percentage is from traffic and cooling/heating buildings for which there are easy options.

The 'liquid tree' (University of Belgrade) takes up less space than trees and claims to be more efficient in removing CO_2 and producing oxygen.

https://www.undp.org/serbia/news/first-algae-air-purifier-serbia

Trees absorb CO_2 and release oxygen back into the air, but:

Algae absorbs the carbon in the form of more algae and it can consume more CO_2 than trees because it can cover more surface area, grow faster, and be used in bioreactors. Of course, it should not replace trees.

Bioreactors can contain large amounts of algae and optimize for its growth. It takes the overgrowth of algae, dehydrates it, and it can then be used as fuel or biomass.

N. Urban air

62. Biofacades: Urban air pollutants (sulfur dioxide, nitrogen dioxide, carbon monoxide) come mostly from fossil fuels such as fuel oil, gasoline, and natural gas that are emitted from power plants, automobiles, and local other combustion sources.

Fungi-filled wall tiles could absorb harmful hydrocarbon air pollution from traffic emissions and fossil fuel use.

When the mycelium-fused fungi grows, it safely sponges up to 80% of the carbon it consumes.

Mushrooms detoxify pollutants

Mushrooms can also eat products made from mushrooms, such as furniture, to form a truly closed-loop system.

Many (not all) toxins are absorbed by the mushrooms and detoxified.

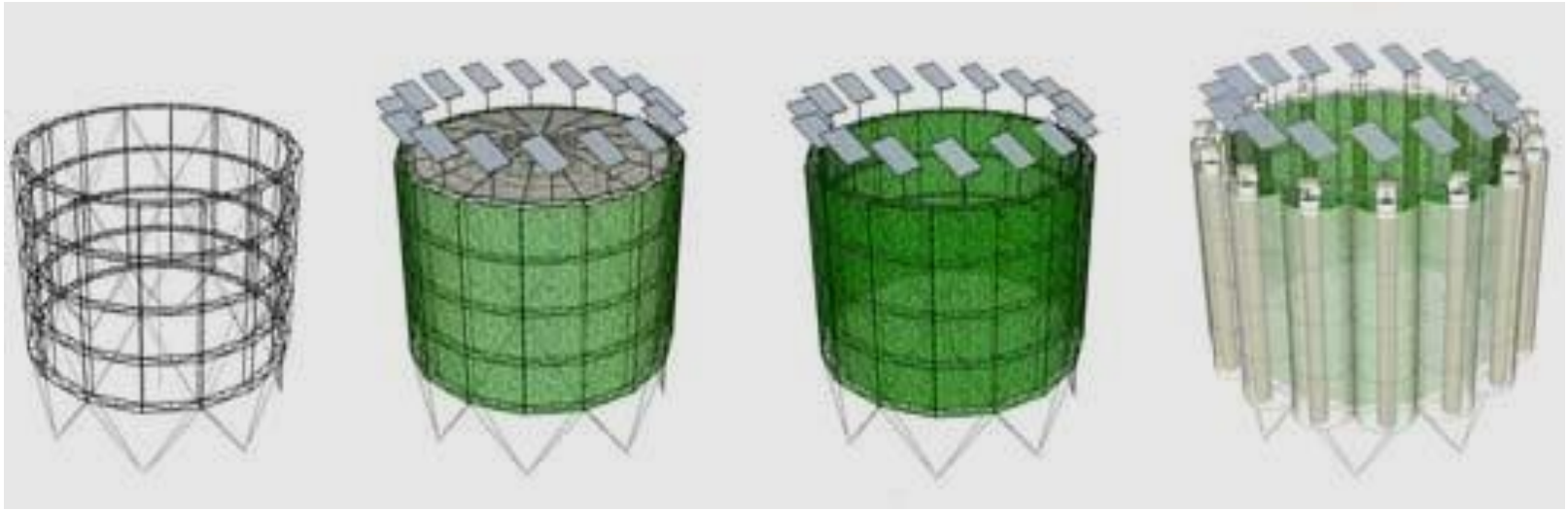
If the waste consumed by mushrooms cannot all be detoxified or harvested, it can be incinerated (bad) or buried in landfill.

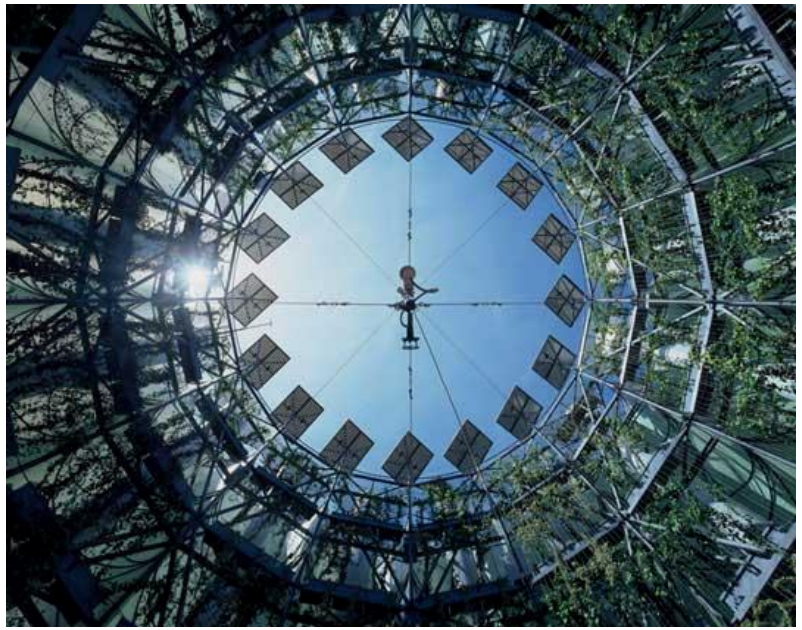
ttps://www.brunel.ac.uk/news-and events/news/ articles/Mushrooms-work-magic

N. Urban air

63. Urban scaffolding: Multilayered structures for screens and plants on roofs or over plazas and streets (Green Scaffolding), could clean urban air, improve air flow and provide better air circulation as well as urban biodiversity habitats, etc.

The important thing is to ensure that any urban structure performs many positive public functions simultaneously.





Spanish 'Urban Ecosystems' propose an air tree called eco-boulevard

N. Urban air

64. Pollution filtration: Pollution can be converted into products.

Air-Ink: Researchers in India captured air pollution and converted it into ink. The ink in pens or printers are made from soot called 'carbon black' (powder that remains after burning coal or oil) and mixed with a polymer and solvent.

https://www.smithsonianmag.com/innovation/ink-made-air-pollution-180972212/

CityTree: This is a biotech fine dust filter for urban spaces using integrated moss modules to ensure that the air is verifiably clean.

It uses an automated irrigation and ventilation system that filters up to 82% of the fine dust in the air through the moss and cools the air by up to 2.5 ° C.

https://greencitysolutions.de/en/citytree/

O. Urban water

65. Water remediation: Fungi, bacteria, seaweed and algae can be used for many environmental remediation purposes, including water treatment.

- **Fungi** can break down complex organic compounds in contaminated water such as petroleum and pesticides.
- **Seaweed** can absorb nitrogen and phosphorus from polluted urban waters, which can reduce the growth of harmful algae and improve water quality.
- **Algae** are particularly effective at removing nutrients such as nitrogen and phosphorus, which are common pollutants in agricultural and urban runoff.

ttps://www.timeshighereducation.com/hub/p/green-and-clean-new-eco-friendly-and-sustainable-algae-based-way-fight-water-pollution

https://janmun.com/fairy-rings-mycoremediation/

A high algal load in the water reduces the nutrients and sunlight for other microorganisms which kills bacteria in the water.

Algae also removes pollutants through bioremediation, which absorbs nutrients and pollutants from the water.

This biomass can then be used for other purposes.

O. Urban water

66. Water security: Urban areas are vulnerable to water shortages as they are centralized and have limited sources.

https://renew.org.au/renew-magazine/water-saving/stormwater-reuse-for-parks-and-whole-cities/

Underground tanks can store filtered water to provide for public gardens' watering needs. These are combined with natural treatment through small wetlands to pre-treat the water.

https://www.tuvie.com/wp-content/uploads/urban-rainwater-collector-by-venn-idc1.jpg

https://www.watertech.com.au/solutions/integrated-stormwater-management/

O. Urban water

66. Bioretention: Permeable pavement and bioretention systems reduce stormwater runoff and pollution that enters local waterways and eventually all water.

Systems to treat runoff from parking lots and roads can use a series of shallow depressions filled with a mixture of sand, compost, etc., to support native plants that filter pollution.

https://wiki.sustainabletechnologies.ca/index.php?curid=1561

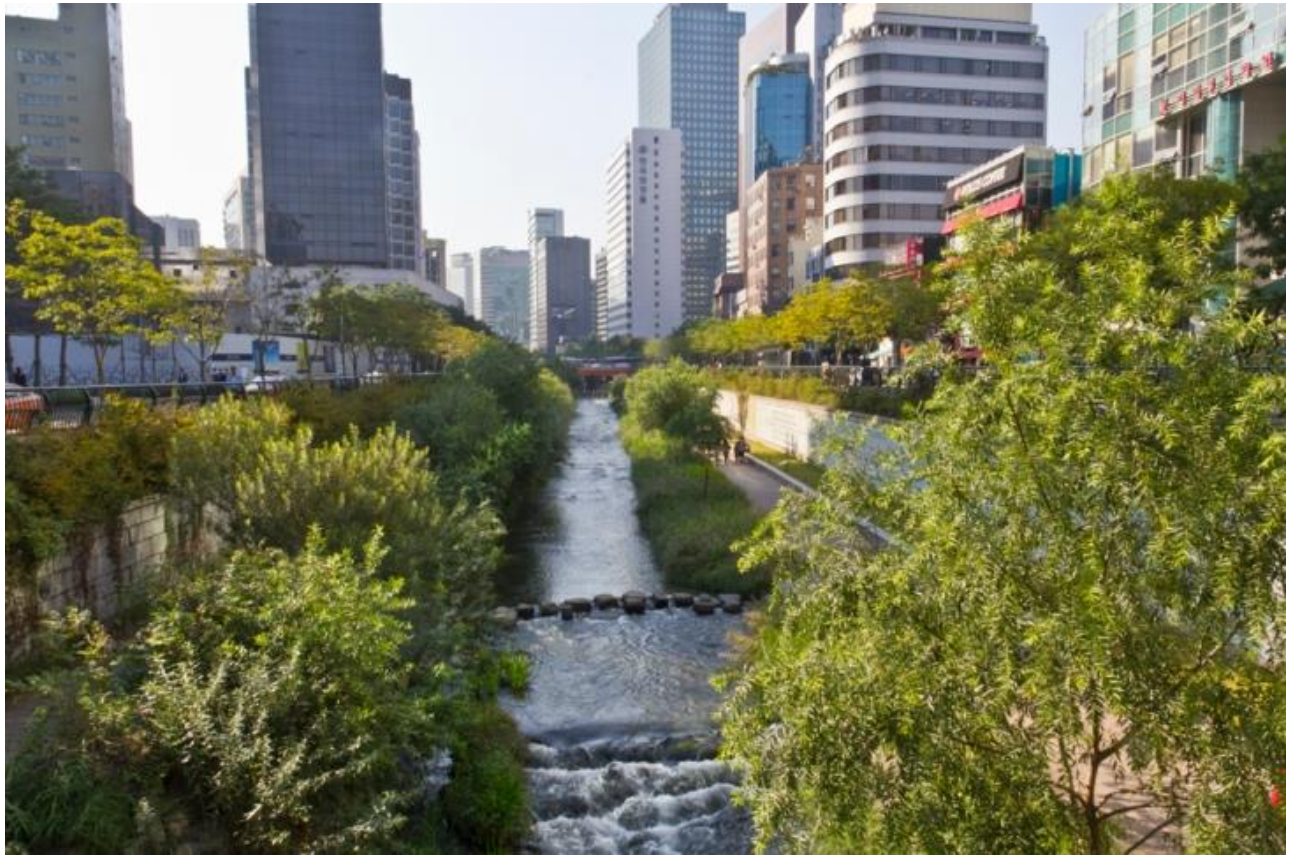
ttps://wiki.sustainabletechnologies.ca/wiki/File:HD_urban_bioretention_1.jpg/

ttps://wiki.sustainabletechnologies.ca/wiki/Mississauga_Elm_Dr_bioswale_001.jpg

https://wiki.sustainabletechnologies.ca/wiki/Bioswale

O. Urban water

67. Daylighting rivers: South Korea's river restoration is an early and famous example of allowing rivers to flow again while cleaning them with parks and public spaces.



