Module 3: DPSIR Tools

This module will present a suite of tools being developed to facilitate development of DPSIR frameworks for specific management problems.

DPSIR Tools – DPSIR Process

We will now present several examples to illustrate how a DPSIR framework can be built to assist decision-makers with a particular problem or management concern.
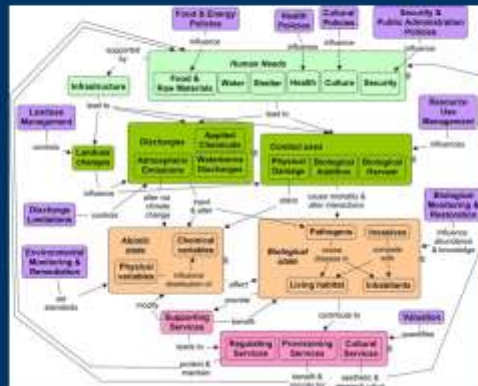
The basic steps to building a DPSIR concept map are to

• Define the system, problem, or management concern

• List key concepts or keywords related to the concern

• Determine concepts or keywords that are linked uphill (causing the problem) or downhill (result from the problem) to the central topic.

• Continue building uphill/downhill until all five sections of DPSIR are filled with relevant, linked concepts

The flexibility of the DPSIR framework allows the initial concept to be anywhere within DPSIR, depending on the specific economic, ecological, or management concerns of the decision maker. Although starting with a narrow set of concerns, framing the problem within DPSIR encourages the decision-maker to adopt a systems approach, and think about the uphill and downhill challenges to the problem within the larger system.

DPSIR Tools – Generic DPSIR Tools

Although DPSIR has been widely used, tools are generally lacking which can aid decision-makers in building a DPSIR framework for their own problem.

DPSIR frameworks are typically developed to address a specific management problem.

EPA has developed a generic DPSIR framework to aid decision-makers in development of specific DPSIR models for their own systems.

This module covers the use of several tools:

•A list of generic DPSIR keywords and the links between them

•A generic DPSIR concept map

It is anticipated that users will use the DPSIR tools as a starting point, retaining or adding keywords that are specifically relevant for their system.

DPSIR Tools – DPSIR Keyword Table

The DPSIR Keyword Table provides a list of DPSIR concepts, spanning a number of ecological systems and management concerns.

Keywords are listed for each of the five DPSIR categories, with additional sub-categories to aid in organizing concepts.

In a series of separate worksheets, the table also provides downhill links between DPSIR concepts:

•Drivers to Pressures – socio-economic sectors and the pressures they create through their activities

•Pressures to State – effects of given pressures on the biological and abiotic state of the ecosystem

•State to Impact – impacts to beneficial services provided by components of the ecosystem

•Impact to Driver – socio-economic sectors which benefit from ecosystem services

•Response to Drivers, Pressures, or State - decision options and the factors they target

The table serves as a starting point for creating a new, problem-specific DPSIR, with the user adding specific details, or additional keywords, for their particular system. It is intended to aid decision-makers or scientists to think outside of their specific area of expertise.

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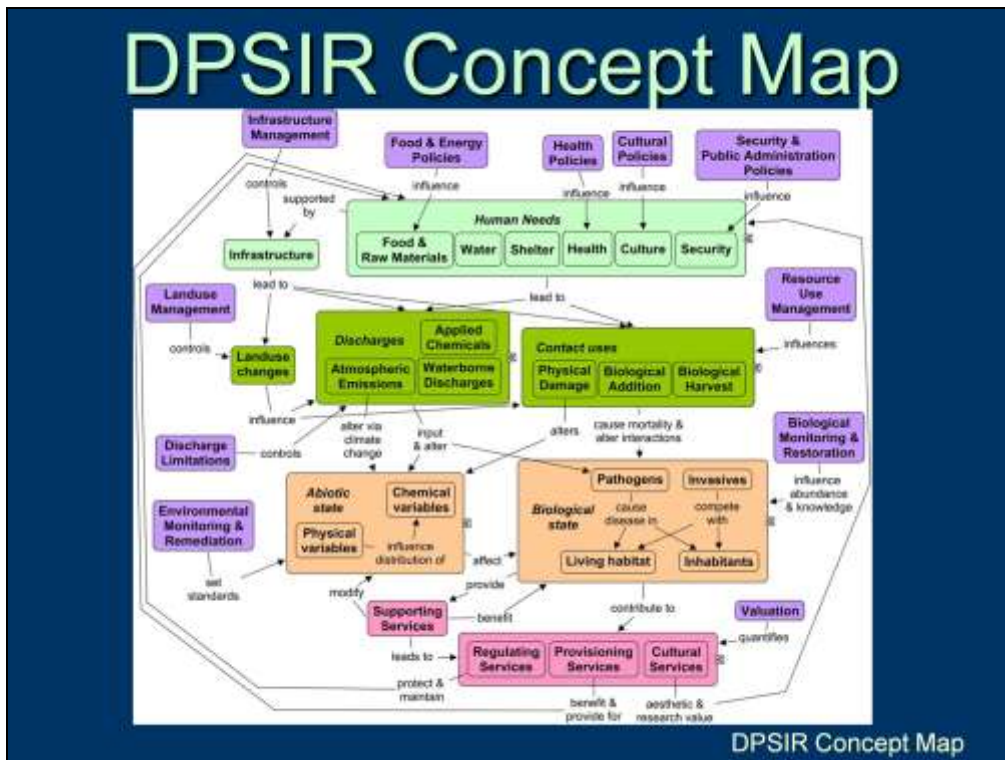
DPSIR Tools – DPSIR Concept Map

The keyword concepts in the DPSIR Keyword Table can be used to generate a DPSIR Concept Map.

Concept mapping is a visual systems approach to show how concepts are linked. Nodes (boxes) are connected by linking phrases, forming a short sentence describing the link between two concepts. Concept mapping is a valuable tool for brainstorming concepts, organizing concepts, and conveying information.

DPSIR categories, concepts, and links listed in the DPSIR Keyword Table can be illustrated through the use of conceptual mapping.

We have created a Generic DPSIR Concept Map to illustrate how a decision-maker or researcher may visualize key concepts related to their specific problem or system. The Generic DPSIR Concept Map is intended to serve as a starting point from which users may remove or add concepts related to their system.

Software programs, such as Microsoft PowerPoint or CmapTools, can be used to generate flow charts showing linked concepts.

This file is available on the DPSIR Tutorial Homepage   (GenericDPSIR.cmap , GenericDPSIR_simple.cmap, GenericDPSIR_cmap.jpg, GenericDPSIR_simple_cmap.jpg).

DPSIR Concept Map

DPSIR Tools – Drivers

Drivers are often defined as socio-economic sectors that fulfill *Human needs* for food & raw materials, water, shelter, health, culture, and security. Other socio-economic sectors do not directly fulfill human needs, but instead support other sectors by building and maintaining the *Infrastructure* needed for the economy to operate.

A useful approach is to derive Drivers from the North American Industrial Classification System (NAICS), the government standard which defines a comprehensive list of sectors of the economy. In creating a generic DPSIR, we found it useful to slightly re-categorize NAICS sectors to reflect human needs, and we emphasized certain sub-sectors that seemed particularly relevant to environmental management, while collapsing other sectors. Some sectors may fall under more than one category (recreational fishing for food & culture), or can be placed where most relevant to a given management issue.

