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Summary of ecosystem services & biodiversity assessments

Informing integrated actions plans

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Objectives of assessments

- Highland aquatic resources and ecosystem services assessed in consultation with stakeholders at the five sites
- Indicators of ecosystem services and biodiversity values developed with stakeholders for participatory monitoring
- Provide scientific data to inform potential management options (*integrated action plans*) to promote conservation, sustain ecosystem services, resolve conflicts and ensure sustainable and wise-use of highland aquatic resources at the 5 project sites

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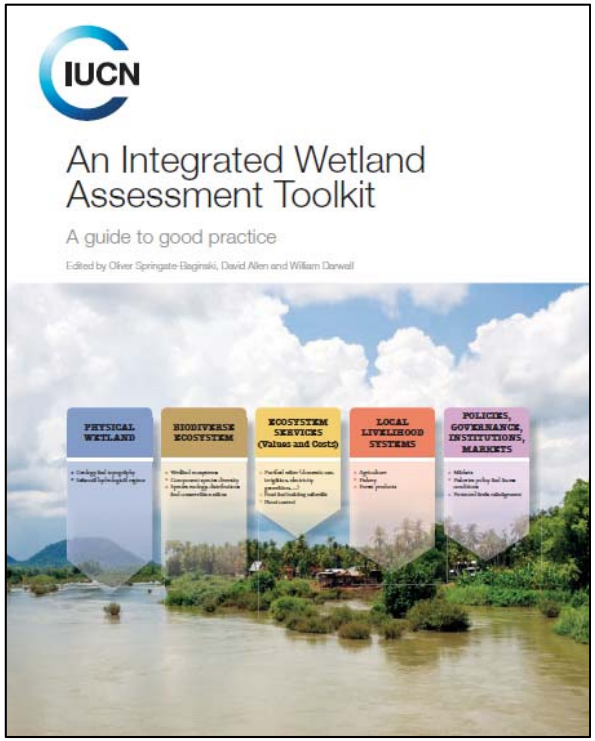
IWA Toolkit

- Main tool used to guide and co-ordinate assessment activities
  - IWAT provides methods and tools to **integrate** biodiversity, ecosystem services valuation and livelihoods assessments
    - An integrated approach
      - produces more efficient research,
      - addresses potential development and conservation conflicts,
      - provides a more complete picture of wetland value
  - IWAT provides specific field methodologies to
    - Assess biodiversity, ecosystem services and livelihoods,
    - Map habitats, ecosystem services and threats



Springate-Baginski, O., Allen, D. and Darwall, W.R.T. (eds.) 2009. An Integrated Wetland Assessment Toolkit: A guide to good practice. Gland, Switzerland: IUCN and Cambridge, UK: IUCN Species Programme. xv+144p
www.iucn.org/species/IWAToolkit/

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Ecosystem services assessment methods

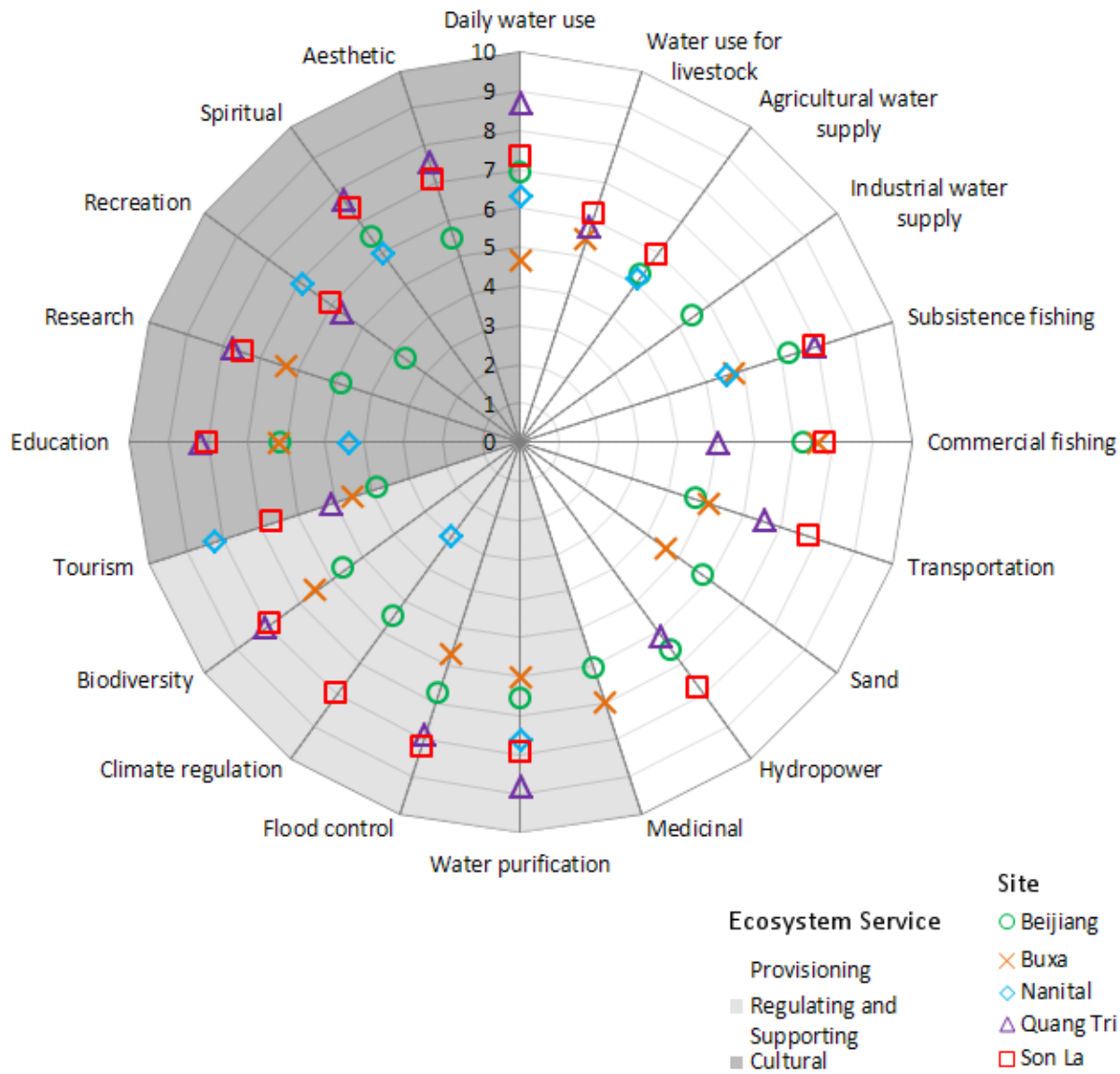
- Stakeholder identification of ecosystem services at each site
- Stakeholder participatory ranking – stated preference approach (non economic valuation)
- Economic valuation undertaken at Beijiang (China) site only (using Costanza updated for China by Xie *et al*., 2003)
- Identification of potential ES indicators