Cheonggyecheon stream in Seoul, South Korea, daylighted from sewers in 2003.
Image: Kaizer Rangwala, Flickr.

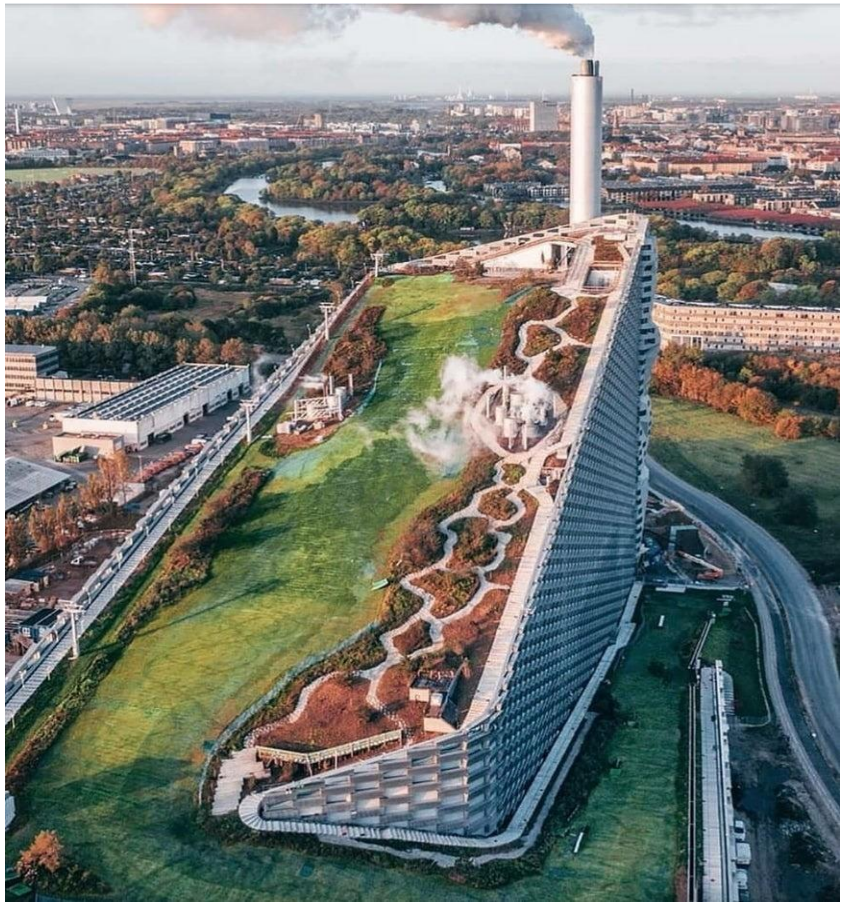
Los Angeles voters wanted their river back. The plan is to restore 11 miles of the LA River between Griffith Park and Downtown.

https://wilderutopia.com/sustainability/land/la-river-urban-ecosystem-makeover-in-transition/

P. Socio-economic gains

70. Recreation: More healthy urban adventures could replace the need to destroy nature for resource exploitation and destructive impulses such as shooting or motor biking in wilderness areas.

These urban adventures include (commercial) rock climbing on walls, citizen races, and even containers that enable people to float on air.

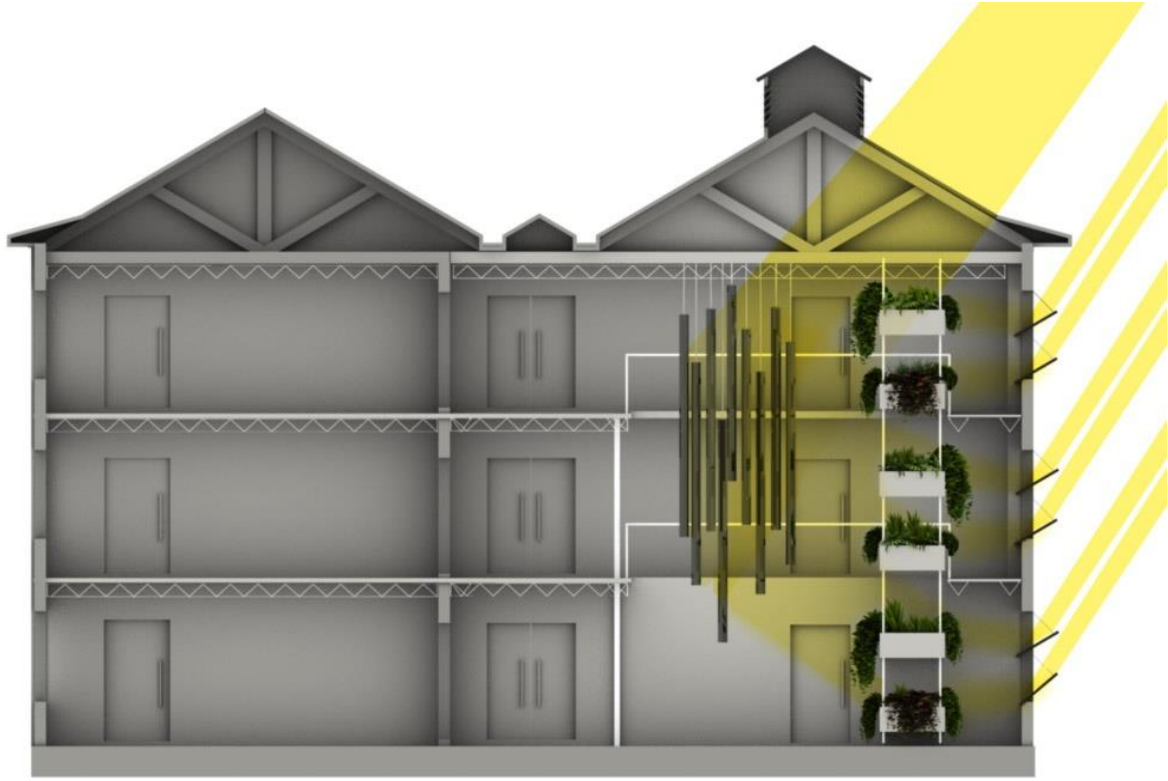


https://www.reddit.com/r/LandscapeArchitecture/comments/ibtnzy/project_by_big/

P. Socio-economic gains

69. Sense of community: Eco-positive retrofitting can preserve established and historic neighborhoods to meet higher standards and code requirements and, at the same time, provide public savings and benefits to offset any costs.

Retrofitting can enable many people to remain in their own neighborhoods as they age or divide buildings into units to provide space for carers or 'boom-mates'.



https://www.theguardian.com/society/2020/jun/02/more-age-appropriate-homes-needed-in-the-uk-says-report

P. Socio-economic gains

70. Stability: Relatively self-sufficient urban settlements in every country could reduce mass migrations due to autocracies, poverty and climate change.

In disadvantaged regions, (low-cost) assistance for basic self-help retrofitting, can produce insulation, building-integrated food production and water collection. This would increase stability and security and reduce migration.

Climate.org

hrw.org

The guardian.com

P. Socio-economic gains

71. Employment: Building improvements and garden maintenance will never be complete, so eco-retrofitting provides more regular and healthy jobs than high-maintenance mechanical systems or new building construction.

The unemployed can find healthy jobs in urban farming, gardening, or retrofitting while living close to their family homes or communities.

The ‘Greenbelly’ project shows how Green Scaffolding can be used to retrofit a blank building wall to improve many things at once.

https://www.designboom.com/architecture/greenbelly-sun-rain-organic-waste-09-13-2018/

Q. Plastic pollution

72. Cigarettes: About 9 billion plastic cigarette butts are discarded in Australia each year, seeping harmful microplastics, arsenic and other toxins into waterways and soil.

Roughly one-third of the nearly 100 chemicals inside cigarette butts are very toxic to marine life as well as people

'Fungi Solutions' in Melbourne propose to divert these from landfill and use fungi to transform the byproduct into a polystyrene replacement.

https://amp.theguardian.com/australia-news/2023/mar/16/oyster-mushrooms-expected-to-break-down-toxins-and-microplastics-in-cigarette-butts-in-australian-trial

Q. Plastic pollution

73. Mushroom leather substitutes: Mushrooms can reduce animal cruelty and the impacts of leather tanning which is energy- and resource-intensive and produces a lot of sludge toxic waste during processing.

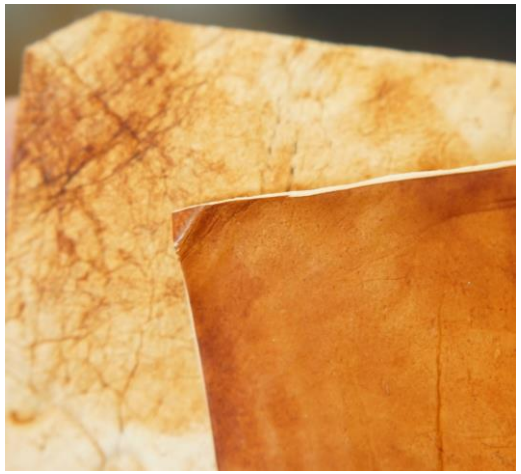
Several companies now make 'faux leather' from mushrooms, such as Mylo.

It is fully recyclable if not mixed with inappropriate materials. It is also biodegradable.

https://www.rmit.edu.au/news/all-news/2020/sep /vegan- leather-

Mushroom leather grows in weeks, while animal hides take years to grow and use up land that could be returned to nature.

https://www.etsy.com/au



https://www.imperial.ac.uk/news/203535/fungus-leather-substitute

https://cosmosmagazine.com/technology/materials/sustainable-textiles-fungi/

https://www.theguardian.com

Q. Plastic pollution

74. Fire toxin removal: Fungi produce enzymes that can break down various types of polymers, including plastics. These enzymes can degrade plastic waste, which could help clean up global plastic pollution.

It takes different mushrooms about two weeks to several months to break down and consume plastic.

Recent large-scale fires generated dangerous ash of all kinds from hazardous household waste, building materials, paint, pesticides, cleaning products, electronics, pressure-treated wood, propane tanks, etc.

This left arsenic, asbestos, plastics, copper, hexavalent chromium, lead, zinc and other pollutants in the soil which pollute waterways through runoff.

Sonoma county California placed more than 40 miles of wattles - straw-filled, snakelike tubes designed to prevent erosion and water pollution - inoculated with oyster mushrooms around parking lots, along roads, and across hillsides.

https://www.yesmagazine.org/environment/2019/03/05/mushrooms

Q. Plastic pollution

75. Plastic and climate: Just 16% of plastics are recycled. About half our global oxygen comes from Plankton which are now eating microplastics, which affects their ability to eat carbon and make oxygen.

Plastic incineration causes serious air pollution.

https://www.weforum.org/agenda/2022/01/plastic-pollution-climate-change-solution/

https://www.pewtrusts.org/en/trust/archive/fall-2020/confronting-ocean-plastic-pollution

R. New food sources

78. Insects: Insects are a good source of protein, and require little land, water, and feed to produce. They can be grown on garbage.

Insects can be roasted, fried, ground into a powder, eaten whole, used in stir fries, or used in stews and soups or used as a crunchy topping.