Sectors providing *Food & raw materials* include…
•Agriculture- croplands, rangelands   •Aquaculture
•Oil & Gas Extraction   •Fishing- commercial fisheries, artisanal fishing, & recreational fishing
•Forestry   •Mining & Quarrying – coal mining, mineral mining

Sectors fulfilling human needs for *Water* include…
•Drinking water supply   •Irrigation

Sectors fulfilling human needs for *Shelter* include
•Housing - home construction, real estate, single family & multi-unit housing
•Textiles & Apparel

Sectors fulfilling human needs for *Health* include
•Medical care – hospitals   •Pharmaceuticals and cosmetics
•Social assistance - child care centers   •Waste management - sewage treatment facilities and landfills

Sectors fulfilling human needs for *Culture* include
•Tourism & recreation – recreational fishing & hunting, beaches & natural lands,
•Education – primary & secondary education, colleges & universities
•Information – telecommunications, scientific research, biotechnology research & development
•Social organizations- churches, outreach groups, families

Sectors fulfilling human needs for *Security* include
•National defense – coastal defense, munitions   •Public administration – government, courts, law enforcement

Infrastructure sectors provide the physical, organizational, and technical support for the economy to function and include…

•Manufacturing & trade   •Transportation – air & road transportation, ship & boat operation, warehousing

•Construction & civil engineering – road, utility line, building, dam, and pipeline construction

•Finance & insurance – banks, insurance   •Utilities – electric power, natural gas

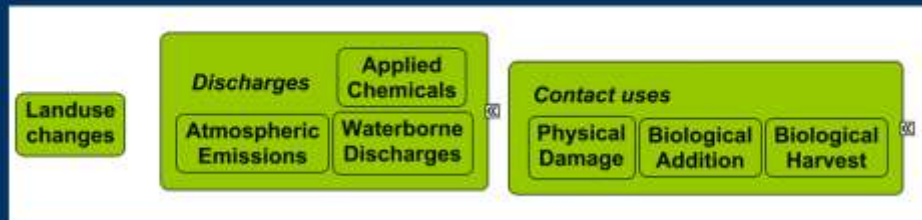•Technical services – management of companies, repair & maintenance services, personal services

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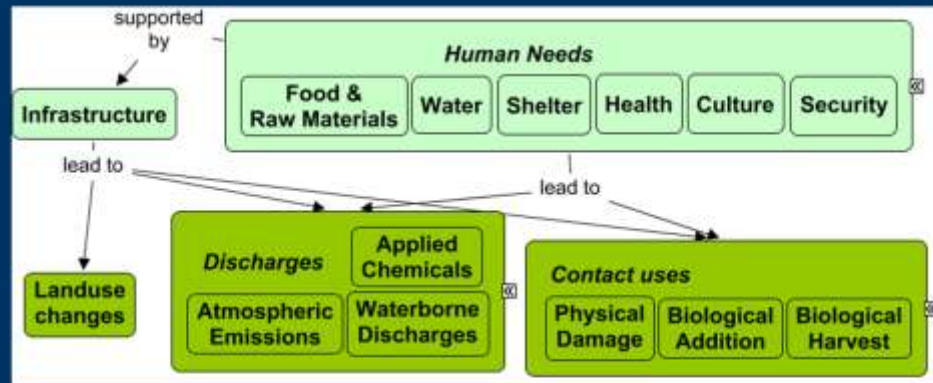
DPSIR Concept Map

DPSIR Tools – Drivers→Pressures

Drivers function through human activities, such as land use changes, discharges, and contact uses, which may intentionally or unintentionally exert **Pressures** on the environment.

DPSIR Tools – Pressures

Pressures are human activities that create stress on the environment and include

Landuse changes resulting from alterations of the natural landscape, typically associated with population growth, including

•Coastal development   •Land development   •Shoreline alteration

•Hydrologic modifications, including impervious surfaces   •Deforestation and devegetation

Discharges of pollutants may result from the operation of industries or vehicles, or the diffuse distribution of contaminants from agricultural lands, roads, or lawns through ground-water or storm-water run-off, and includes both

•Applied chemicals – use of fertilizers, pesticides, insectides, and herbicides

•Atmospheric discharges – vehicle & smokestack emissions including greenhouse gas emissions, sulphur & nitrogen oxide emissions, volatile organic compound emissions

•Waterborne discharges – point and non-point source discharges including wastewater discharges, contaminant discharges, and impervious surface run-off

•Littering

Contact uses are human activities that lead to a direct alteration or manipulation of the environment, and include

•Physical damage – dredging & filling, boat gear & anchor damage, vessel groundings, trampling, movement of boats

•Biological addition – ballast discharge, release of non-natives, feeding, creation of artificial habitat

•Biological harvest – harvesting, fishing, accidental by-catch, clear cutting
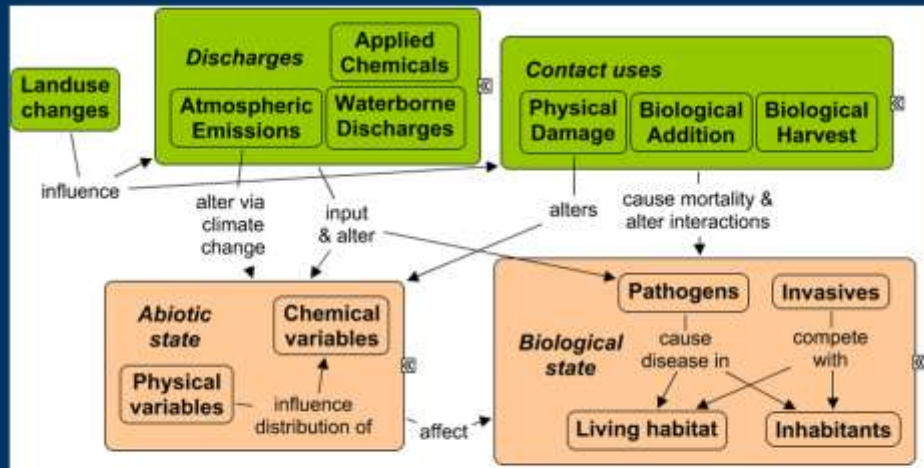
DPSIR Tools – Pressures→State

The **Pressures** exerted by society may lead to unintentional or intentional changes in the **State** of the environment, including the concentration and quantity of physical and chemical variables through inputs of contaminants or sediments, or climate change, as well as altering the abundance, size, and diversity of biological variables by causing mortality or altering interactions among species.

State
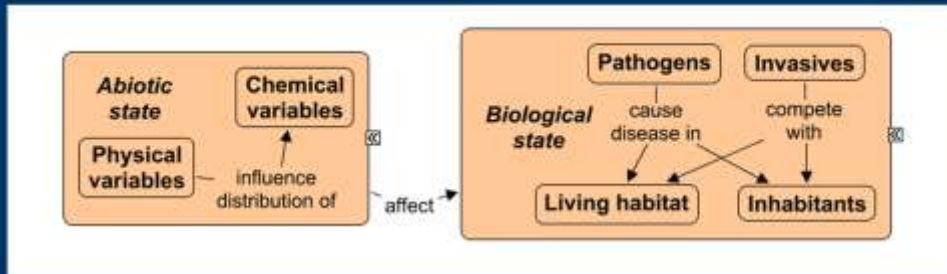
DPSIR Concept Map

DPSIR Tools – State

Abiotic state reflects the magnitude, frequency, and concentration of the environment including

•**Physical variables** – climate variables (air and sea temperature, precipitation, storms & hurricanes, drought), hydrology, ocean circulation patterns, turbidity, fire

•**Chemical variables** – contaminants, nutrients, pH, atmospheric CO_2 levels, salinity

The abiotic environment determines the survival, growth, and distribution of living organisms in the Biological state.

Biological state includes the biological components of the ecosystem and their interactions. In general, this includes sessile plants or animals that provide the living habitat and base of the food web that supports a number of inhabitants.

Living habitat is generally defined by the ecosystem of interest. These sessile plants and animals compete for space, light, and nutrients within the physical habitat, and generally form the basis of the food web as primary producers.

•Desert – desert plants   •Wetlands – seagrasses, mangroves, wetland forests

•Grasslands – grasses, shrubs, trees   •Forests – trees, understory plants

•Reefs – oyster beds, stony coral, algae, sponges & anemones   •Agricultural Plants

Living habitat, including plants and sessile animals, form the foundation of primary productivity and habitat that support **Inhabitants** and form the food web including

•Birds & Mammals   •Reptiles & amphibians   •Fish   •Invertebrates - including shellfish, insects

Their diversity is often strongly linked to the diversity of living habitat.