Ecosystem services results

Values between sites

- ES identified by all sites:
  - Daily water use
  - Subsistence fishing
  - Water purification
  - Tourism
  - Education
- High value (score 6+ by 4+ sites)
  - Daily water use
  - Water purification
  - Education
- Similar value between sites:
  - Water for livestock
  - Agricultural water supply
  - Hydropower
  - Spiritual
  - Aesthetic



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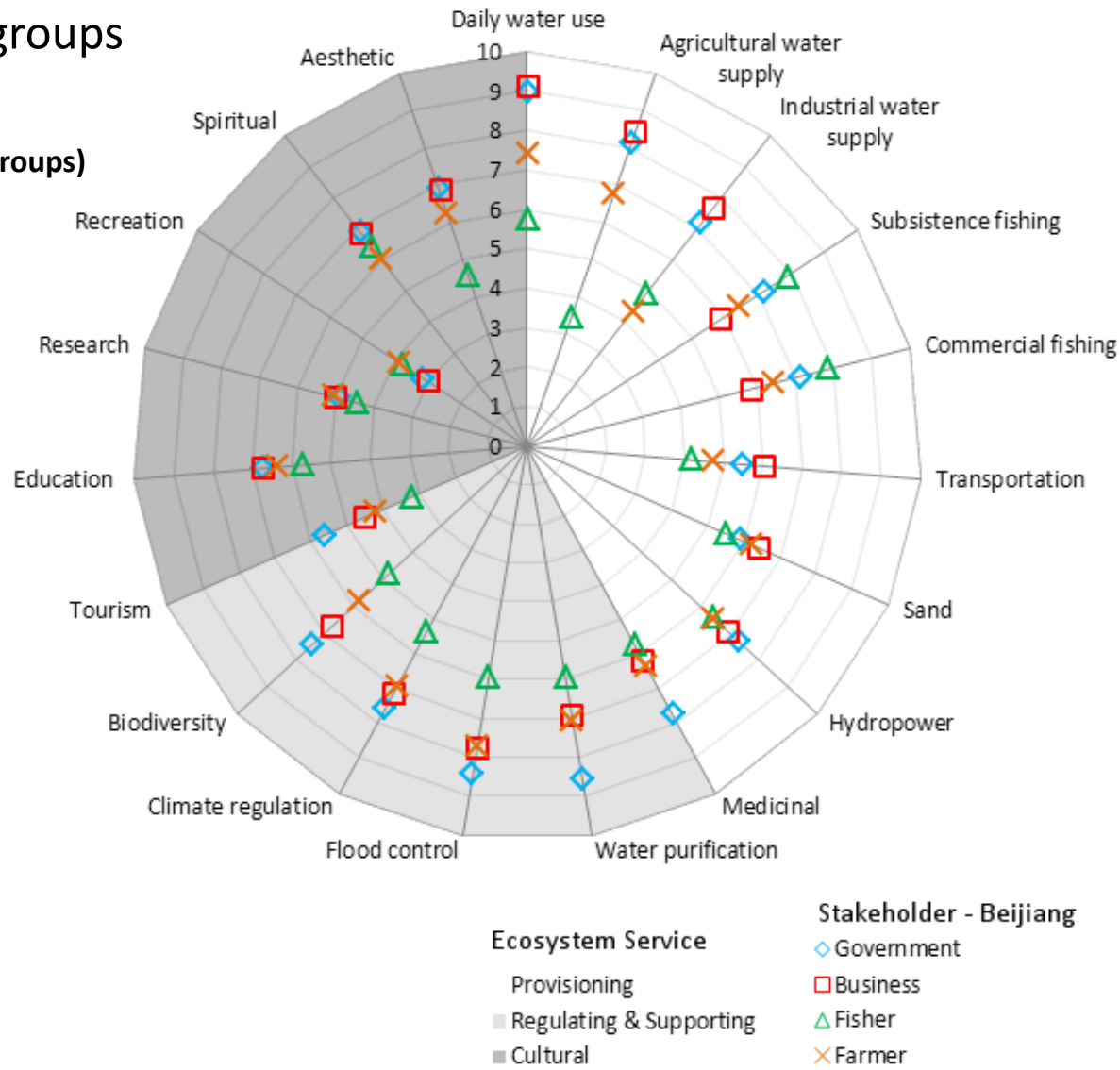
Ecosystem services results

Values between stakeholder groups Beijiang River, China

- **All groups - high value (score 6+ by all groups)**
  - Hydropower
  - Water purification
  - Flood control
  - Spiritual