- **Crickets** are eaten in Mexico, Thailand, Uganda
- **Mealworms** are eaten in China, Thailand, Mexico
- **Grasshoppers** are eaten in S. America, Africa, Asia
- **Ants** are eaten in Brazil, Colombia, Thailand
- **Termites** are eaten in many parts of Africa.
- **Silkworms** are eaten in parts of China, Korea, Japan. They are sometimes steamed or boiled.
- **Witchetty grubs** are eaten in Australia
- **Tarantulas** are eaten in Cambodia
- **Scorpions** are eaten in China

All photos from https://www.foodandwine.com/travel/gourmet-bug-dishes-around-world /

R. Food Sources

77. Algae or seaweed: Algae is a nutritious and sustainable food source used in many food products, such as protein-rich powders. They can be grown in a wide range of environments, from deserts to coastal regions.

- **Algae smoothie** combines fruits, vegetables, etc. Spirulina, a blue-green algae, is a popular ingredient.
- **Seaweed salad** consists of a mix of different types of seaweed, dressed with a vinegar-based dressing.
- **Algae chips** are similar in composition to potato chips.
- **Sushi,** from Nori, is a type of seaweed often used to wrap sushi rolls, and some sushi restaurants have rolls made with spirulina.
- **Noodles** can be made from algae which are high in protein.
- **Algae burgers** are high in protein and other nutrients.
- **Algae additives** can be added to meats and pastas to enrich them

https://www.bbc.com/travel/article/20210111-how-mexico-is-reclaiming-spirulina

https://eatsmarter.com/recipes/ingredients/algae-recipes-0D

https://www.self.com/gallery/how-to-cook-with-seaweed-the-latest-it-ingredient

R. Food sources

78. Fungi foods: Livestock can have extensive carbon, water and soil impacts in some regions (eg. Australia). Plant-based meats are 'improving'.

A fungus found in geothermal springs is also producing meat and dairy substitutes. The fungus-based protein is a food that can be eaten by itself.

https://www.naturesfynd.com/

It is reputedly even more efficient to produce than plant-based proteins.

R. Food sources

79. Mushroom health benefits: Mushrooms are magic.

- **Nutrients**: They are low in calories and an excellent source of B vitamins, copper, potassium, and selenium.
- **Antioxidants**: They help protect against cell damage and reduce the risk of some cancers and heart disease.
- **Immune system**: Some, such as Shiitake, may boost the immune system to help fight infections and diseases.
- **Blood sugar**: Certain types of mushrooms (eg. Reishi and Maitake) help to improve insulin sensitivity.
- **Gut health**: They are a good source of fiber, which promotes healthy digestion and supports the gut microbiome.
- **Fat and cholesterol**: They are naturally low in fat and cholesterol, which is good for the heart.
- **Convenience**: They can come in powders which are portable and storable.
- **Save land**: They can be grown in abandoned buildings or other temporary facilities.
- **Brain Health**: Studies increasingly indicate that mushrooms are good for the brain (at least mice brains).

https://www.clevermushroom.com.au/

https://grocycle.com/how-to-set-up-a-low-tech-mushroom-farm/

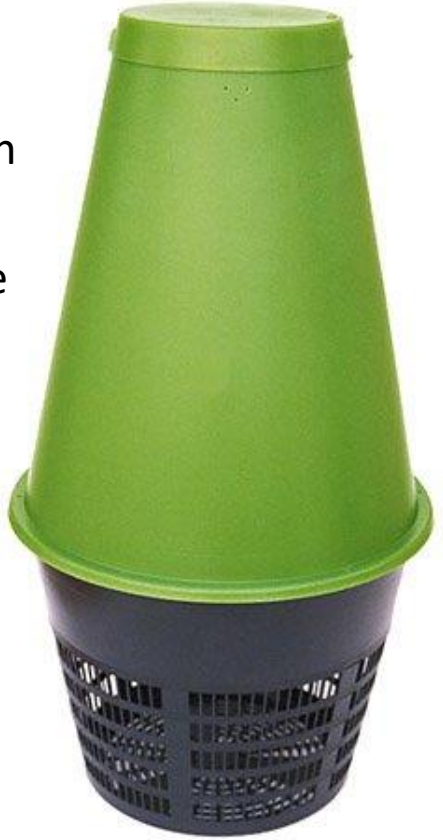
S. Drought

81. Individual water: The solar cone can help in drought or a refugee crisis. It is a solar-powered water desalinator that generates freshwater through evaporation.

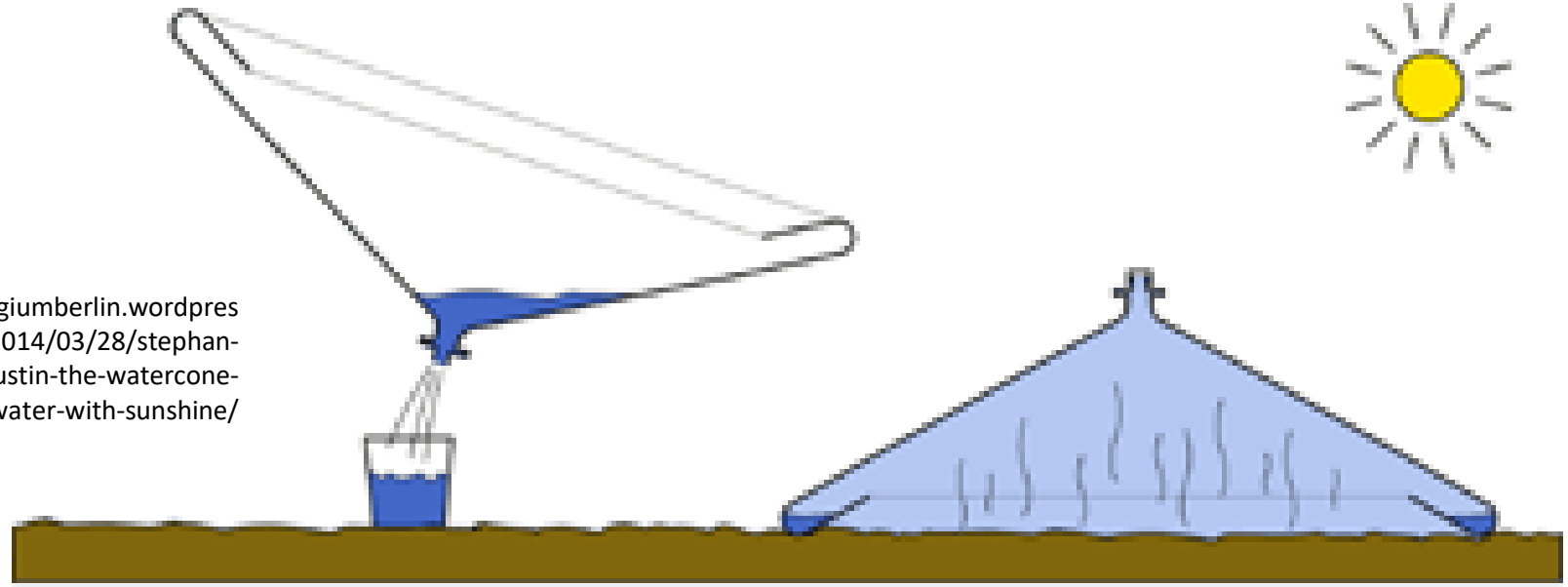
Place over a pan of salty water (or over a marsh, or any damp ground) and leave it out in the sun. The water evaporates and the condensation trickles down the side of the cone, at the end of the day you flip it over, remove the cap at the top and drink the water.

Solar cone composter: Waste in refugee camps can be converted to compost more quickly, in large or small systems.

The waste is open to the ground, but the cone produces solar heat.



https://www.addisoncountyrecycles.org/food-scraps/composting/green-cone



https://refugiumberlin.wordpress.com/2014/03/28/stephan-augustin-the-watercone-cleaning-water-with-sunshine/

S. Drought

82. Water for crops: Desert greenhouses can function without soil, pesticides, fossil fuels or ground water. Peruvians long used nets to condense fog which drip into drainage pipes that run downhill into storage tanks. This principle can be used in desert greenhouses. Or, ocean water can be desalinated using passive systems.

https://www.researchgate.net/publication/282536727_Harvesting_Fresh_Water_from_Fog_in_Rural_Morocco_

http://sustainablefootprint.org/peruvians-harvesting-water-from-fog/

https://agri.com.sa/blog/the-potential-of-desert-greenhouses/#Three_Seawater_to_power_irrigate

https://www.newscientist.com/article/2108296-first-farm-to-grow-veg-in-a-desert.

S. Drought

83. Building water conservation: There are myriad ways of collecting, treating, and storing rainwater that can be integrated into the building to double as thermal insulation and fire security.

https://www.architectureanddesign.com.au/news/how-far-would-you-go-for-sustainability-water-tank

https://www.yourhome.gov.au/water/rainwater

https://www.architectureanddesign.com.au/news/aaa-thurgoona-csu Marci Webster-Mannison

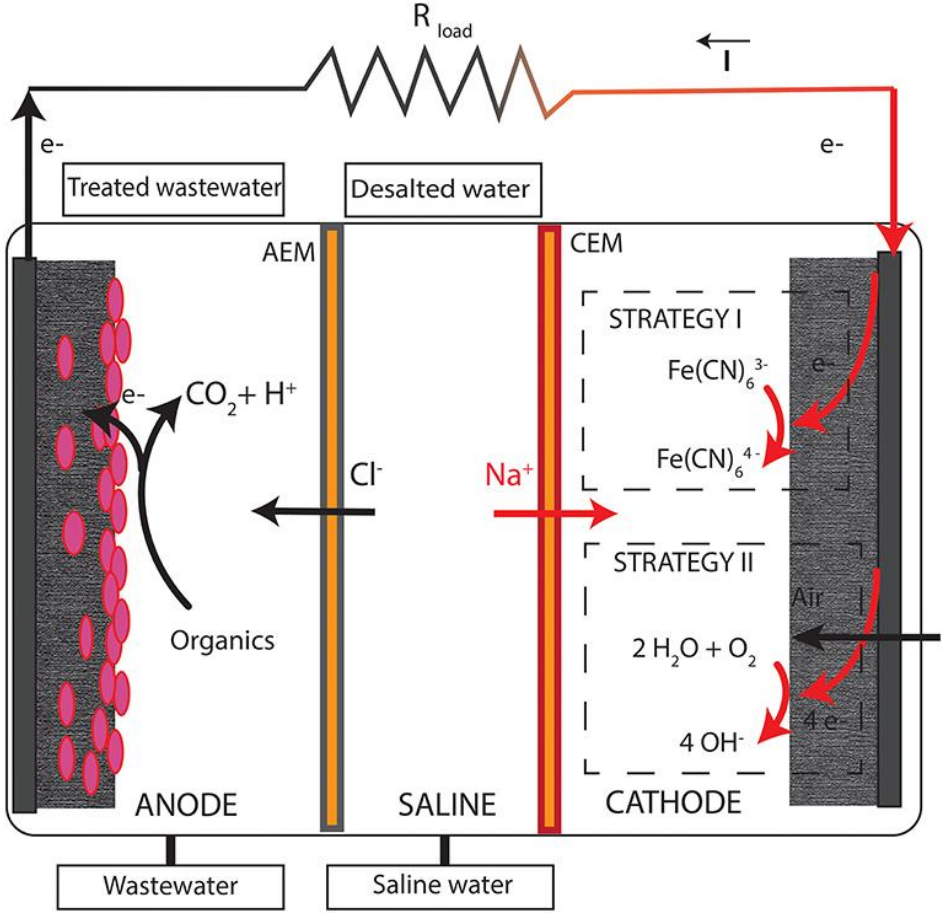
Other water conservation methods:

- **Rainwater tanks** store water during the rainy season for drinking water or landscape irrigation
- **Rain gardens** capture and absorb urban rain to increase soil moisture and reduce runoff.
- **Permeable paving** allows rainwater to infiltrate the soil and recharge groundwater.
- **Green roofs** reduce runoff during periods of heavy rainfall and retain moisture.
- **Bioswales** are vegetated ditches and mounds that direct and capture stormwater to increase soil moisture and reduce runoff.
- **Drought-tolerant plants** in dry landscapes require very little water.
- **Graywater systems** capture (non-potable) water and treat it with filtration systems (eg. sand, biological systems, or chemicals).
- **Drip irrigation** is more efficient in landscaping that sprinklers.