Invasive species compete with, prey upon, or alter interactions among native species. They may enter the system through intentional introductions, hitchhiking on human transportation (cars, boats) or other animals, or accidental release of pets, garden plants, or aquarium species. Invasive species include

•Aquatic species – including fish & aquatic invertebrates

•Animals – including birds, insects

•Plants – including grasses, shrubs, vines, and trees

The USDA has a list of species identified as invasive, found at http://www.invasivespeciesinfo.gov.

Microorganisms and pathogens may have benefits in ecosystem function, such as decomposers or mycorrhizae, or be disease-causing agents, and include

•Bacteria   •Fungi   •Viruses

The relevant species and interactions included in a DPSIR framework should reflect the specific ecosystem and concerns for which the framework is being developed.

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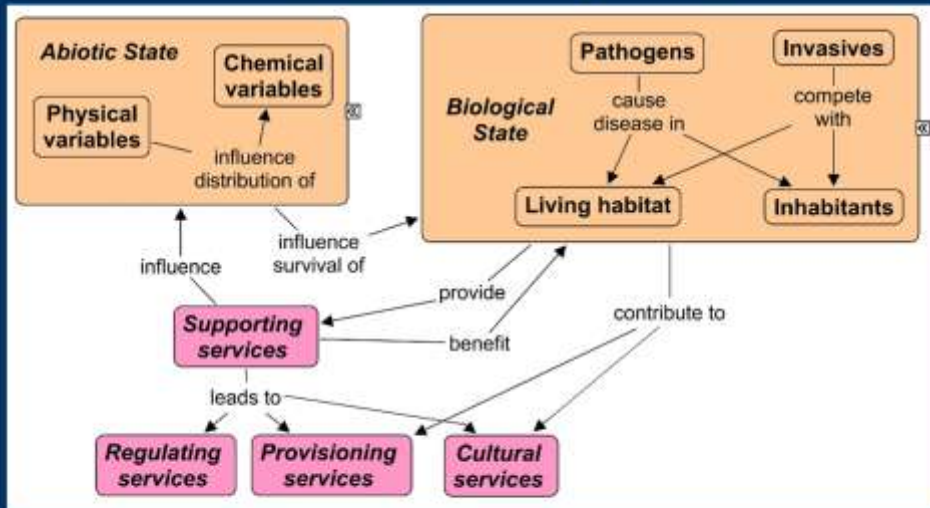
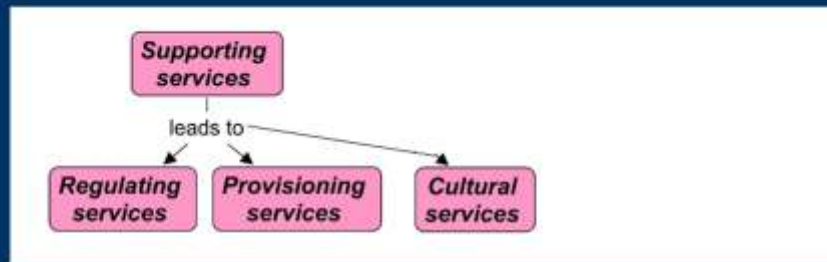**DPSIR Tools – State→Impact**

Changes in the quality and functioning of the ecosystem **State** have an **Impact** on the welfare or well-being of humans through the provision of ecosystem services.

DPSIR Tools – Impact

The Millennium Ecosystem Assessment (*Hassan et al. 2005*) defined four categories of ecosystem services:

Supporting services - biophysical processes that maintain the functioning of the ecosystem, and are necessary for the production of other ecosystem services, but may not have direct impacts to humans, including

•Structure – Soil stabilization, wave energy attenuation   •Nutrient & contaminant processing

•Water cycling   •Carbon storage & cycling – including primary production

•Provision of food and habitat to critical species

Regulating services – biophysical processes that regulate the ecosystem, including

•Air quality regulation   •Climate regulation   •Water regulation   •Erosion regulation

•Water purification and waste treatment   •Disease regulation   •Pest regulation

•Pollination   •Natural hazard regulation

Provisioning services – the biological, chemical, or products obtained or harvested from ecosystems for human use including

•Water resources – including fresh water

•Food resources – including finfish, shellfish, and hunting stock

•Biochemical & genetic resources – for pharmaceutical development, or breeding of wild & controlled populations

•Raw materials – including fuel, fiber, and ornamental resources

Cultural services – include the nonmaterial benefits people obtain from the ecological integrity of ecosystems through spiritual enrichment, cognitive development, reflection, recreation, and aesthetic experiences, including

•Recreational value & ecotourism   •Aesthetic value   •Cultural value

•Spiritual or religious value   •Social relations   •Sense of place

•Educational or knowledge value   •Research potential   •Untapped future potential
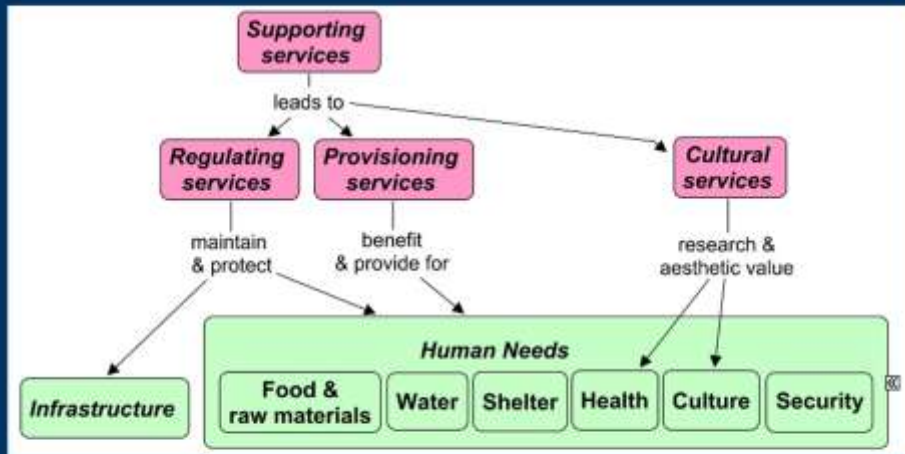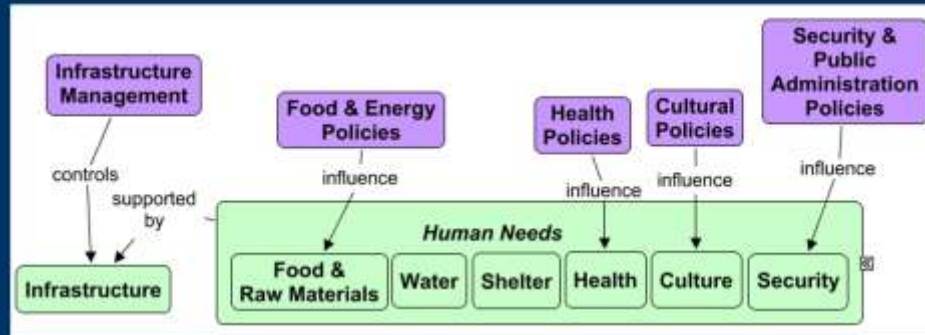
DPSIR Tools – Impact→Drivers

An **Impact** on Ecosystem services has a consequence for human well-being, because ecosystem services directly or indirectly benefit human social or economic **Drivers**. Often the drivers which benefit from the ecosystem are the same drivers which exert pressures which Impact the ecosystem.

DPSIR Tools – Response→Drivers

Humans make decisions in **Response** to the impacts on ecosystem services or their perceived value. Responses are actions taken by groups or individuals in society and government to prevent, compensate, ameliorate or adapt to changes in the state of the environment.