- **3 highest valued ES by group**
  - **Government**
    - Daily water use
    - Water purification
    - Flood control
  - **Business**
    - Daily water use
    - Agricultural water supply
    - Flood control
  - **Fisher**
    - Subsistence fishing
    - Commercial fishing
    - Spiritual & Hydropower
  - **Farmer**
    - Flood control
    - Daily water use
    - Water purification



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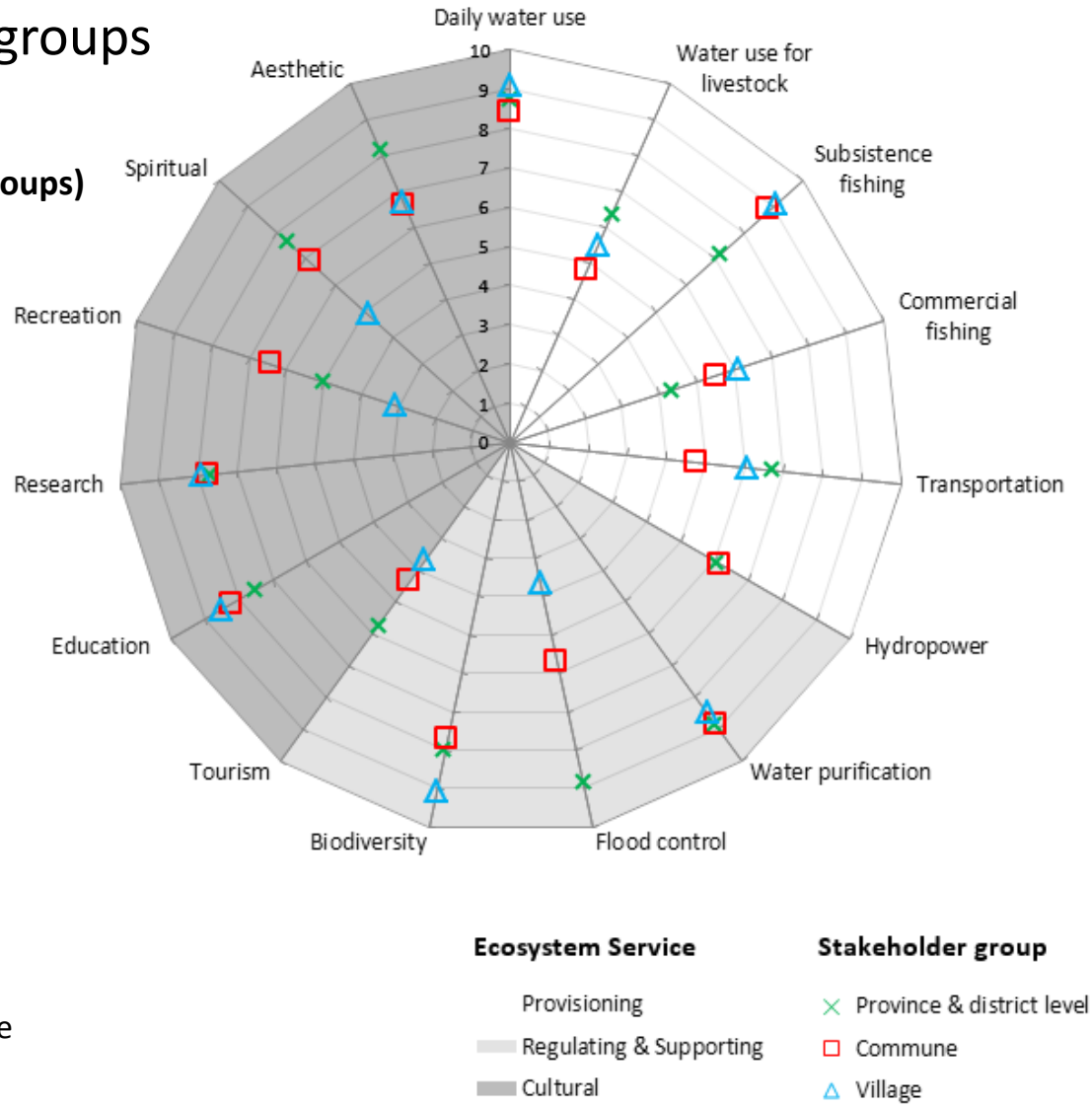
Ecosystem services results

Values between stakeholder groups Quang Tri, Viet Nam

- **All groups - high value (score 7+ by all groups)**
  - Daily water use
  - Subsistence fishing
  - Water purification
  - Biodiversity habitat maintenance
  - Education
  - Research

- **3 highest valued ES by group**
  - **Province & District level**
    - Flood control
    - Water purification
    - Daily water use
  - **Commune**
    - Subsistence fishing
    - Water purification
    - Daily water use
  - **Village**
    - Subsistence fishing
    - Water purification
    - Biodiversity habitat maintenance