S. Drought

84. Microbial desalination: Particular microorganisms, such as cyanobacteria and algae, can remove salt and other minerals from seawater or brackish water for agriculture - if powered with renewable energy. Traditional processes, such as reverse osmosis and thermal distillation, are more energy-intensive, emit greenhouse gas emissions and discharge more brine waste.

Still largely experimental, the Microbial Desalination Cell (MDC) allows the simultaneous treatment of wastewater, electricity generation and desalination.



https://www.frontiersin.org/articles/10.3389/fenrg.2019.00135/full

Other solutions:

- **Solar stills** use solar energy to evaporate seawater and leave the freshwater, on a large or small scale.
- **Membrane distillation** uses renewable energy to separate water vapor from saltwater through a porous membrane.
- **Forward osmosis** uses a concentrated salt solution to draw freshwater through a semi-permeable membrane. It uses less energy than reverse osmosis and can use waste heat from industrial processes.
- **Electro-dialysis** uses renewable energy to separate salt ions from water with an electric current, resulting in freshwater and saltwater streams. This also reduces brine waste.

T. Refugee camps

84. Employment of refugees in sustainable industries.

Agricultural production in refugee settlements can create jobs that generate income as well as food. Reforestation around refugee camps can regenerate the environment.

Clean energy initiatives in refugee settlements, such as solar panel installations or wind turbines, can create jobs (eg/ waste recycling systems using renewable energy.

The cocoon prevents evaporation, stops weeds, animals and birds from eating the young plants, and shelters them from heat and dry winds.

https://www.icrc.org/en/document/kenya-dadaab-refugee-camp-recycle-plastic-income-livelihoods

ttps://thred.com/change/the-refugee-camp-recycling-plastic-waste-into-furniture/

https://landlifecompany.com/projects/minawao-refugee-camp-cameroon/

T. Refugee camps

85. Food sources: Multi-story planters can save space in camps.

- **Container gardening** in pots or containers can be moved easily and placed where some access to sunlight is blocked.
- **Vertical gardening** structures can maximize space, increase yields and can include hydroponic systems or use movable containers.
- **Microgreens** are small, nutrient-dense seedlings that can be grown within a few weeks in small spaces.
- **Hydroponics** (growing plants in nutrient-rich water), can produce a range of foods (including fish) in areas with limited space.
- **Mushrooms** can be grown in small spaces, and they require minimal resources and inputs.

https://inforboit.wordpress.com/2021/01/02/multi-storey-gardening/

https://www.unhcr.org/4b7becf99.pdf

https://www.icfi.nl/news/innovative-multi-storey-gardens-enhancing-food-security-in-kenya

T. Refugee camps

86. Emergency shelters: 40 million people are displaced by crises.

Solar-powered tents use embedded photovoltaic cells to generate electricity, lighting and charging stations for electronic devices.

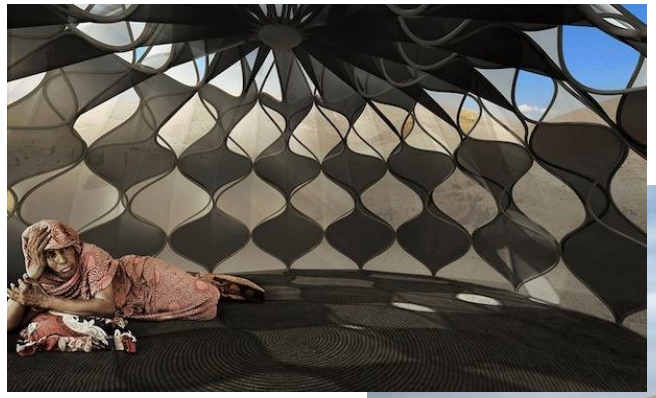
Reflective tents are made of heat-reflective material can be used to keep the tent cooler in hot climates.

Shipping containers can be easily modified to include windows, doors, etc. (toxins can remain.)

Earthbag homes are made by filling bags with soil or sad and stacking them to create walls.

Bamboo shelters are lightweight, durable, and easily transported.

Modular shelters use separate, interlocking units that can be combined to create larger structures.



ttps://www.greenprophet.com/2014/03/collapsible-woven-refugee-shelters-powered-by-the-sun/

Woven housing

Flat Pack housing (Ikea)

https://www.csmonitor.com/World/Global-Issues/2013/0619/Why-do-we-still-put-refugees-in-tents-IKEA

ttps://www.theguardian.com/sustainable-business/2014/jul/30/refugee-shelters-new-designs-ikea

T. Refugee camps

87. Community water: Refugee camps can have limited water supplies and sewage treatment capacity but are increasingly using solar-powered systems.

(The only solution to refugees is to solve problems in their own countries - not moving 'problems' around.]

ttps://www.unhcr.org/news/briefing/2019/1/5c2f239b4/innovation-green-tech-sunlight-help-secure-safe-water-rohingya-refugees.html

Tiger Worm Toilets (TWTs) contain composting worms that digest poo inside the vault, so no desludging or sludge treatment infrastructure is needed. These are used in national parks as well.

https://watermission.org/news/serving-refugees-largest-solar-water-project/

https://www.unhcr.org/news/briefing/2019/1/5c2f239b4/innovation-green-tech-sunlight-help-secure-safe-water-rohingya-refugees.html

U. Democracy

88. Access to needs: 'Co-housing' and other kinds of intentional communities share many facilities. They often have a common house with a central kitchen and dining room along with shared equipment, such as gardening tools or cars.

They often engage in self-governance and participatory design.

Some projects are created by retrofitting whole urban blocks.

Cohousing.org

Cohousing.ca

Transitionaustralia.net

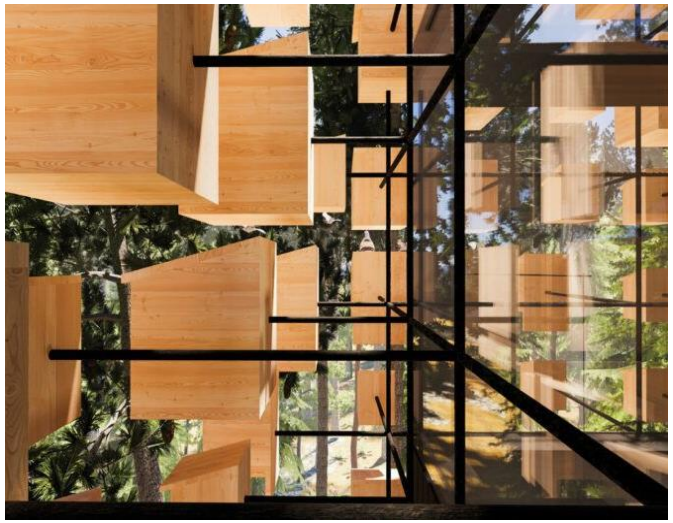
T. Democracy

89. Real choices: People who want sustainable homes and lifestyles cannot choose what is ***not*** on the market. Sustainable homes can be of any appearance or aesthetic.

However, many developers still avoid passive, nature-based design on grounds that there is no market demand and think they can cut costs by using less educated designers.

https://inhabitat.com/net-zero-emissions-area-will-be-built-on-renewable-energy/oosc21-scaled-1/

https://inhabitat.com/net-zero-emissions-area-will-be-built-on-renewable-energy/oosc21-scaled-1/



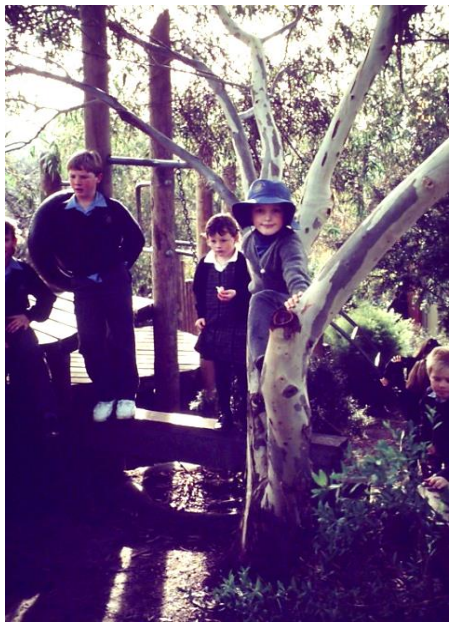
U. Democracy

90. Education: Ignorance is the enemy of democracy and sustainability. Children today have little contact with nature and little exposure to eco-logical design thinking, let alone design.

Nature-positive urban environments using passive and natural systems can expose urban children to the wonder of the complex, interconnect web of life.