Responses may seek to control **Drivers** through policies or economic decisions that directly influence sectors, including

Infrastructure management

•Construction codes   •Economic markets – including carbon markets

•Transportation management   •Corporate responses   •Manufacturing & trade regulations

Food & energy policies

•Agricultural & aquacultural Policies – including Agricultural Best Management Practices, pest and nutrient management, or conservation buffers

•Fishing & hunting policies – such as catch limitations, consumer preferences for sustainable species

•Energy policies – including carbon credits, emissions testing, alternative energy sources

Health policies

•Waste-treatment policies   •Biomedical research funding   •Patent laws regarding naturally found bio-chemicals

Cultural polices

•Environmental education and outreach – including training, demonstrations, or brochures

•Tourism & recreation policies – including establishing visitor centers or marketing to increase, decrease, or direct tourism activities

•Cultural protections – including religious and historical protections

•Funding & donations

Security & public administration policies

•Actions to improve enforcement of existing laws   •Political pressure by citizens or officials on government

•Collaboration & partnering   •Decision support tools and management planning

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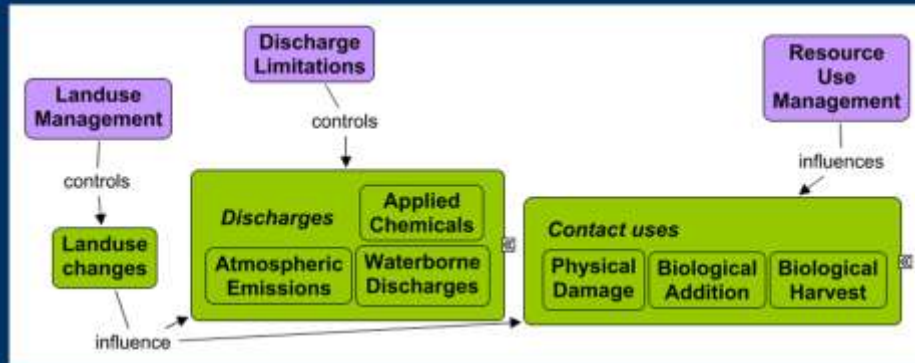
DPSIR Concept Map

DPSIR Tools – Response→Pressures

Responses may also seek to control **Pressures** through regulations or technology that limit human activities, or decisions designed to modify human behavior, including

Land-use management which seeks to plan and control development of lands through
•Landuse management
•Building permits
•Beach renourishment
•Designation of protected areas

Discharge limitations which place limits on and monitor pollution including
•Non-point source discharge regulations
•Point or mobile source discharge regulations
•Improved technology – including alternate energy sources such as solar or wind power

Resource-use management
•Setting designated uses
•Designating protected areas, such as conservation lands or Marine Protected Areas
•Fishing, harvesting, & hunting regulations
•Boating regulations

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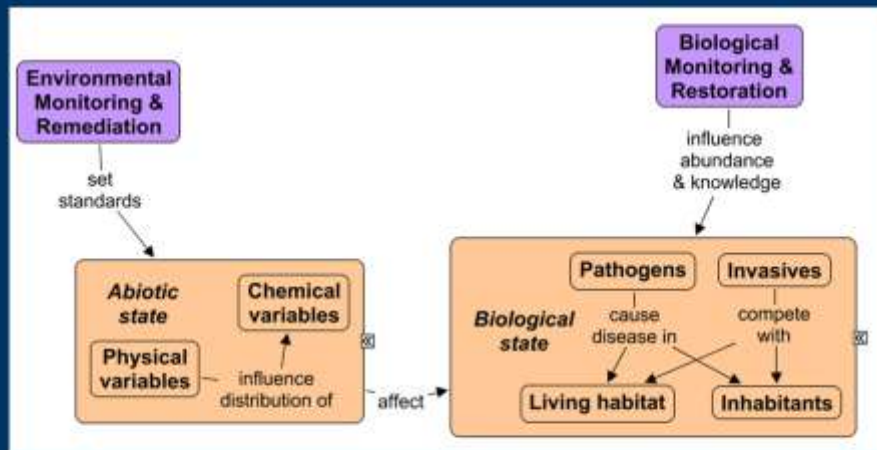
DPSIR Tools – Response→State

Responses may also directly impact the **State** of the environment, through

Environmental responses which seek to control the physical and chemical environment including
•Water quality monitoring
•Air quality monitoring
•Setting water or air quality criteria

Ecosystem responses which control or alter the ecosystem through
•Monitoring
•Scientific research
•Setting biological criteria
•Restoration activities – including efforts to re-establish native species
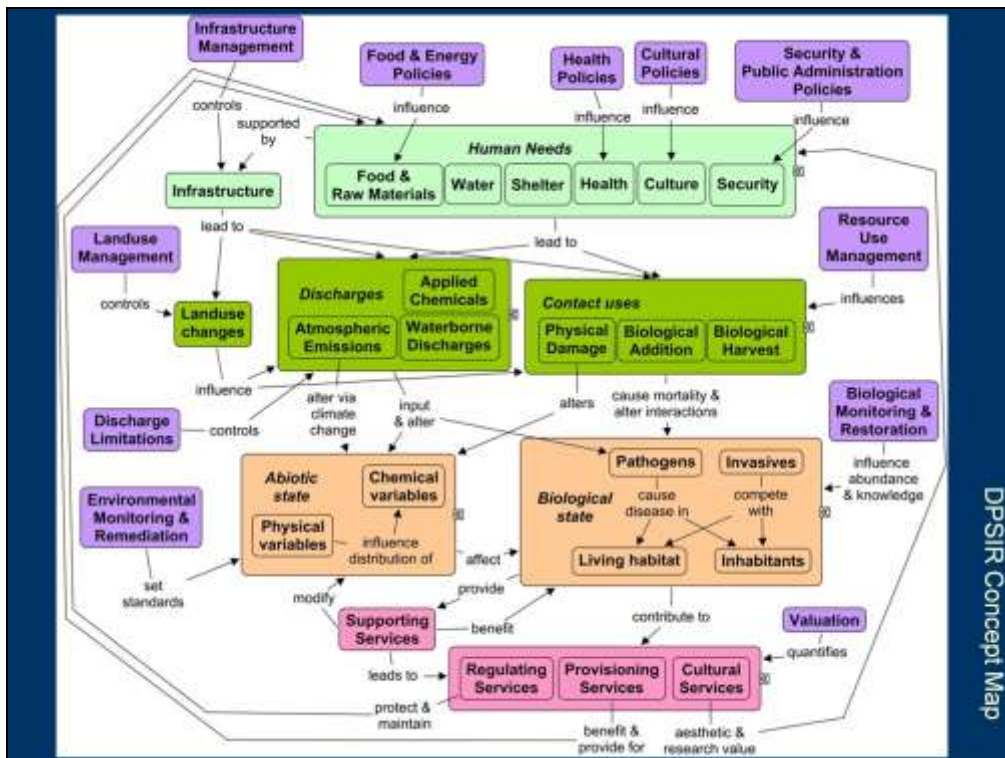
DPSIR Tools – Response→Impact

Responses may also be conducted to evaluate the potential costs or benefits of any **Impacts** on the provision of Ecosystem Goods and Services.

Valuation methods seek to quantify the value of ecosystem services, such that their value can be incorporated into decision analyses for comparison of tradeoffs under alternative scenarios.

•Monetary valuation methods – including willingness to pay, economic market values.

•Non-monetary valuation methods – including methods such as multi-criteria attribute theory which are used to quantify stakeholder preferences

DPSIR Tools – DPSIR Concept Map

Linking all the individual concepts together forms a DPSIR conceptual map.

The final map highlights the uphill and downhill concepts related to a given topic of concern or management issue.