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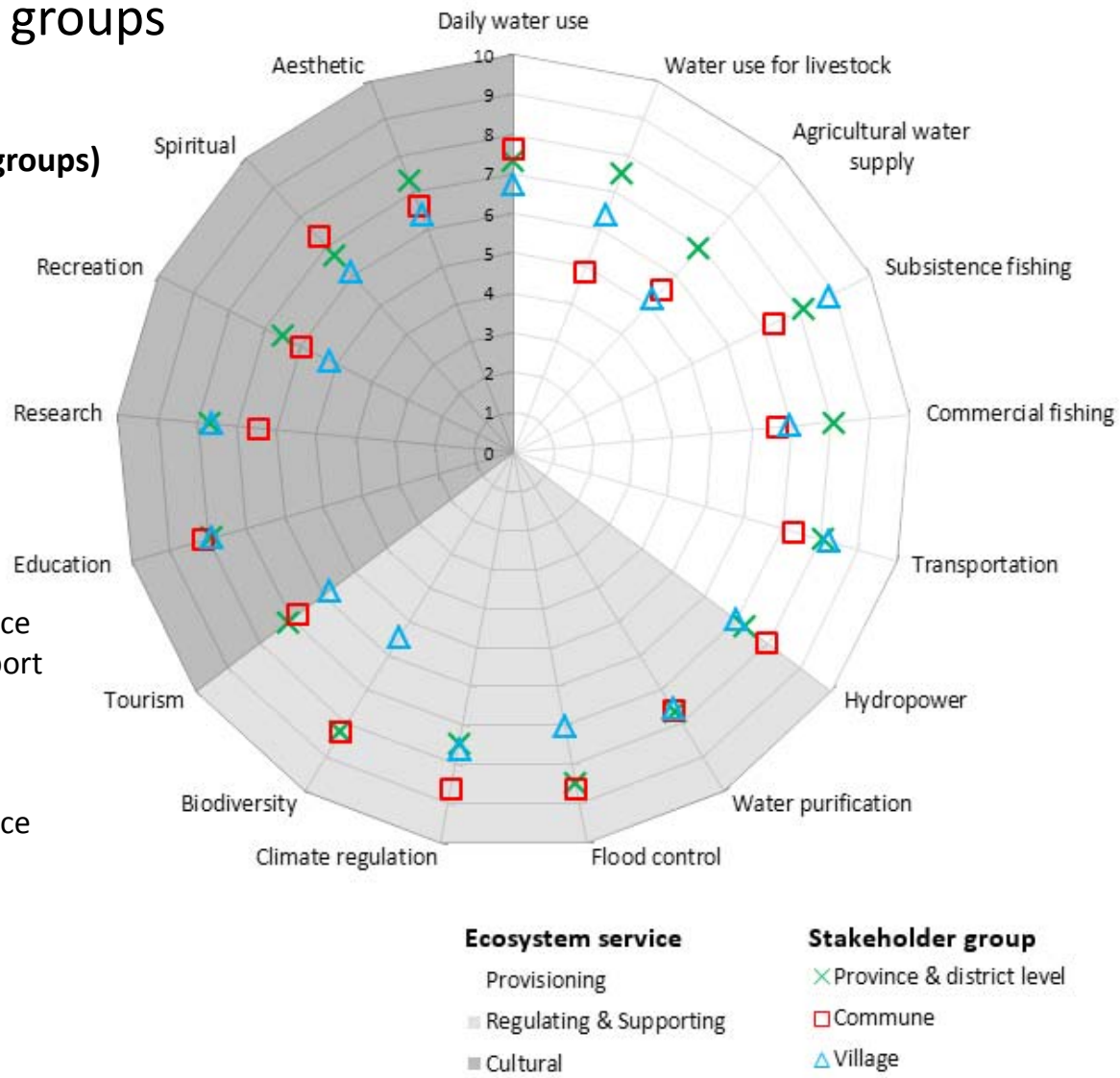
Ecosystem services results

Values between stakeholder groups Son La, Viet Nam

- **All groups - high value (score 7+ by all groups)**
  - Subsistence fishing
  - Transportation
  - Water purification
  - Flood control
  - Climate regulation
  - Education

- **3 highest valued ES by group**
  - **Province & District level**
    - Flood control
    - Biodiversity habitat maintenance
    - Sub. & Comm. fishing & Transport
  - **Commune**
    - Flood control
    - Climate regulation
    - Biodiversity habitat maintenance
  - **Village**
    - Subsistence fishing
    - Transport
    - Education



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Economic valuation

Beijiang River watershed economic valuation of ecosystem services

- Using 2007 Shaoguan land use data; & methodology/values from Xie *et al.* (2003)[1]
- All ecosystem services within watershed valued at 29,801.45 million Yuan (~4,832 million USD)
  - Gas regulation, Climate regulation, Water conservation, Soil formation, Water treatment, Biodiversity conservation, Food production, Raw materials, Recreation

- Woodland greatest contributor by far, 27,385.23 million Yuan,
- Water bodies are the most valuable by unit area, 0.0411 million Yuan/hm2

Type of land use	Cropland	Woodland	Grassland	Water surface	Land for construction	Unused land
Area hm2	242986.67	1387926.67	2460.00	35813.33	70440.00	89413.33
Total value million Yuan	1517.75	27385.23	16.09	1471.26	9.15	29801.45
Total value /hm^2 million Yuan	0.0062	0.0197	0.0065	0.0411	0.0001	0.0162

[1]Xie, G.D., Lu, C.X., Leng, Y.F., Zheng, D. and Li, S.C. 2003. Ecological assets valuation of Qinghai-Tibet Plateau. *Journal of Natural Resources.* 18(2): 189-196

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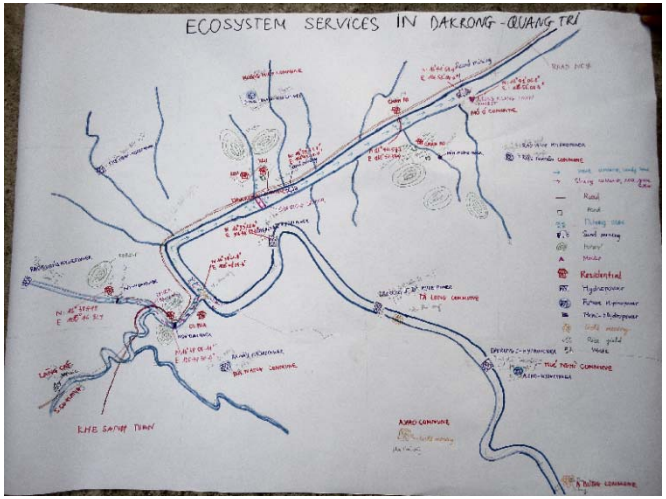
ES Indicators