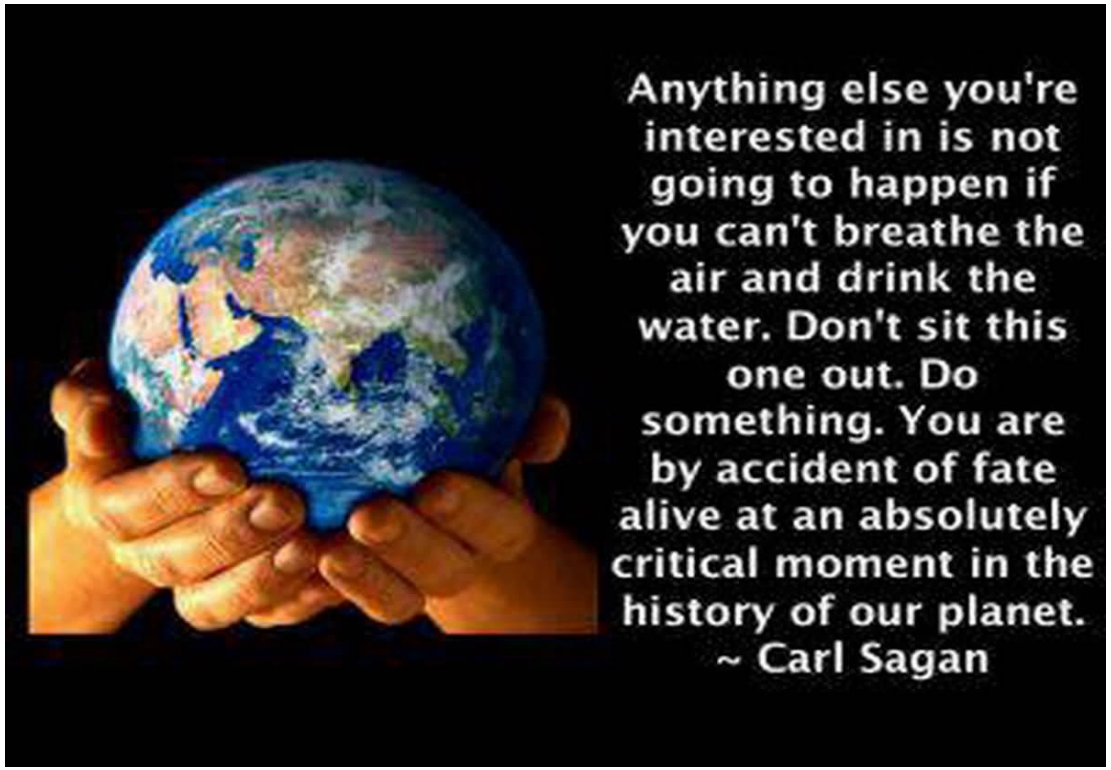
https://montessorirocks.org/

Nature Playgardens.
Birkeland 1980s

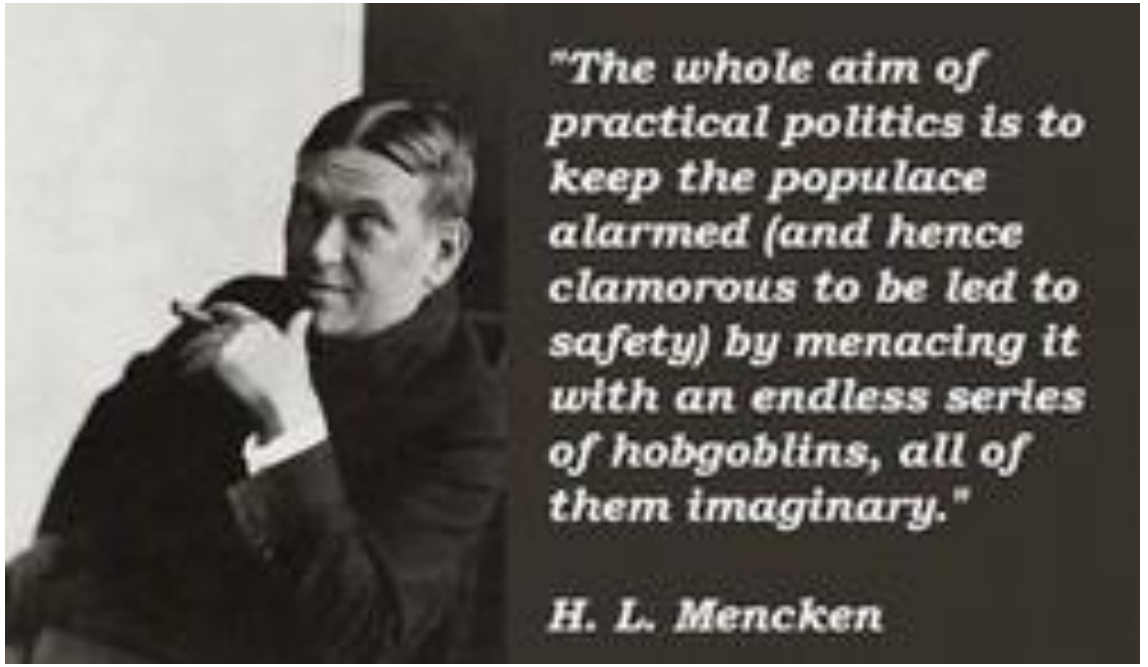


U. Democracy

91. Politics: People do not have equal access to markets, even for basic needs. Democracy requires environmental security and direct universal access to the means of survival and wellbeing. Otherwise, people can be intimidated or threatened for political purposes through economic manipulation, such as driving up the cost of food and shelter.



Carl Sagan died in 1996. https://www.quotemaster.org/global+politics



V. Industrial toxins

92. Design for decomposition: Industrial chemicals damage plants, animals and ecosystems. Hazardous chemicals end up in landfills and the wider environment while creating risks for workers.

Chemical products can be designed to be non-toxic but also break down into harmless molecules at the end of their functional life.

Despite increased use of biobased materials, traditional products used in construction (eg. paints, plastics, solvents, cleaners, fuels and lubricants) still end up on the air or water and many bioaccumulate in species.

These are only gradually being replaced.

Some chemicals break down with:

- light (photodegradation),
- water (hydrolysis) or
- biological species, often with enzymes (biodegradation).

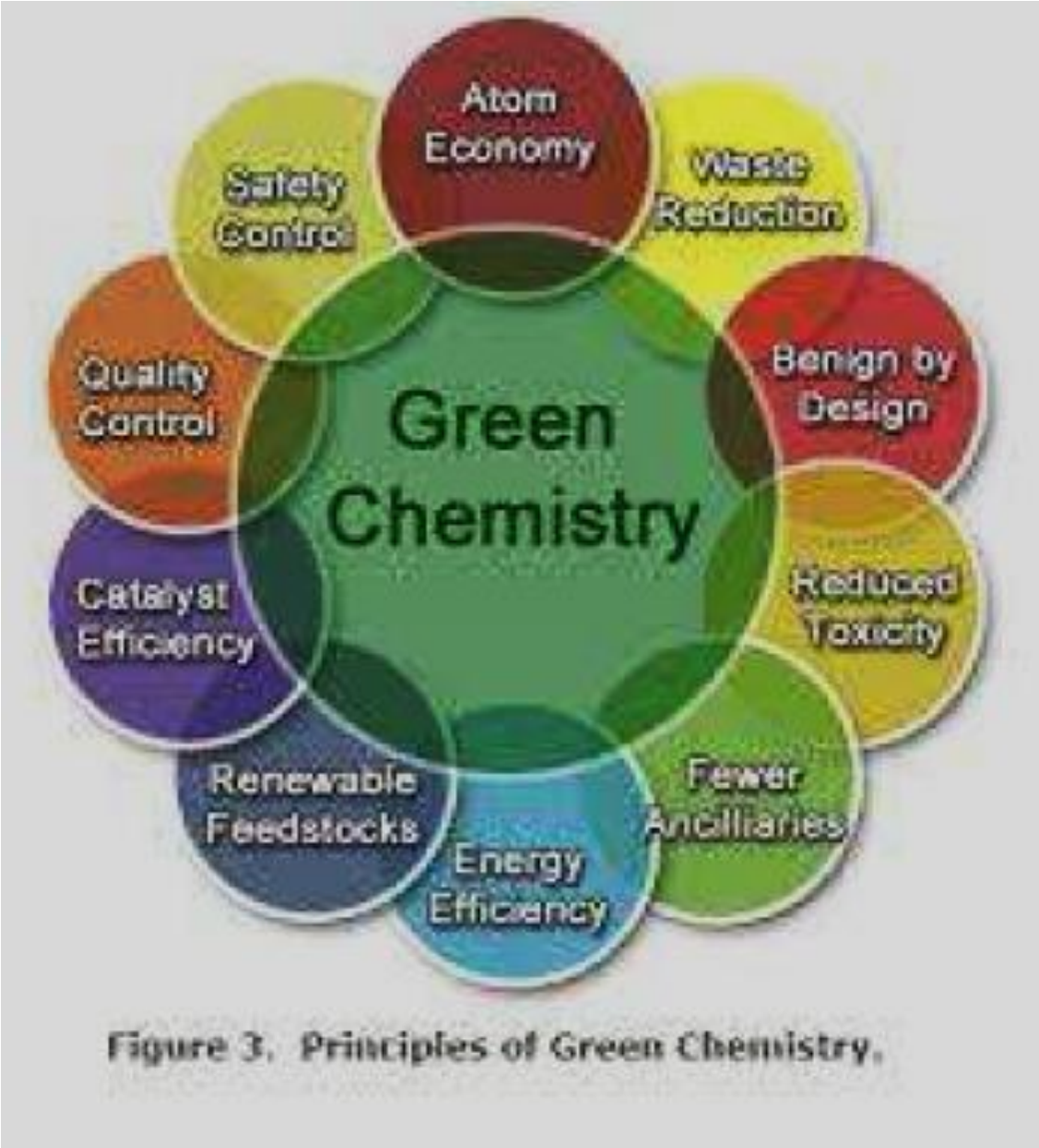


Figure 3. Principles of Green Chemistry.

https://www.theaic.org/pub_thechemist_journals/Vol-86-No-1/Vol-86-No1-Article-5.html

V. Industrial toxins

93. Green solvents: These are *less* harmful than petroleum-based solvents still often used in manufacturing or construction.

These can be derived from the fermentation of biomass (eg. corn, sugarcane, woody biomass) to replace petroleum-based solvents.

- **Vanillin and toluene** can be made from lignocellulosic biomass (which is composed of lignin, cellulose, and hemicellulose).
- **Ethyl lactate**, from corn starch, can replace traditional solvents in paints and coatings.
- **FAME** (fatty acid methyl esters) comes from natural plant oils, such as soybeans, canola, or sunflower seeds.

https://www.cdc.gov/niosh/topics/organsolv/default.html

https://www.medsnews.com/health/solvents-the-hazardous-chemicals-to-avoid-in-everyday-life/

Some harmful chemicals that can be replaced:

- **Benzene** (plastics, resins, synthetic fibers)
- **Chloroform** (fats, oils, rubber)
- **Formaldehyde** (resins, textiles, cosmetics, fertilizers, etc.)
- **Toluene** (paints, coatings, adhesives)
- **Xylene** (printing, rubber, and leather)
- **Methylene chloride** (paint strippers, degreasers, etc.)
- **Trichloroethylene** (dry cleaning, metal degreasing, etc)
- **Carbon tetrachloride** (cleaning agent, refrigerants, etc.)
- **Ethylene glycol** antifreeze, brake fluid, etc.)
- **Methyl ethyl ketone (**plastics, textiles, etc.

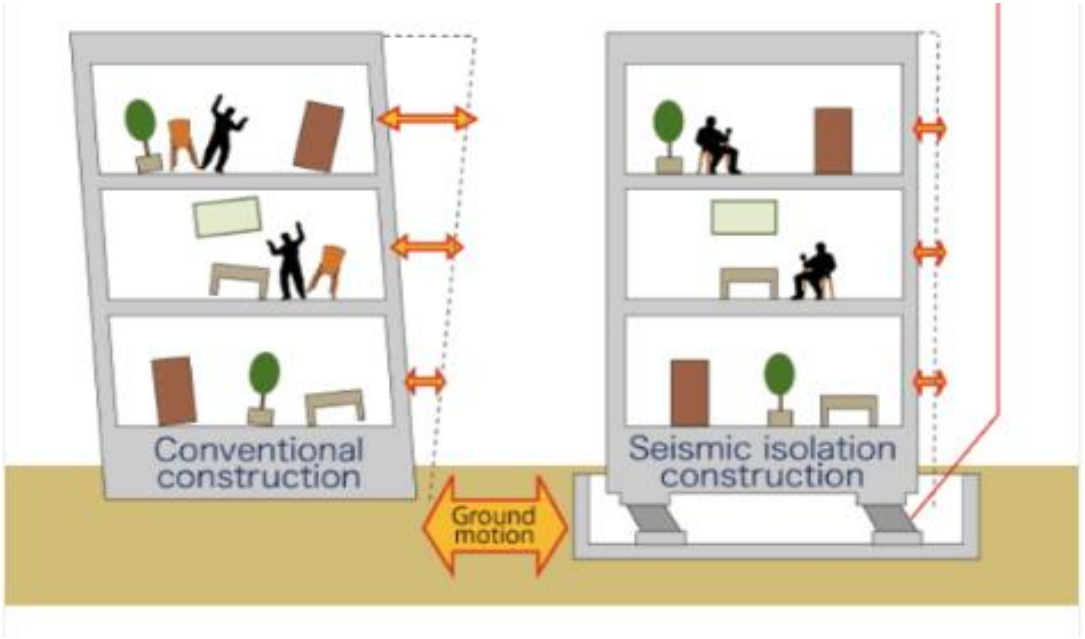
V. Industrial toxins

94. Green adhesives: Traditional adhesives can contain harmful solvents and other chemicals. Green adhesives, such as those made from soybean oil, are more sustainable and less harmful to human health and the environment.

- **Soy-based adhesives**: Soy can be used instead of (toxic) glue in plywood, particleboard, etc.
- **Cellulose-based adhesives**: Plant-based materials can be used in the production of paper, packaging, etc.
- **Natural rubber adhesives**: The sap of rubber trees can be used to produce tapes, labels, etc..
- **Cornstarch-based adhesives**: Corn can be used as an alternative in paper packaging, bookbinding, woodworking, etc.

https://www.buildersmart.in/blogs/rubber/

Rubber floors and tiles are quiet and resilient. Rubber is used as a bonding and waterproofing material in mortars, cement plaster, polymer concrete etc.