The DPSIR Keywords List and DPSIR Concept Map are intended to serve as starting points for creating a problem-specific or system-specific DPSIR.
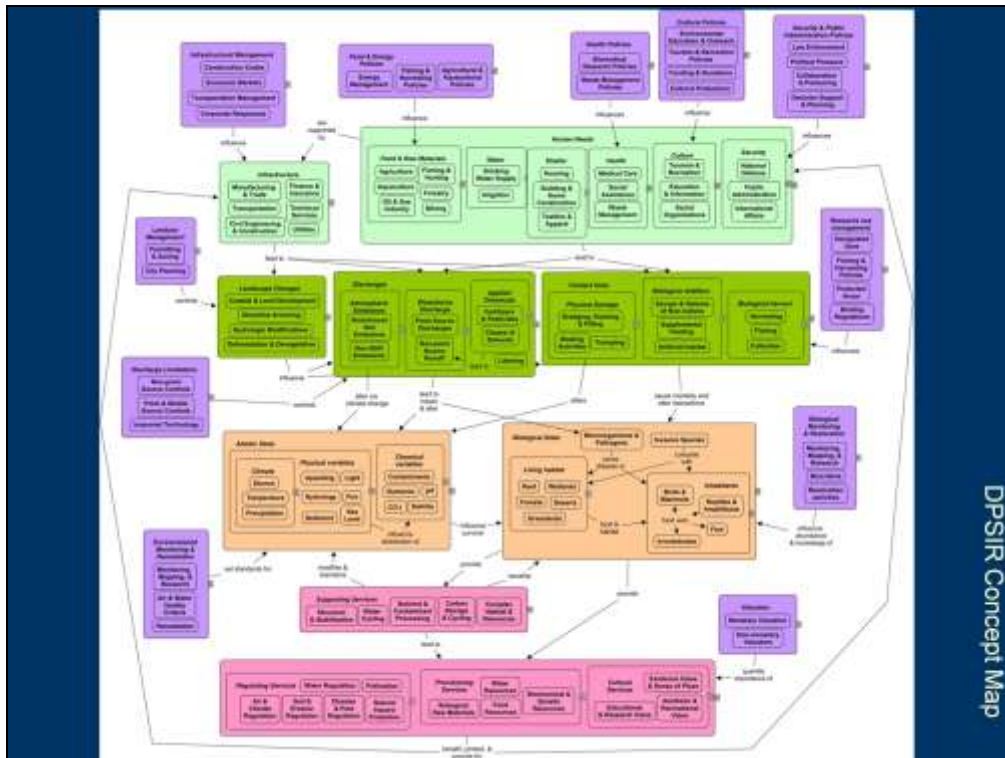
Software programs, such as Microsoft Powerpoint, CMAPTools, or other drawing applications, are useful for creating concept maps or flow-chart diagrams. A specific DPSIR can either be created from scratch, drawing keywords and connections from either the DPSIR Keywords List or DPSIR Concept Map. Alternatively, the DPSIR Concept Map may be downloaded and modified. Concepts can be removed, added, or altered to reflect the specific problem or system. It is anticipated that details of the ecosystem state, such as key species or interactions, will need to be added.

Click to the next slide to see the more detailed generic DPSIR conceptual map.

These files are available on the DPSIR Tutorial Homepage.

GenericDPSIR_simple.cmap

GenericDPSIR_simple_cmap.jpg

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DPSIR Concept Map

DPSIR Tools – DPSIR Concept Map

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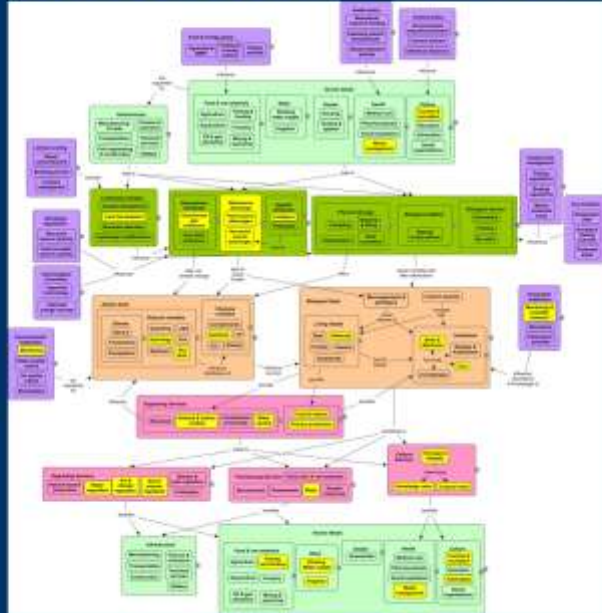
GenericDPSIR_cmap.jpg

GenericDPSIR.cmap

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DPSIR Tools – Wetlands Example

Problem – Wetlands provide numerous ecosystem services that contribute to human well-being, including habitat for wildlife, stock for fisheries, flood and storm surge protection, recreational opportunities, carbon sequestration, and improving water quality. Yet wetlands are subject to numerous stresses, including development, hydrologic modifications, invasive species, pollution, land-use changes, and resource exploitation.

A DPSIR framework can be used to link stressors to their impacts on ecosystem services, and to highlight the causes of stresses and potential management actions.
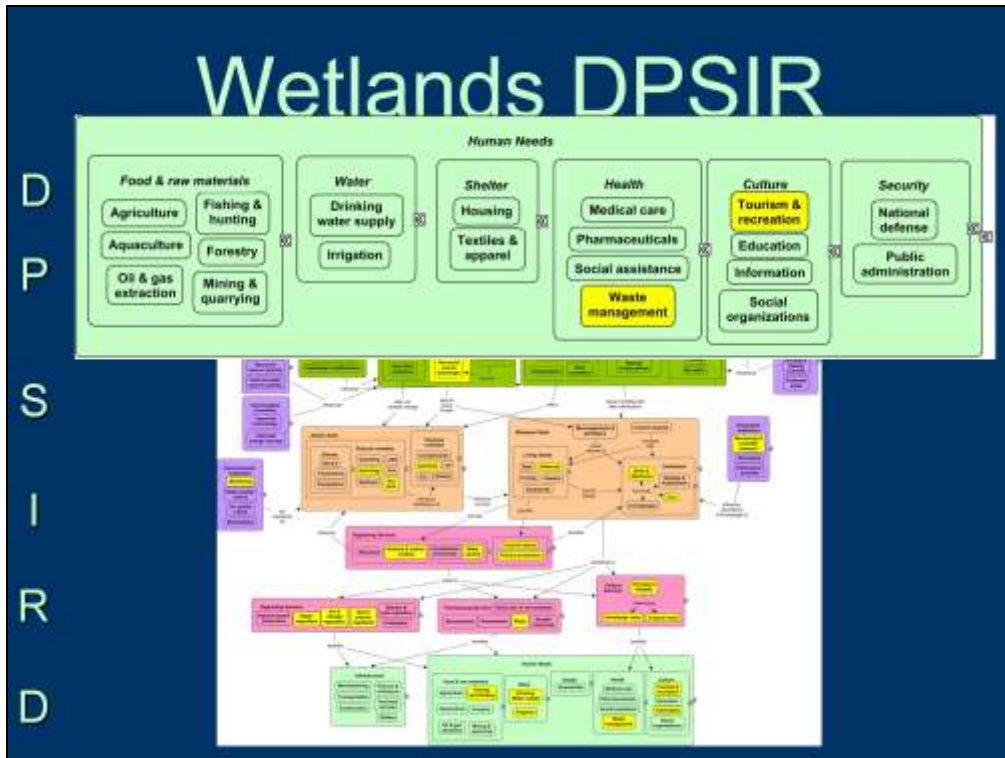
DPSIR Tools – Wetlands DPSIR

The Wetlands DPSIR was created by highlighting concepts from the generic DPSIR concept map which were applicable to wetlands.