- Potential indicators for the key ecosystem services have been identified for each site
  - **Beijiang, China:**
    - Fish harvesting – Fish market surveys, fish release/stocking data, govt. catch monitoring data
    - Water quality – Periodic govt. statistics of water quality
  - **Nainital, India:**
    - Water quality – Official lake water quality data
    - Tourism – Local government tax income on tourist activities, govt. data on hotel rooms booked, number of boatmen on lakes
    - Recreation – Angling licences issued
    - Water for irrigation – Official lake water level data
  - **Buxa, India:**
    - Water quality – Water quality and sediment tests (by community groups)
    - Fish provision – Fish market surveys (commercial), periodic household surveys (subsistence)
    - Tourism – Forest department records of tourist lodge use, number of guides from communities
  - **Quang Tri, Viet Nam**
    - Water provision – Commune water quality monitoring
    - Micro-hydropower – Number of hydropower generators used, number of floods (caused by dam release)
    - Water transport – Number of days river during wet season river in flood and not navigable (social surveys)
    - Fish provision – Market surveys, official harvesting records
  - **Son La, Viet Nam**
    - Fish harvesting - Market surveys, official fish harvesting statistics reported by Phu Yen Local Peoples Committee
    - Water provision – Official statistics on the water levels of reservoir

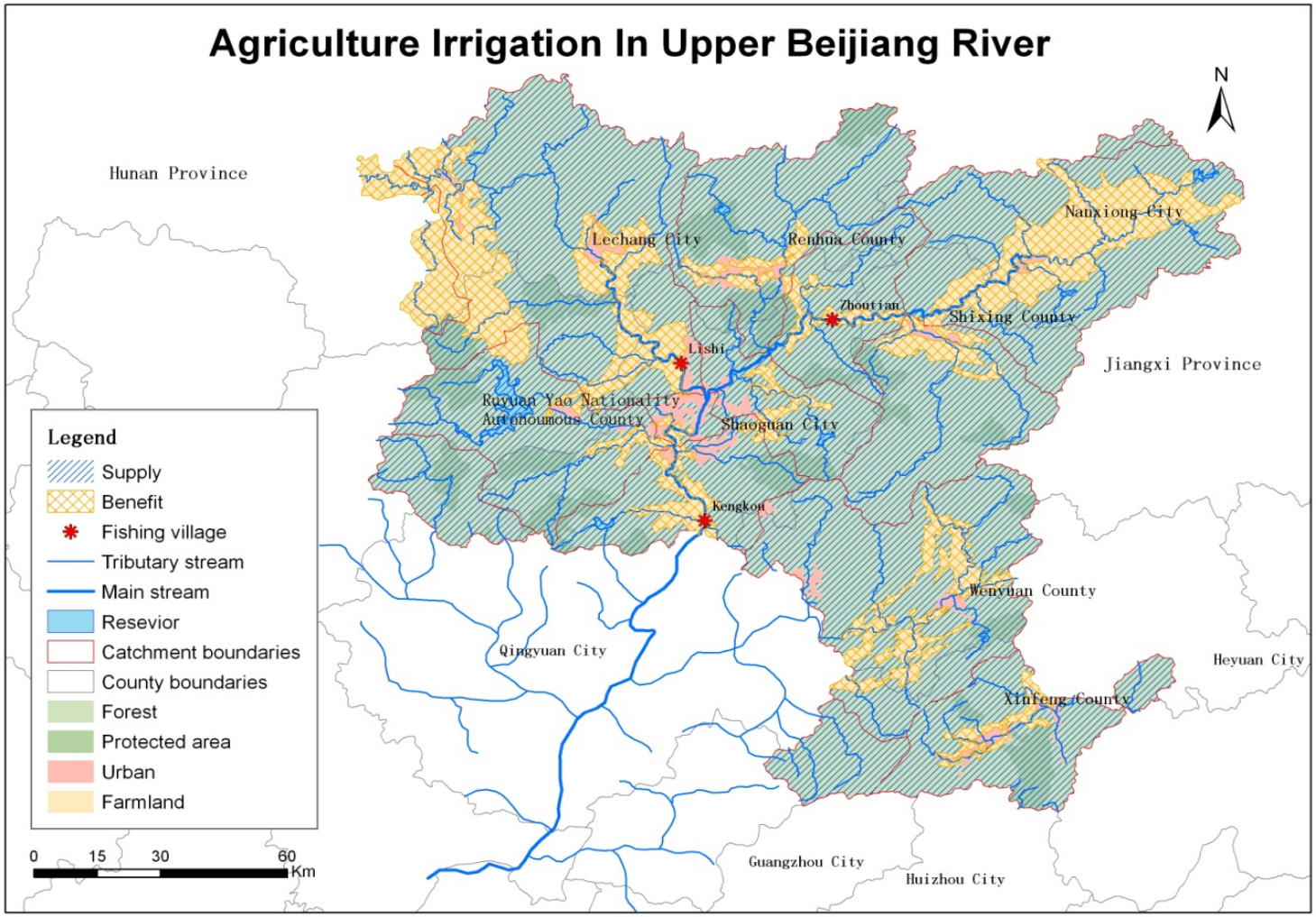
Mapping methods

- Based on field maps, observational data, stakeholder input and additional GIS data, digital maps produced:
  - of the sites habitats & wider catchments
  - of ecosystem services (areas providing services and those areas benefiting)
  - of threats to freshwater biodiversity and ecosystem services



Ecosystem service maps

Areas generating ES & areas benefiting from ES mapped, e.g.