Natural rubber bearings between the foundation and structure creates an earthquake isolation layer which reduce the seismic energy.

https://www.china-gnma.com/products/natural-rubber-bearing.html

V. Industrial toxins

95. Forever chemicals: Many industrial chemicals are found in buildings or can be mitigated in buildings.

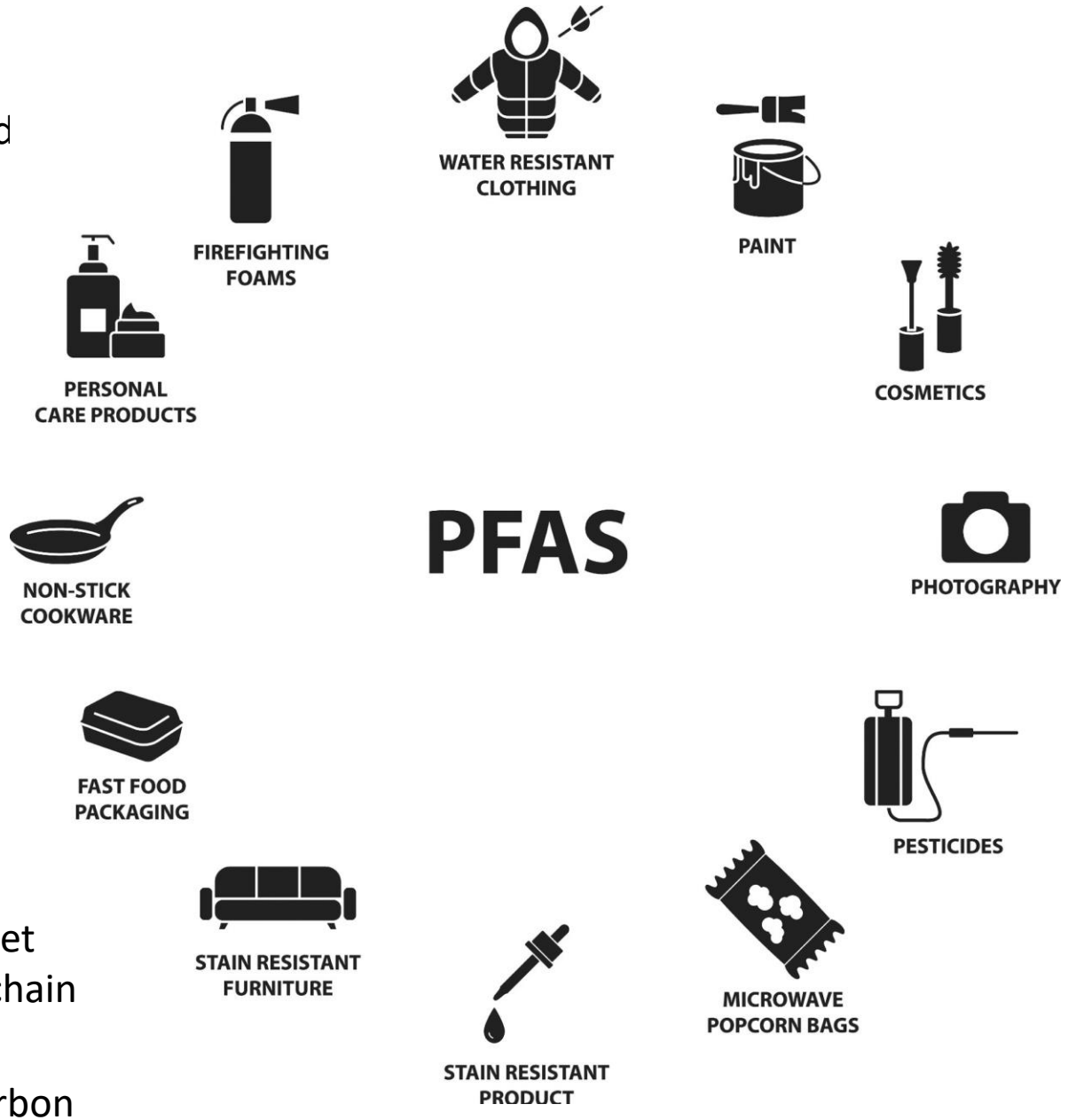
Toxic PFAS (per- and polyfluoroalkyl substances) are permanent and now everywhere in our water, homes and bodies - even artic ice.

Many come from consumer goods, such as:

- Most non-stick cookware
- Food packaging: pizza boxes, popcorn packs, etc.
- Waterproof and stainproof textiles, carpets, etc.
- Firefighting foam
- Water-resistant and outdoor gear: rain jackets, hiking boots, etc.
- Cosmetics and personal care products

UV treatment exposes PFAS-contaminated water to ultraviolet light to break down the carbon-fluorine bonds into shorter-chain PFAS compounds that are less toxic.

This also helps to remove bacteria and viruses. Activated carbon filtration can complete their removal.



https://www.news-medical.net/news/20220815/Costly-Chemicals3b-The-Health-and-Economic-Impact-of-Forever-Chemicals.aspx

W. Housing supply

96. Double-decker 'burbs': Existing suburbs are losing land and environmental amenities with infill development, while new suburbs have almost no garden spaces.

The new high-density model does not save nature, because the biggest impact on nature is resource extraction (the ecological footprint).

To increase density, second floor units could be added which 'solarize' both units with passive solar power, water and air purification systems and increase biodiversity.

ttps://www.realestate.com.au/news/most-popular-suburbs-to-buy-a-home-northwest-sydney-tops-preferences/

Is this a choice?

Both suburban models - the old 'large lawns' and the new 'no lawns' - are bad designs. They not only are wasteful and inefficient but militate against our social and natural support systems.

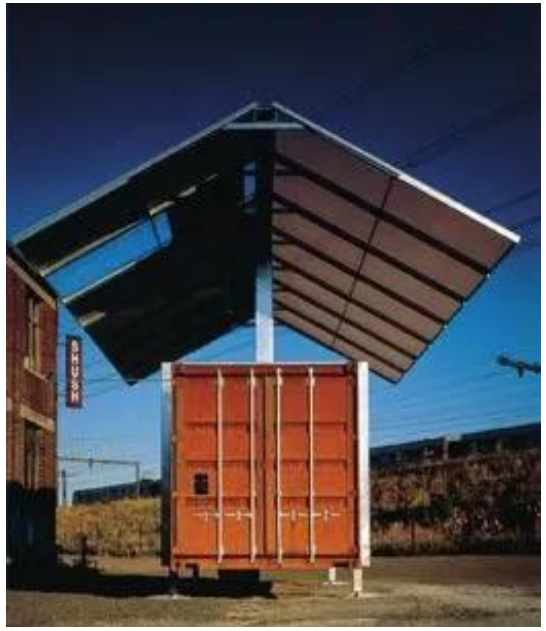
W. Housing supply

96. Temporary housing: Surplus shipping containers have been used while longer-term options are developed.

Shipping containers can be self-contained or stacked to create multi-story apartments to save space near cities. Some containers may have stored toxic materials in the past.

Bridge housing are typically converted from existing buildings, such as motels or dormitories. Units can be added to existing homes.

https://www.gatewaycontainersales.com.au/shipping-containers-housing-the-homeless/



ttps://www.treehugger.com/different-ways-to-put-a-roof-over-your-head-in-these-tents-tizzzzmes-4857630

https://www.hopeofthevalley.org/nohoshelter/

https://www.sbs.com.au/topics/voices/culture/article/2017/05/30/pop-ups-dont-work-why-homeless-people-deserve-more-converted-shipping-containers

Note: These temporary design solutions for shelter are often not replaced with long -term solutions for the impacts of poor government and economic policies which cause homelessness in the first place.

W. Housing supply

97. Affordable housing. Housing is essential to reduce poverty. Sustainable design can be more affordable, secure and beneficial to the whole community - or not - depending on the design.

Yimby = "Yes In My Backyard" advocate for increased density, mixed-use developments, and affordable housing projects in their own communities.

Phimby = "Public Housing In My Backyard" advocate for publicly-owned or subsidized affordable housing in their communities.

Nimby = "Not In My Backyard" are against new development in their communities.

Generally, none yet call for net nature-positive development.

Mueller Airport Reuse Plan in Austin, Texas, a master-planned community

https://www.npr.org/2015/02/12/385474414/with-porches-and-parks-a-texas-community-aims-for-urban-utopia

https://www.kvue.com/article/news/austin-habitat-for-humanity-brings-new-style-of-affordabl

https://guidetoaustinarchitecture.com/places/mueller-development-former-robert-mueller-municipal-airport/

W. Housing supply

98. Homeless shelters: These benefit everyone although they are only due to poor policy decisions.

Bus shelters can provide temporary sleeping spaces during extreme weather conditions. These shelters can be equipped with heating or cooling systems, and basic amenities like toilets and showers.

Pop-up shelters are temporary lightweight, portable shelters that can be moved to where a crisis has occurred.

https://invisiblepeople.tv/bus-shelters-temporary-housing-solution/

https://www.treehugger.com/different-ways-to-put-a-roof-over-your-head-in-these-tents-times-4857630

https://designerecotinyhomes.com.au/charity/

Tiny houses on wheels can be moved to different locations as needed. They can have rainwater collection and food production walls. etc.

X. Mental health

99. Biophilia: Many studies now show that being in nature leads to lower cortisol levels and improved mood. People who engage in outdoor activities have lower stress, anxiety and anger.

Integrating nature into cities for the benefit of humans (and sometimes nature) is now called biophilia.

The term originated in Fromm's *The Anatomy of Human Destructiveness* (1973) and was popularized by E.O. Wilson in 1984 whose work began a movement.

https://www.architectureanddesign.com.au/news/biophilic-design-crown-group

https://www.jumpinnovates.com/thinking/how-brands-can-harness-the-power-of-biophilia-to-ease-consumer-angsts

https://www.newhabitz.com/biophilic-design/

https://anthology-magazine.com/interiors/biophilia/

X. Mental health

100. Negative ions: The air by the ocean and in the mountains is cleaner and fresher than in urban areas, with more oxygen (less CO2). This is due to molecules floating in the air or atmosphere that have been charged with electricity.

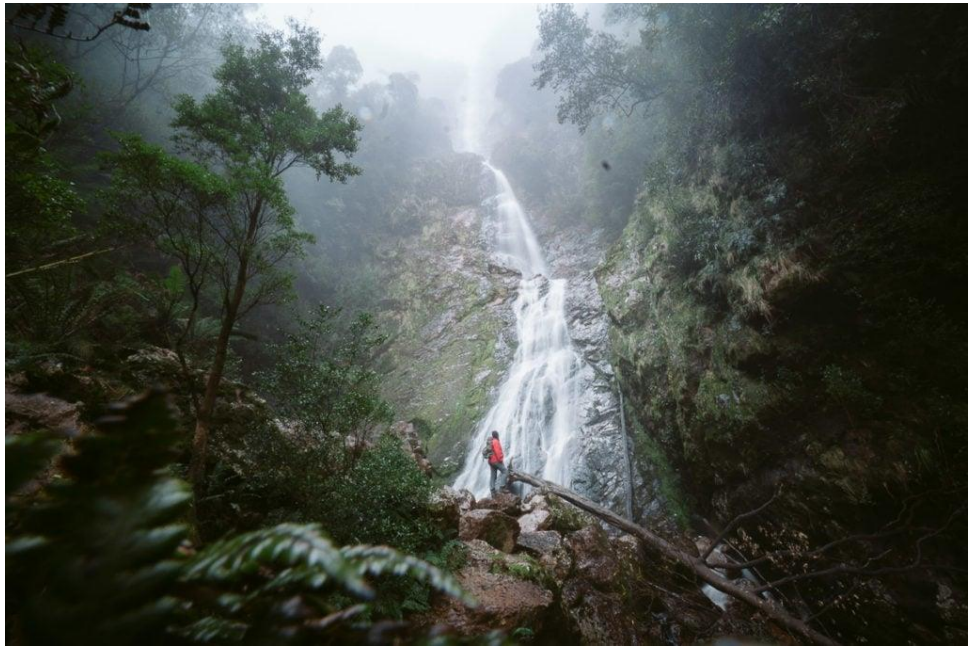
These molecules reduce the number of airborne pathogens and allergens, improving lung function, and reduce inflammation.

Saltwater releases salt into the air through aerosolization which helps to clear mucus, making it easier to breathe.

Salt air can improve the symptoms of asthma and other respiratory conditions, such as bronchitis and sinusitis.