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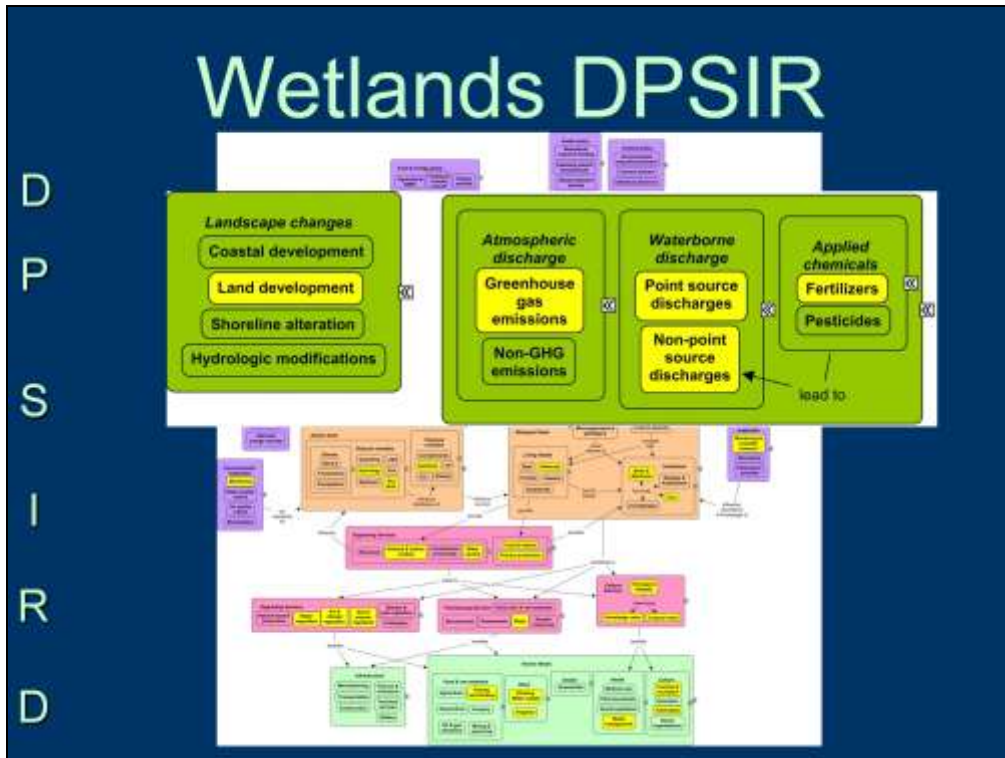
Key Drivers whose activities were creating pressure on the wetland ecosystem included
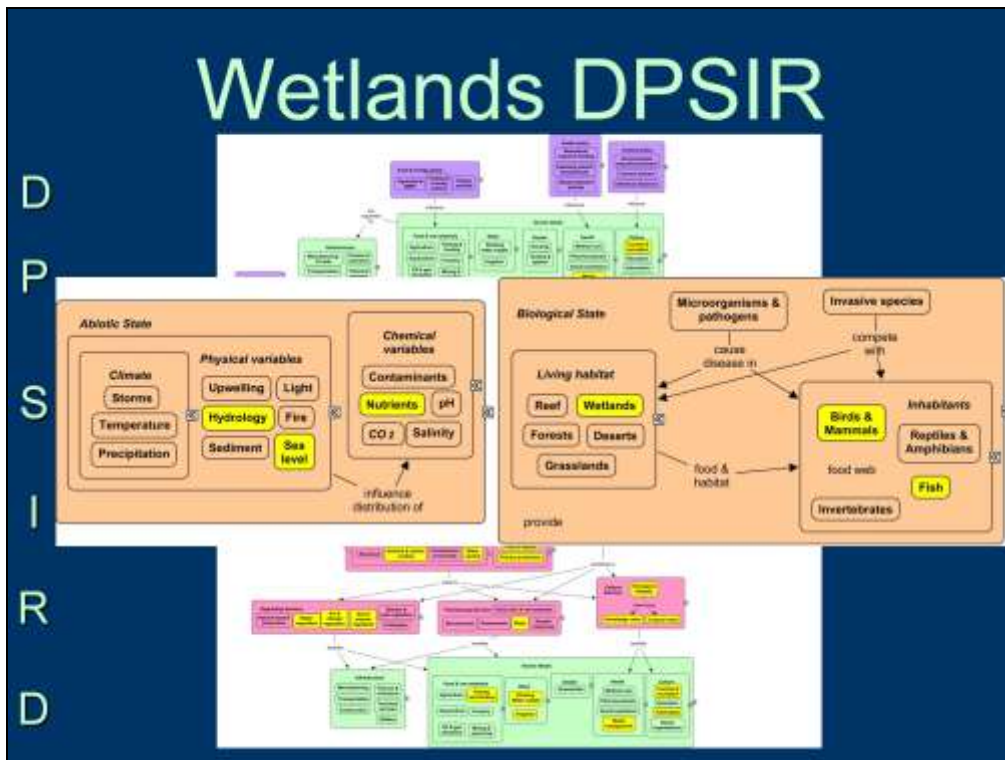•Waste management
•Tourism and recreation

DPSIR Tools – Wetlands DPSIR

The Wetlands DPSIR was created by highlighting concepts from the generic DPSIR concept map which were applicable to wetlands.

Key Pressures were identified as
•Land development
•Greenhouse gas emissions
•Waterborne discharges
•Fertilizer use

DPSIR Tools – Wetlands DPSIR

The Wetlands DPSIR was created by highlighting concepts from the generic DPSIR concept map which were applicable to wetlands.

Key abiotic and biotic variables within State included
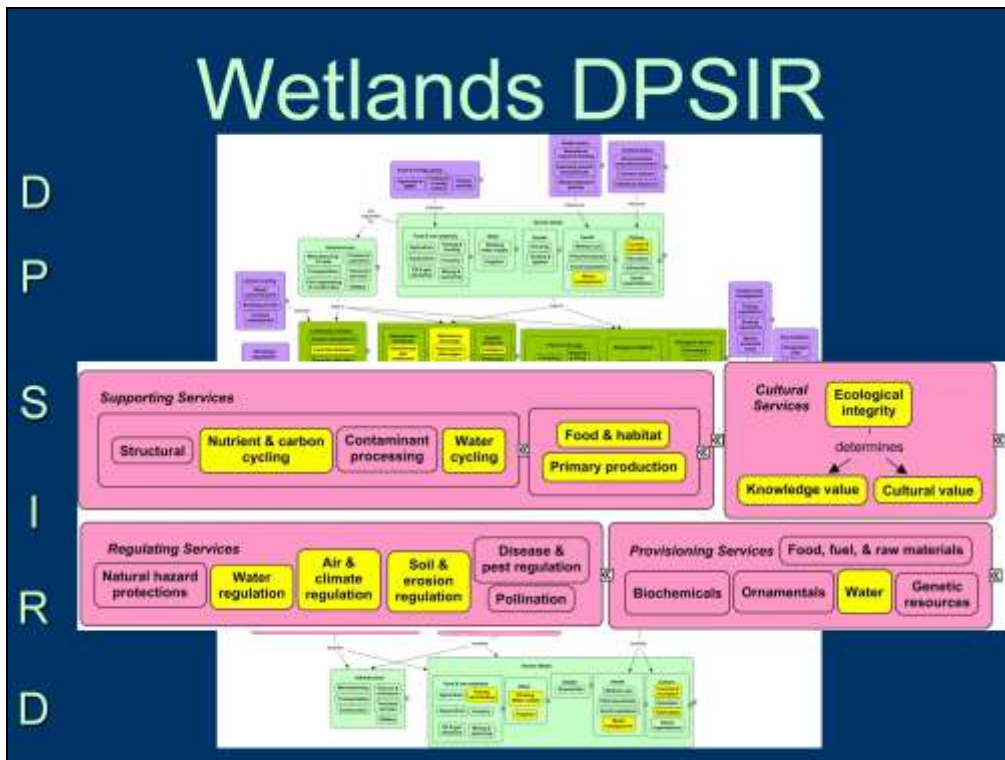•Hydrology
•Sea Level
•Nutrients
•Birds & mammals
•Fish

DPSIR Tools – Wetlands DPSIR

The Wetlands DPSIR was created by highlighting concepts from the generic DPSIR concept map which were applicable to wetlands.