See www.higharcs.org for all maps in site reports

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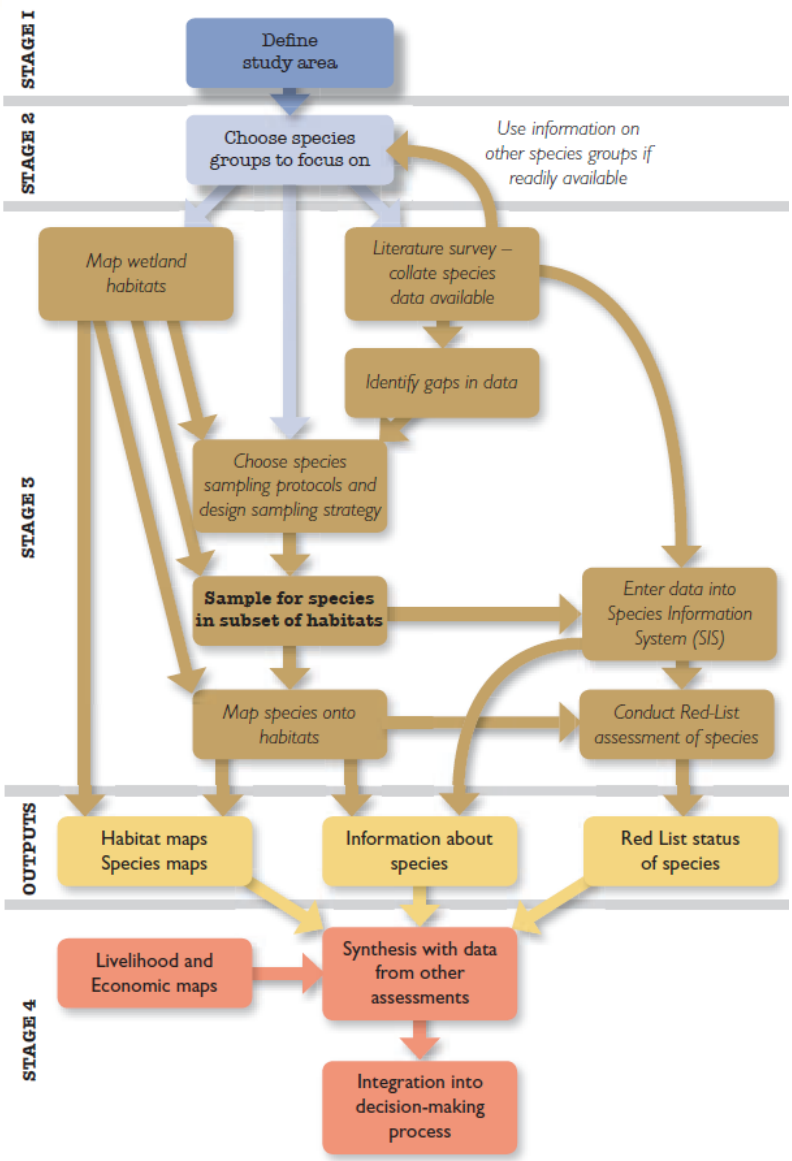
Biodiversity assessment methods



Without knowing what **biodiversity** is present at the site, we cannot:

- Identify the conservation status of biodiversity at the site
- Identify which *species* are important to livelihoods (direct use and through other ecosystem services)
- Develop conservation or sustainable use management plans as each species will require different conservation measures. E.g. a migratory species will need to managed in a different way to a resident species, all will have their own unique requirements for sustainable management - hence we need information at the species level - info on "natural capitol" is not sufficient.
- Easily monitor impacts of conservation management plans, ecosystem service indicators

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Biodiversity results

Literature, field surveys, market surveys, linked to Red List assessments

- Beijiang River, China
  - Fish, mollusc and plant species highly utilised, some commercially
  - 1 globally threatened and important commercial species; fish *Pseudohemiculter dispar*
  - 3 nationally threatened and utilised species; fish *Metzia formosae*, snails *Cipangopaludina ampulliformis* and *Bellamya limnophila*
  - Some species have disappeared from site e.g. Marbled Eel (*Anguilla marmorata*) and herring/shad (*Tenualosa reevesii*) – due to dams and overharvesting
  - Data on population trends lacking but catches are down (despite increased stocking) and two species *P. dispar* and *Misgurnus anguillicaudatus* (both high value species) are known to be declining
  - Number of non-native species present - carp (*Cyprinus carpio*), water hyacinth (*Eichhornia crassipes*) & Apple Snail (*Pomacea sp.*).
  - Dragonflies species present, but all widespread and resilient species (therefore not good indicators)
  - Molluscs good indicators – two species sensitive to pollution present at sites - *Semisulcospira libertina* & *Cipangopaludina chinensis*
  - Most plants species widespread and adaptive (not good indicators), but 2 species (*Hydrilla verticillata* and *Vallisneria natans)* are potential indicators

More information: Shiming, L., et al. 2011. Freshwater ecosystem services and biodiversity values of the Beijiang River, China. HighARCS Project, Work Package 3 report. South China Agricultural University.

Species summary		**Fish**		**Molluscs**		**Odonata**		**Plants**	
		All spp.	Thr. spp.	All spp.	Thr. spp.	All spp.	Thr. spp.	All spp.	Thr. spp.
Beijiang	Site	26	1	8	0	25	0	11	0
	Utilised	16	1	8	0	0	0	10	0

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Biodiversity results

Literature, field surveys, market surveys, linked to Red List assessments

- Nainital, India
  - 2 globally threatened fish species both utilised Golden Mahseer (*Tor putitora*) and Snow Trout (*Schizothorax richardsonii*)
  - Utilisation of fish banned in Nainital and highly regulated in Bhimtal and Naukuchiatal
  - Lakes are stocked with both native and non-native species
  - Most molluscs species common and widespread species (some occurring in polluted waters – not good indicators)
  - 2 molluscs species declining due to introduce mosquito fish (*Gambusia affinis*) eating eggs
  - Cold water carps good indicator for key threat of eutrophication as sensitive to low oxygen levels (there have been fish kills in the past). Bivalve species are also a potential indicator species as filter feeders their tissue samples could be used to identify pollutant levels.