Waterfalls, ocean surf and thunderstorms produce negative ions.

Negative ions can be produced in the home using fountains or by using products that produce it.



https://www.weseektravel.com/waterfalls-in-tasmania/

https://en.wikipedia.org/wiki/Wind_wave

X. Mental health

101. Pet therapy: Engaging with animals have been shown to reduce stress, anxiety, depression and to improve overall well-being and mood.

Companions: Interacting with animals in a recreational or educational setting or in pet zoos for children can measurably improve mental and physical health.

Companion animals provide comfort and support to people with mental health conditions and people in hospitals or nursing homes.

Disabilities: Animals are trained to perform specific tasks for individuals with disabilities (eg. visual or hearing impairments).

Animal-assisted activities or farm work with animals can also improve mental and physical health of able people.

https://udservices.org/animal-assisted-therapy-children/

https://en.wikipedia.org/wiki/Equine-assisted_therapy

https://www.wltx.com/article/news/local/street-squad/youve-goat-to-be-kidding-goat-therapy-is-a-real-thing/

https://petwelfare.org.au/2016/06/07/pets-in-aged-care-facilities/

X. Mental health

102. Nature therapies: These include the following ways that nature helps to reduce stress, anxiety, and depression and to improve mental health, and overall well-being. There are many versions or practices:

- **Forest therapy** (or shinrin-yoku): Immersing oneself in nature and using all senses to connect with nature.
- **Ecotherapy**: Connecting with nature through gardening, hiking, or working with animals.
- **Blue space therapy**: Spending time near water bodies, such as lakes or oceans (salty air).
- **Horticultural therapy**: Working with plants and gardening

https://www.morethantokyo.com/forest-bathing-shinrin-yoku/

https://www.theguardian.com/lifeandstyle/2019/nov/03/blue-space-living-near-water-good-secret-of-happiness

https://www.wildernessreflections.com/event/listening-to-the-wind-a-brief-introduction-to-ecotherapy-aug-14-2021/

Y. Over-population

103. Economic design: The current economic system relies on continuous population growth and consumption, wherein sustainability is impossible.

Governments, including American and Australian political leaders, have actively campaigned for *increased* population to sustain an economy that depends on perpetual growth - rather than redesigning the economic system - which only governments can do.

The 'circular economy' is largely based on applying traditional sustainable development principles but in an economic framework: reducing waste and pollution, increasing resilience, whole-system recycling, reusing, regenerating, restoring, etc.

Recycling is essential but cannot address the impacts of population growth since (among many other things) it does not increase nature in proportion to (unavoided) growth.

Zero = nothing

https://www.europarl.europa.eu/news/en/headlines/economy/20151201STO05603/circular-economy-definition-importance-and-benefits

Y. Over-population

104. Doing nothing: There are numerous - unpleasant - nature-based solutions to over-population which are caused, paradoxically, by human interference in nature:

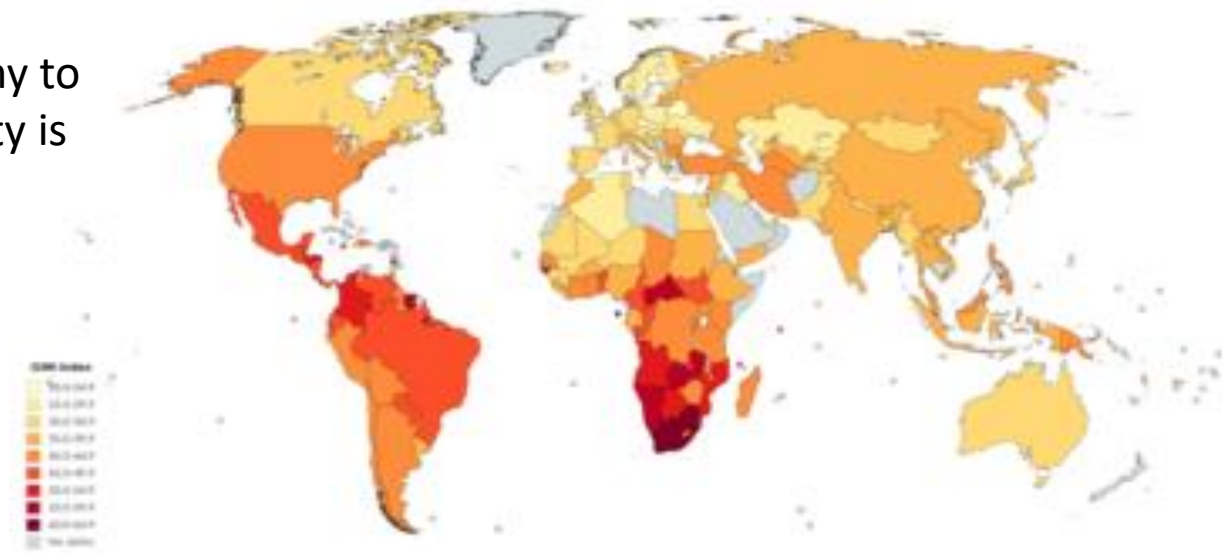
- **Pandemics** are caused by disruptions to nature such as zoonotic diseases, such as Ebola, Rabies, and Avian influenza.
- **Natural disasters** (earthquakes, hurricanes, tsunamis, volcanic eruptions, and wildfires) are exacerbated by bad urban planning.
- **Famine and drought** involve food shortages, malnutrition, and lack of clean water, causing many deaths each year.
- **The heat island effect** shortens many lifespans during heat waves in cities, as does the lack of passive solar energy for heating and cooling.
- **Climate change** destroys basic needs like water, food, and shelter, which often causes population displacement, conflict over resources, and greater exposure to diseases.

https://www.npr.org/2022/11/26/1139276588/italy-ischia-landslide-casamicciola

https://www.coloradoan.com/story/news/2020/10/27/cameron-peak-fire-more-than-400-structures-damaged-since-fires-start/3749567001/

Y. Over-population

https://en.wikipedia.org/wiki/Economic_inequality



105. Inequitable design: Along with redesigning the economy to value quality of life over wealth, equality or equal opportunity is essential to sustainability. Increasing wealth differentials are self-perpetuating shorten the lifespans of the poor.

The built environment can reduce inequality while reducing pollution and poverty, which risks the lives of everyone everywhere.

https://www.phnompenhpost.com/opinion/are-democracies-better-reducing-poverty

https://www.bworldonline.com/world/2022/10/06/478955/world-bank-

https://www.premiumtimesng.com/opinio/

A handful of individuals have more wealth than half of the world's population put together and this disparity continues to increase. Gender poverty gaps are still increasing.

Y. Over-population

106. Gender inequality: Equal rights for women generally reduces population growth in less draconian ways than nature-based solutions, such as environmental crises.

A reduction in gender-based violence, discrimination, and practices like child marriage may enable women to participate more in decision-making processes.

Access to services: Women with access to education, healthcare, nutrition, employment, credit, and property ownership have greater control over their life choices. healthier children, and lower infant and maternal mortality rates.

Urban and regional planning: The built environment can provide access to services (affordable housing, healthcare, education, transport, family planning, employment opportunities). Planning can improve rural regions to reduce migration and urbanization.

Hence, urban planning can make it easier for women to have fewer children.

https://ecampusontario.pressbooks.pub/womenintheworld/chapter/chapter-1-women-and-poverty/

https://share.america.gov/why-do-more-women-than-men-live-poverty/

Z. Concrete

107. Cement substitutes: 14 billion cubic meters of concrete is produced every year. The clinker that binds concrete is made by roasting limestone in extremely hot coal-powered kilns. Current solutions can reduce some emissions:

- Using alternative heat sources, such as burning waste instead of coal (but this causes pollution).
- Capturing and storing the CO2 after produced.
- Capturing CO2 emissions from other industrial processes to use as feedstock
- Using clinker substitutes such as fly ash or calcinated clay.
- Fly ash, a waste product of burning coal, can partially replace Portland cement.
- Slag, a waste product of the iron and steel industry, can be a partial replacement for Portland cement and it uses less energy.
- Recycled concrete aggregate can be used in roads and construction.

https://www.aboutmechanics.com/what-is-slag-cement.htm

Slag was used as a construction material for centuries. In the late 1800s it began being used to replace some of the cement.

Fly ash has been used in concrete for over 60 years to replace some of the cement. It is a hazardous waste that can be sequestered in buildings while improving the quality of the concrete. However, coal should not be burned in the first place.

https://www.stanwell.com/energy-assets/new-energy-initiatives/coal-combustion-products/

Y. Concrete

108. Self-healing bacteria: Shape-memory polymers, minerals, resins, and other materials - in capsules containing healing agents - are embedded in the concrete mix. When the pellets crack with the concrete, moisture in the air triggers the spores to germinate and feed on calcium lactate in the presence of moisture and oxygen to form limestone, sealing the cracks.

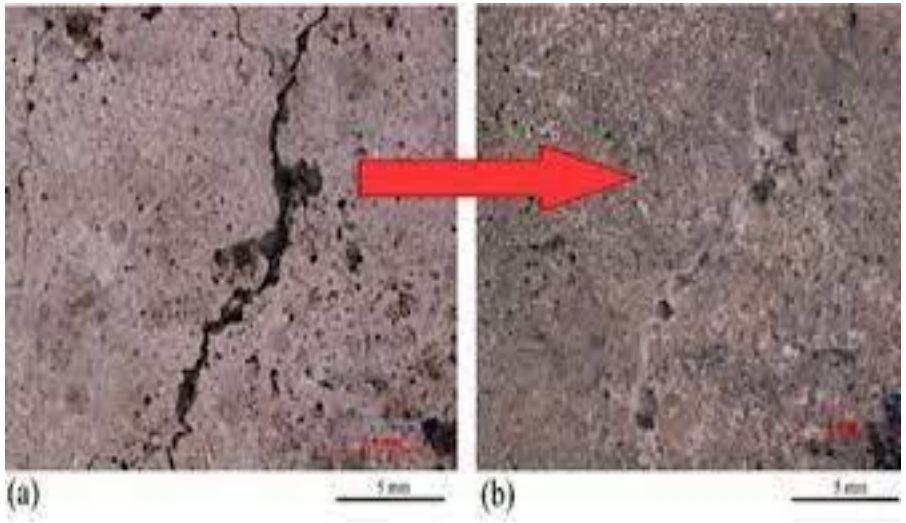
Bacteria: Alkali-tolerant bacteria can survive the high pH of concrete. Some researchers have mixed clay pellets containing calcium lactate and spores of limestone-producing bacteria into concrete.

This healing can happen in within three weeks.

This technology may come onto the market in three different forms:

- a concrete
- a mortar for patching cracked concrete
- a liquid that can be sprayed onto existing structures.

https://cen.acs.org/articles/94/i6/Helping-Concrete-Heal-Itself.html



https://www.materialsperformance.com/articles/material-selection-design/2018/09/new-bacterial-process-developed-to-heal-concrete

Y. Concrete

109. Self-healing Fungi: Fungi can also be used in capsules that contain spores in concrete. These germinate when water enters a crack. These grow into hyphae, which then produce calcium carbonate and other minerals to fill the crack.

There have been some small-scale tests of self-healing concrete in real-world settings

https://www.dezeen.com/2016/11/21/sonnesgade-11-office-building-architecture-cracked-concrete-facade-sleth-aarhus-denmark/

https://www.smithsonianmag.com/innovation/with- fungi-in-mix-concrete-can-fill-its-own-cracks-180967911/

Delft University researchers used Trichoderma reesei, a type of fungus, encapsulated in calcium alginate beads. When germinated, the fungal spores grew hyphae (filaments) which filled the cracks.

Newcastle University and the University of Bath are also working on this nature-based solution.

https://newatlas.com/self-healing-concrete-fungus/53036/

Z. Concrete

110. Hempcrete: Loadbearing hempcrete blocks can be made of hemp, lime and water. Hemp can be load-bearing as well as used as infill within a wall. It has been used in large buildings.