Impacts to human well-being derived from wetland ecosystems included
•Nutrient & carbon cycling
•Water cycling
•Food & habitat for wildlife
•Primary production
•Water regulation
•Air & climate regulation
•Soil & erosion regulation
•Provision of water
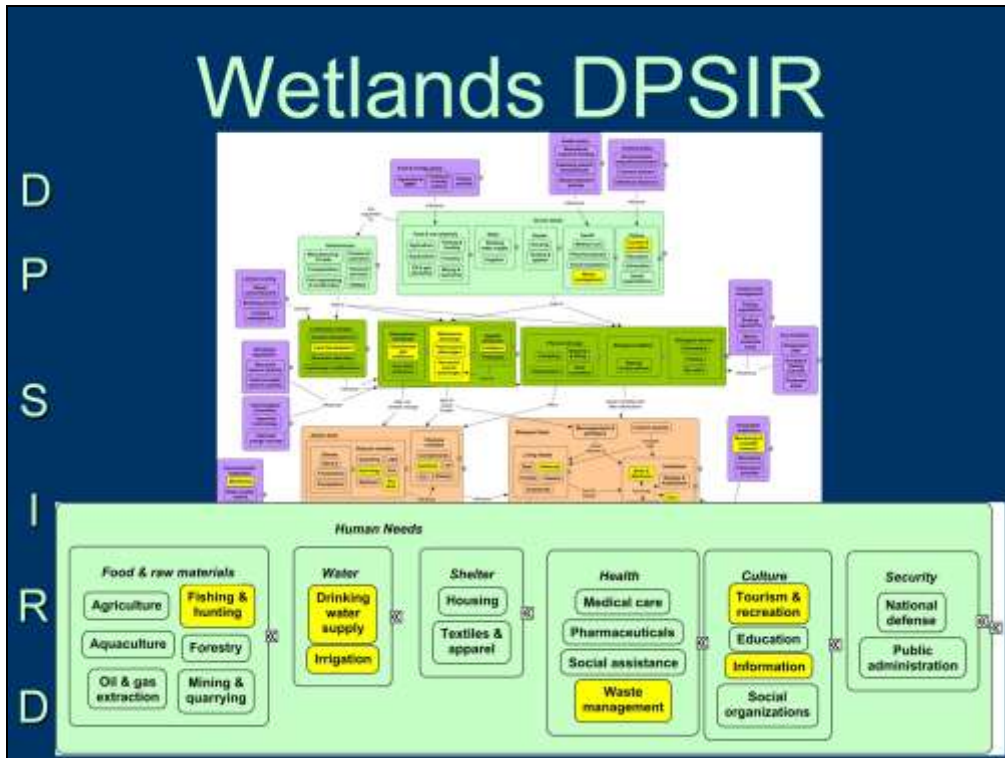•Ecological integrity
•Knowledge value
•Cultural value
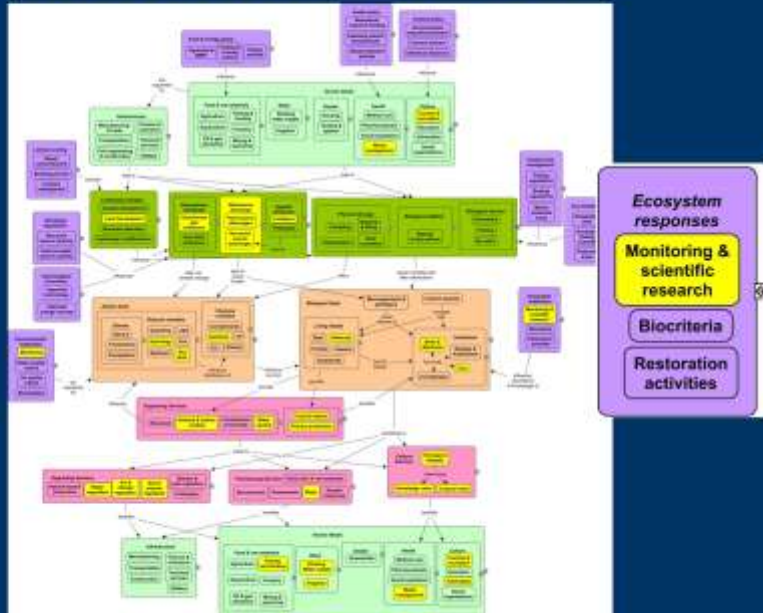
DPSIR Tools – Wetlands DPSIR

The Wetlands DPSIR was created by highlighting concepts from the generic DPSIR concept map which were applicable to wetlands.

Wetland ecosystem services were considered to have direct benefits for socio-economic Drivers, including
• Fishing and hunting sector
• Drinking water supply
• Irrigation
• Waste management
• Tourism & recreation
• Information sector

DPSIR Tools – Wetlands DPSIR

The Wetlands DPSIR was created by highlighting concepts from the generic DPSIR concept map which were applicable to wetlands.

The key Response identified was to conduct monitoring and scientific research.

Guanica Bay Example

- Sediment run-off into Guanica Bay, Puerto Rico

Photo courtesy of NOAA

Coral Reef Example
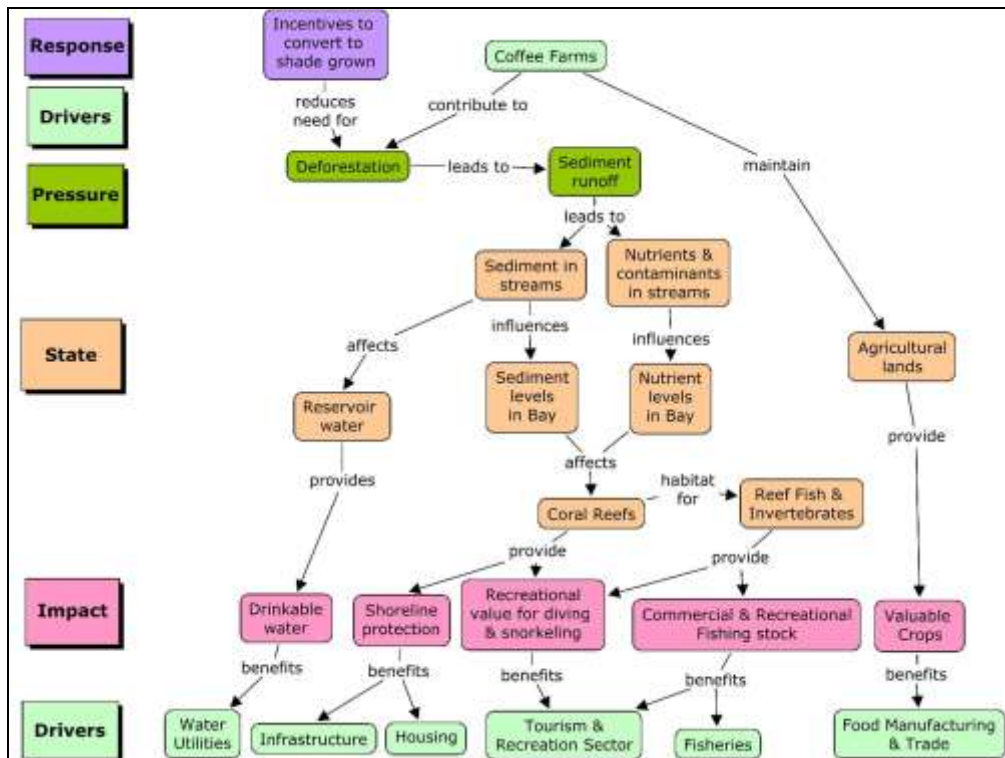
DPSIR Tools – Guanica Bay Example

Problem - Agricultural, residential and commercial development in the Guanica Bay watershed of southern Puerto Rico has led to land use changes that influence the type and amount of (nonpoint) pollution entering the streams, lakes and coastal zone.

Recently, federal, commonwealth and non-government agencies have initiated a program to limit sediment runoff to the once-pristine coral reefs outside Guanica Bay (CWP 2008).

Historically, the watershed (150 square miles) experienced deforestation for sugar cane production and, in the 1950's, a water project in the mountainous coffee-growing headlands region and drainage of a large lagoon affected sediment transport and filtration. The program is multi-faceted, and will attempt to reduce upland erosion in coffee-growing regions, reduce sediment transport from reservoirs, reduce in-stream channel erosion, restore a filtration lagoon, remove legacy contaminants and enhance sewage treatment.