More information see: Pal, M. and Kundu, N. 2011. Freshwater ecosystem services and biodiversity values at Nainital, Uttrakhand. HighARCS Project Work Package 3 report. Centre For Environmental Management And Participatory Development, and Institute Of Environmental Studies And Wetland Management, Kolkata, India.

Species summary		**Fish**		**Molluscs**		**Plants**	
		All spp.	Thr. spp.	All spp.	Thr. spp.	All spp.	Thr. spp.
Nainital	Site	42	2	9	0	14	0
	Utilised	13	2	0	0	1	0

Biodiversity results

Literature, field surveys, market surveys, linked to Red List assessments

- Buxa, India
  - 46 fish species identified (65 fewer than cited by previous study (Das 2005) for Buxa) non
  - High level of fish utilisation – 24 used subsistence level, 23 commercial value
  - Most fish species believed to be declining and catches not sufficient to meet local demand as fish brought in from outside area
  - Number of non-native fishes incl. common, grass and silver carp (*C. carpio, Ctenopharyngodon idella, Hypophthalmichthys molitrix*) present at site
  - Plants also utilised (8 of 25 recorded), most widespread species
  - Very high level of non-native plant species (11 of the 25) incl. water hyacinth (*Eichhornia crassipes*)
  - Possible indicator species; harvested fish species (through market surveys), plant species widespread and common except liverworts (*Riccia spp.)*

Species summary		Fish		Plants	
		All spp.	Thr. spp.	All spp.	Thr. spp.
Buxa	Site	46	0	25	0
	Utilised	46	0	8	0

More information see: Ray, D. and Mishra, R. 2011. Freshwater ecosystem services and biodiversity values at Buxa, West Bengal. HighARCS project Work Package 3 report. Centre for the Development of Human Initiatives, Jalpaiguri, India.

Biodiversity results

Literature, field surveys, market surveys, linked to Red List assessments

- Quang Tri
  - 3 fish species nationally threatened Marbled Eel (*Anguilla marmorata), Spinibarbus hollandi* and *Onychostoma laticeps* all high economic value and declining at the site
  - 8 of the 15 species that are utilised are declining at the site
  - Potentially a number of undescribed species
  - 38 fishes recorded at site likely to be underestimate (72 species recorded from upper catchment)
  - The monitoring of harvested species (through market surveys and fishermen interviews) is a potential indicator for overharvesting and pollution

Species summary		Fish	
		All spp.	Thr. spp.
Quang Tri	Site	38	0
	Utilised	15	0

More information see: Nguyen, T.D.P., Nguyen T.H.T., Do, V.T., Nguyen, T.T. and Nguyen, H.D. 2011. Freshwater ecosystem services and biodiversity values of the Dakrong River, Quang Tri, Viet Nam. HighARCS Project Work Package 3 report. Research Institute for Aquaculture No.1, Viet Nam.

Biodiversity results

Literature, field surveys, market surveys, linked to Red List assessments

- Son La – data from Da river (wider than site)
  - Site is non-natural habitat (reservoir)
  - 126 fish species recorde, 2 are globally threatened species *Bangana tonkinensis* and *Pseudohemiculter dispar*
  - *Cyprinus multitaeniata* once present at site is now extirpated in Viet Nam
  - Eight species present listed on Viet Nam national Red List
  - 18 species utilised at site
  - 8 non-native fish species (incl. *C. carpio, G. affinis, O. niloticus*)

Species summary		Fish	
		All spp.	Thr. spp.
Son La	Site	126	2
	Utilised	18	1

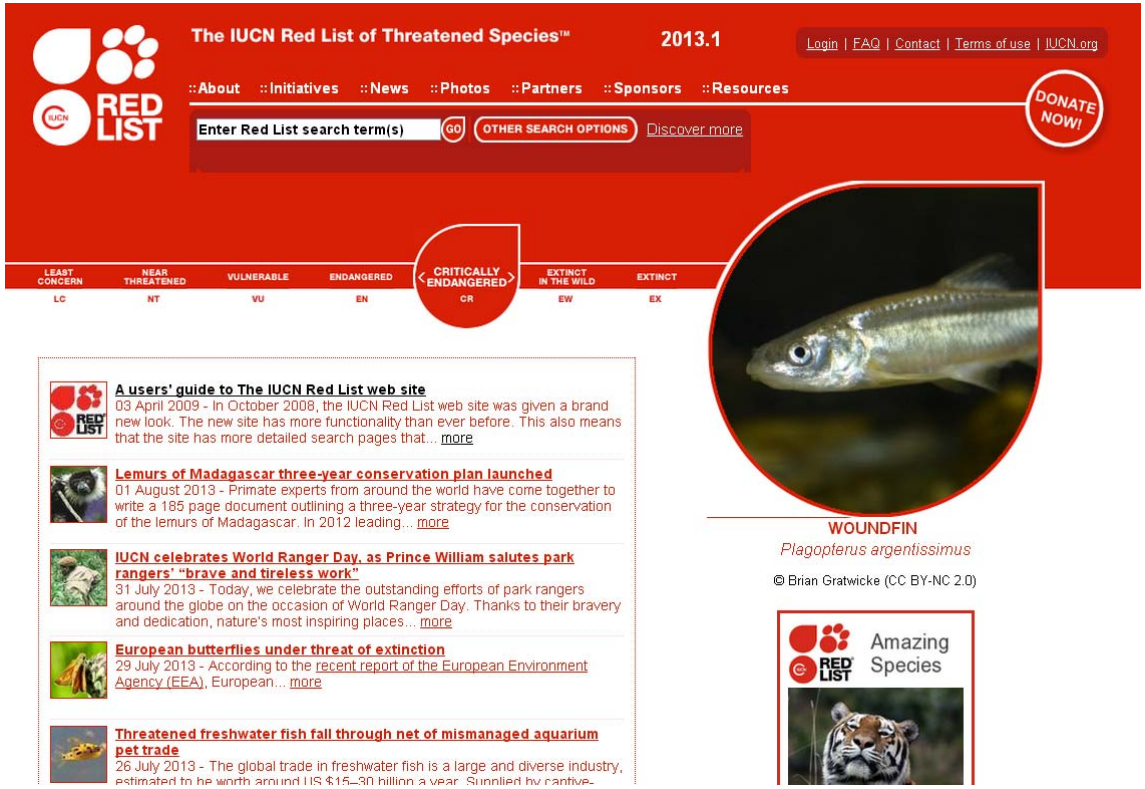
More information see: Nguyen, T.D.P., Nguyen T.H.T., Do, V.T., Nguyen, T.T. and Nguyen, H.D. 2011. Freshwater ecosystem services and biodiversity values of Phu Yen District, Son La, Viet Nam. HighARCS Project Work Package 3 report. Research Institute for Aquaculture No.1, Viet