These blocks provide acoustic insulation, thermal mass, humidity regulation, fire, pest and mold resistance and it is breathable and sequesters carbon. It is claimed to be ten times stronger than concrete and one sixth of the weight.

https://renew.org.au/sanctuary-magazine/building-materials/hemp-hemp-masonry-and-hempcrete/

https://www.crown.co.za/construction-world/projects-and-contracts/21412-the-world-s-tallest-building-constructed-with-hempcrete-is-in-cape-town

&. Biodiversity and carbon sinks

The IPCC, in 2021, estimated that natural land sinks sequester about 11 gigatons while oceans absorb about 23 gigatons carbon per year. This is roughly 29% of human-caused CO2. Human activities emit around 42 gigatons of CO2 per year. The remaining 71% accumulates in the atmosphere. Different species support carbon capture and storage in natural systems in various ways and they are essential to maintain the health of those systems.

However, natural carbon sinks (eg. oceans, soils, grasslands, forests) are being destroyed or degraded daily.

Biodiversity loss contributes to the destruction of these major natural carbon sinks.

&. Biodiversity and carbon sinks

111. Ocean sinks: The world's oceans may absorb up to 3 gigatons/year (25% of CO_2 emitted by humans). Ocean creatures take up carbon. Acidification and ocean warming, decrease the ability of some organisms to form shells and skeletons - leading to more emissions.

- **Phytoplankton** may absorb up to 50 billion M tons of carbon each year via photosynthesis.
- **Whales** eat the phytoplankton and their poo feeds marine life. When large whales die, they sequester a significant amounts of CO_2 at the bottom of the ocean
- **Seagrasses** absorb CO_2 from the water and may sequester up to 83,000 Mt of carbon per sq. kms./year.
- **Bivalves** (eg. oysters and mussels) filter CO_2 from the water and sequesters it in shells. Oyster reefs may sequester up to 4.4 million Mt of carbon/year.
- **Algae** absorb CO_2 from the atmosphere in photo-synthesis (and reduce CO_2 when used as biofuels).
- **Sea otters** that help maintain kelp forests are declining, causing over 100,000 Mt of carbon emitted per year on the west coast of the USA.

https://www.euronews.com/green/2021/10/27/restoring-whales-to-their-pre-hunted-numbers-could-capture-1-7-billion-tonnes-of-co2-a-year

https://ocean.si.edu/ocean-life/plants-algae/fish-feeding-seagrass

https://www.themarinediaries.com/tmd-blog/one-fish-two-fish-three-fish-shellfish

https://a-z-animals.com/blog/what-eats-algae/

https://www.nationalobserver.com/2023/02/06/news/west-coast-kelp-sea-otters

&. Biodiversity and carbon sinks

112. Soil sinks: Microbes and invertebrates (eg. earthworms, ants, termites, soil bacteria, fungi) break down organic matter which improves soil health and productivity as it accumulates in the soil.

Soil biota may sequester up to 1.2 gigatons of carbon/yr.

- **Fungi** may increase soil carbon by up to 70%.
- **Earthworms** may increase soil carbon by up to 37%. They aerate the soil which increases the sequestration rate.
- **Soil bacteria** may increase soil carbon by up to 50%. They improve soil structure and fertility, which increases the sequestration rate.
- **Ants** may increase soil carbon by up to 36%.
- **Termites** break down dead plant material which releases carbon into the soil. Their underground nests also store carbon.

  However, they also produce methane which may cause 20 million Mts of CO_2 equivalent per year.

https://www.permaculturenews.org/2014/05/07/fungal-soil-want/

https://www.soilquality.org.au/factsheets/soil-bacteria-and-fungi-nsw

https://d-tec.com.au/2021/06/14/termites-in-garden/

https://www.panna.org/blog/got-worms-why-healthy-soil-matters

https://meadowia.com/soil-layer/

&. Biodiversity and carbon sinks

113. Grassland sinks: Grasslands sequester CO_2 from the air via photosynthesis and store CO_2 in their roots and soil. Wild or properly managed grasslands are a net carbon sink and may sequester up to 1.1 G tons of carbon/year globally.

They support biodiversity and are well suited for wind and solar power facilities.

- **Grazers** help to maintain grasslands and may increase the amount of carbon stored in grassland soils by up to 33%. However, livestock needs to be managed to reduce methane.

  Cattle may cause about 2.7 billion M tons of CO_2 equivalent per year.

  Camels produce less methane than other livestock such as cattle and sheep by 15-20%.

- **Prairie dogs** increase organic matter in the soil by burrowing and grazing. Their colonies may sequester up to 20,000 M tons of carbon per sq. km.

https://news.cgtn.com/news/2020-07-10/Deer-frolic-in-the-grasslands-of-NW-China-S0OmhHNYTS/index.html

https://www.agric.wa.gov.au/livestock-movement-identification/documentation-importing-camels

https://homestead-animal-hospital.com/articles/general/627580-prairie-dogs

&. Biodiversity and carbon sinks

114. Forest sinks: Forests may sequester up to 2.8 G tons of carbon per year (roughly 30% of CO_2 caused by humans). However, deforestation and forest degradation from clear-cutting, burning, and intensive logging decreases sequestration and releases about 2.8 G tons of CO_2 per year.

- **Elephants** help maintain the health of forests, which sequester carbon by opening the forest canopy and allowing light to reach the forest floor, which increases photosynthesis.
- **Birds** spread seeds which helps to restore degraded forests and other landscapes.
- **Butterflies** pollinate plants which increase the carbon stored in the soil. Butterfly pollination may increase soil carbon by up to 26%.
- **Beetles** and **ants** break down and incorporate dead wood into the soil, aerate it and increase its fertility. Beetle activity may increase sequestration by up to 20%, and ant activity may increase soil carbon sequestration by up to 36%.

https://www.earth.com/news/elephants-are-forest-gardeners-that-help-reduce-global-warming/

https://www.dailysabah.com/life/2019/08/26/superstitions-busted-bird-droppings

https://www.google.com/search?q=butterflies+pollinating+flowers&tbm

https://bygl.osu.edu/node/1535

&. Biodiversity and carbon sinks

115. Wetland sinks: Wetlands have a layer of peat, which is partly-decomposed plant material that sequesters carbon. Plants, such as cattails and reeds, take in CO_2 during photosynthesis, and later decompose in the soil. They may store up to 30% of the world's soil carbon.

Beavers build dams that create wetlands.

Fish (eg. salmon, trout, catfish) breed in wetlands wherein marsh plants provide a nursery for the young.

Problems: Like other natural systems, if degraded they can emit more carbon than they sequester.

- **Rice paddies** use flooded fields that are conducive to methane-producing microbes and may be responsible for around 1.5 billion metric tons of CO_2 equivalent per year.
- **Methane** is produced in waterlogged conditions that support methane-producing microbes and may cause 190 million metric tons of CO_2 equivalent per year.

https://today.oregonstate.edu/news/more-wolves-beavers-needed-part-improving-western-united-states-habitats

https://natureglenelg.org.au/the-link-between-drains-wetland-restoration-and-native-freshwater-fish-conservation/

https://ny.audubon.org/conservation/10-marsh-birds-teaching-us-about-wetlands

Takeaways

The greenest buildings still damage our essential natural and social life-support systems

Socio-ecological harms, material-energy flows, etc., are still systemic and undercounted

Current design closes off positive future options (eg. biodiversity losses, toxins, waste)

Replacing cities would cause too much materials, energy, and nature destruction

Retrofitting cities for 'net-positive' public gains is therefore a sustainability imperative

This can occur everywhere at once and pay for itself through public and private savings

Passive, adaptable, multifunctional and a 'net-positive' design paradigm is necessary

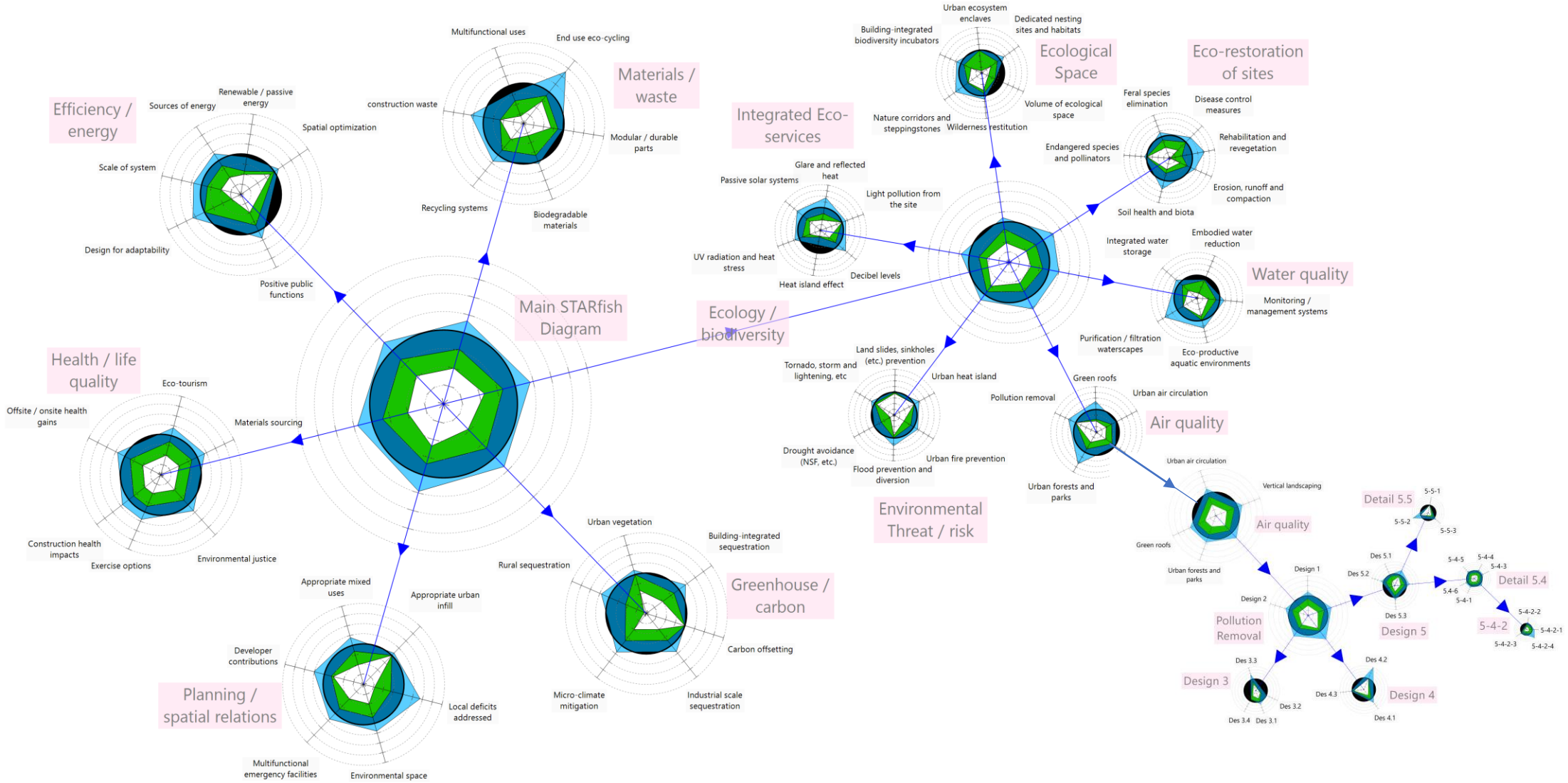
'Net-positive' means *beyond* sustainable (not just 'zero net impact' or 'more good-less bad')

Cities can be a 'silver bullet' if net-positive design is used to increase nature and justice

Since cities affect all sustainability issues, urban and building design can improve all issues

NET POSITIVE DESIGN ACTIONS and OUTCOMES are *finally* MEASURABLE only with this *free* 'STARfish app'

DOWNLOAD FROM Http://netpositivedesign.org



Questions, suggestions, comments to :
Janis Birkeland at netpositivedesign@gmail.com