Decision alternatives can be captured in a DPSIR framework, to aid in thinking about the problem and potential consequences of decisions within a systems framework. The generic DPSIR concept map or the list of keywords can be used to provide examples of factors. Concept mapping within the DPSIR framework is one tool for generating feedback from small groups of decision-makers or stakeholders.

DPSIR Tools - Guanica Bay Example: Sediment run-off

One potential management action under consideration is offering incentives to farmers to revert to shade-grown coffee practices. Historically, coffee plantations produced shade-grown coffee, but converted to sun-grown coffee in the 1950's, which requires deforestation.

A recent resurgence of shade-grown coffee minimizes deforestation, maintaining forests which stabilize the soils, thus reducing sediment runoff.

The conversion to shade-grown coffee clearly will impact coffee farmers and their ability to maintain productive agricultural lands and produce crops to supply to food and manufacturing sectors.

However, the concerns of coffee farmers should be balanced with the consequences of sediment runoff.

Sediment washes into the streams, along with nutrients and contaminants. This sediment can build up in reservoirs, or wash further downstream entering the bay.

Sediment, nutrients, and contaminants can be carried out to coral reefs, affecting the growth, reproduction, and survival of coral. This has further consequences for fish and invertebrates, which depend on the reefs for food and habitat.

Degradation of the reef ecosystem will impact humans as well. Sediment in reservoirs can impact the availability of drinking water. Reefs provide essential ecosystem services including shoreline protection, recreational value, and fishing stock which benefit numerous socio-economic sectors, including providers of drinking water, tourism and recreation, infrastructure, and fishing sectors.

Development of a DPSIR provides one framework for visually comparing the consequences and tradeoffs of a decision.
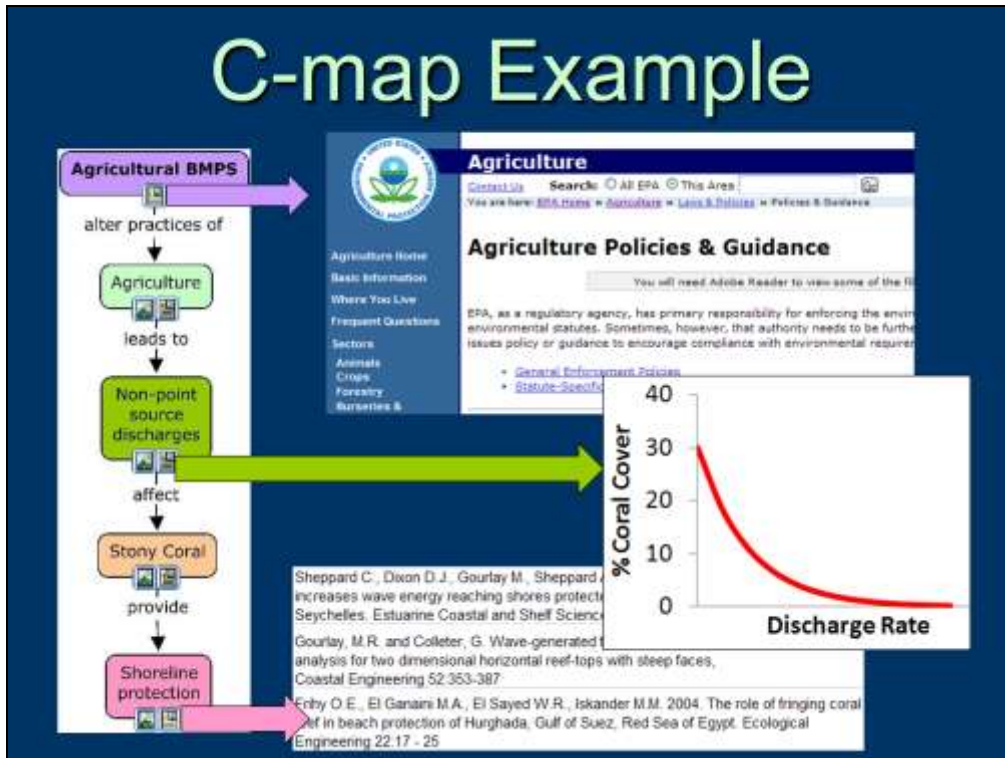
DPSIR Tools: C-map Example

Software, such as C-map Tools software can be used to add icons which provide direct links to information from the keywords within DPSIR concept maps.

DPSIR concept maps can be used as a knowledge base for cataloguing information related including:
•Literature citations
•Rate functions
•Images
•Legislation, regulations, and statutes
•Data and Maps
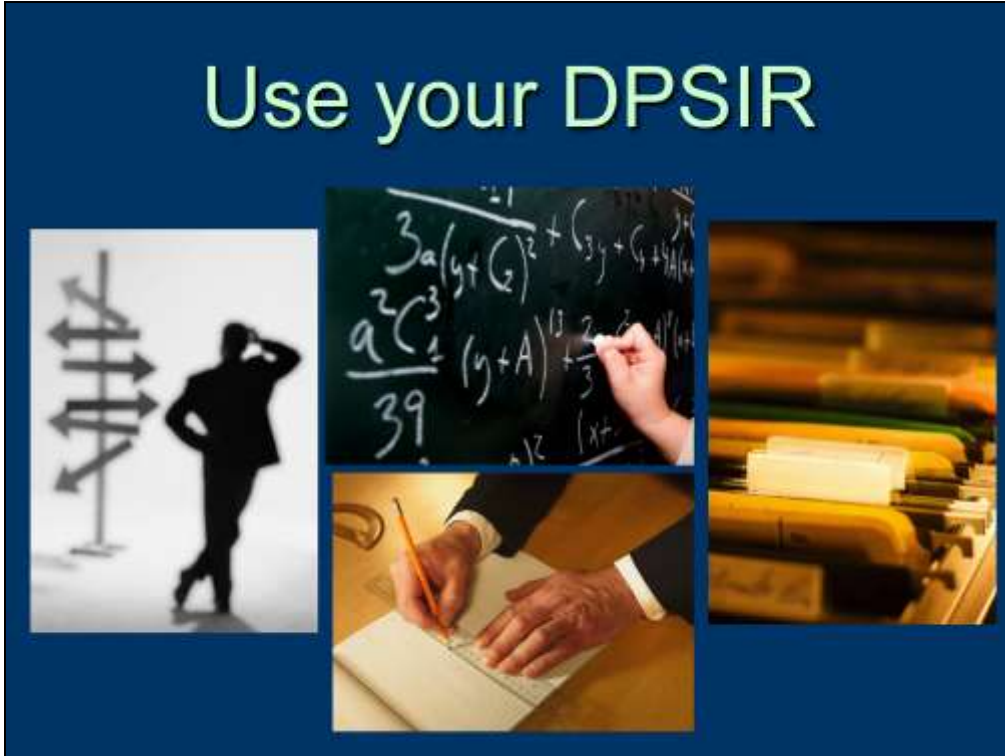
DPSIR Tool – Use your DPSIR

The process of creating a DPSIR allows decision-makers or scientists to characterize major stressors, interactions, and tradeoffs related to a decision, and to brainstorm alternative decision options.

A DPSIR concept maps have several uses within a research program or decision process, including

•Characterizing major stressors, interactions, and tradeoffs related to a decision

•Brainstorming or characterizing alternative decision options

•Developing measurable objectives or criteria

•Characterizing where data or research are needed

•Visualizing specific problems within a systems approach

•Conceptualizing interactions and needs for development of predictive mathematical models

•Enhancing communication with scientists, decision-makers, or the public

DPSIR can also be used as an organizing framework for characterizing the state of knowledge and gathering information, including

•Scientific data, models, or literature

•Certainties and knowledge gaps

•Legislation and possible management actions

•Social decision networks

In software such as CMAPTools, concepts can be annotated with notes, documents, maps, and other information.

We emphasize that DPSIR is just one tool in the decision-making process, but is a useful one for encouraging a systems approach to decision-making, and encouraging scientists, stakeholders, and decision-makers to think beyond their topic of expertise. For more on systems thinking and decision-making, refer to Module 1.