Species Red List assessments

- The IUCN Red List of Threatened Species™ is widely recognized as the most comprehensive, objective global approach for evaluating the conservation status (risk of global extinction) of plant and animal species.

- Species data collated through HighARCS project has contributed to IUCN Red List assessments

- Red List assessments for all species found at the HighARCS sites can be found at: www.iucnredlist.org



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Integrated Action Plans

- IAPs produced through stakeholder engagement and feasibility and sustainability testing, produced for all sites (using biodiversity, ecosystem services, livelihoods & policy assessments)
- See www.higharcs.org for each sites full integrated action plan and methods for identifying and prioritising actions

- Key actions include:
  - **Beijiang**
    - Compensation received from sand mining and hydropower to be used for conservation of aquatic resources (motion for the Guangdong People's Political Consultative Conference)
    - Implementation and monitoring of no fishing season incl. development of an education and information programme for fishers
    - Improved reporting of iron polluting
  - **Son La**
    - Training on fisheries and environmental protection regulations District and Commune staff and fishers from the communities,
    - Campaign to raise awareness of aquatic conservation issues - school outreach, village conventions
  - **Quang Tri**
    - Publication of new fish species (international journal)
    - Comprehensive fish surveys and publication of fish atlas
    - Awareness raising of fisheries and environmental regulations and conservation issues
    - Helping enforcement of water pollution regulations and raising awareness of impacts of polluting activities (incl. water quality monitoring by RIA1 and taken to local govt.)
  - **Buxa**
    - Build capacity of existing self-help groups for biodiversity conservation activities - monitor household & agricutlural pollutant, documenting biodiversity and raising awareness in communities
    - Awareness building and information dissemination about biodiversity protection and provisions and acts
  - **Nainital**
    - Monitoring of illegal fishing, and catch and release of species of conservation concern
    - Expansion of lake warden scheme and monitoring of waste water pollution,
    - Fish release programmes - engaging with stakeholders to try and encourage conservation focus

DPSIR Framework

Drivers (D)

D1. Economic development and population growth locally and in adjacent plains areas resulting in increased demand for construction building materials
D2. Demand for construction material in Bhutan
D3. Demand to produce more agricultural crops from same land area
D4. Lack of understanding and awareness regarding biodiversity regulations at all levels and weak monitoring and limited capacity from relevant institutions
D5. Poor regulation and controls on mining and forestry upstream and in adjacent areas
D6. Poor monitoring and regulation of agricultural activity permitting inappropriate practices on farms, notably those close to rivers

Pressures (P)

P1. Sand and boulder mining from river beds
P2. Increased levels of agricultural (nutrient loads, chemicals) and domestic (sewage) pollution entering rivers
P3. Use of destructive fishing practices (poison)
P4. Mining for bauxite and dolomite in Bhutan
P5. Forest cover loss outside Buxa Tiger Reserve and in Bhutan
P6. Continued land-use and agricultural practices that result in soil erosion and land-slides during the monsoon
P7. Unsustainable water extraction (especially in Jayanti River)

State (S)

S1. Flow regimes (amount and timing of water flow)
S2. Sediment load in river water
S3. Chemical content (pollution) of river water
S4. Aquatic biodiversity populations (particularly native fish species populations)
S5. Natural aquatic habitat availability and diversity

Responses (Primary target group)

R1. Build capacity of existing self-help groups for biodiversity conservation activities (P)

R2. Awareness building and information dissemination about biodiversity and prevention of provisions and acts (D)

R3. Setting up community owned Farmers Clubs/ Innovation Forums

R4. Set up a livestock promotion and insurance programme (P)

R5. Work with Panchayat to reorient and sharpen their governance efficiency (D)

Impacts (I)

I1. Decreasing water quality (high levels of agricultural pesticides and fertilisers, domestic sewage, poisons used in fishing)
I2. Declining fish populations
I3. Increased frequency and extent of floods (in monsoon season) and occurrence of droughts (in dry season) due to change in flow regimes and raising of river beds (due to high sediment loads)
I4. High levels of non-native plants

Figure 5. Driving forces, Pressures, State, Impacts, Response (DPSIR) framework for the IAP for Buxa. *Some of the Responses have been reworded (compared to the IAP) to better reflect their content

Drivers, Pressures, State, Impact, & Response Framework used at each site to
- Assess and understand drivers of change to ecosystem services and biodiversity
- Present situation and responses (actions)

	Drivers						Pressures							State				Impacts			
Responses	1	2	3	4	5	6	1	2	3	4	5	6	7	1	2	3	4	1	2	3	4
1								X	X			X			X		X				
2				X																	
3																					
4								X				X									
5				X																	
Total	0	0	0	2	0	0	0	2	1		0	2	0	0	1	0	1	0	0	0	0

Matrix used to assess targets of each action to identify strengths and weaknesses of action plans

See www.higharcs.org for full DPSIR reports