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People's Republic of China: Institutionalization of Urban-Rural Environmental Master Planning to Guide Environmentally Sustainable Urbanization in the People's Republic of China

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Report 1: Executive Report

Prepared by the consultants of TA 8537-PRC: Institutionalization of Urban-Rural Environmental Master Planning to Guide Environmentally Sustainable Urbanization in the People's Republic of China

For the Ministry of Environmental Protection

Asian Development Bank
TA8537 (47061) PRC

Technical Assistance Consultant Report:

Institutionalization of Urban-Rural Environmental Master Planning to Guide Environmentally Sustainable Urbanization in the People's Republic of China

Protecting the PRC's Green Land from Urban Development, Urban Sprawl and Overdevelopment

Report 1
EXECUTIVE REPORT

Asian Development Bank
TA8537 (47061) PRC

Institutionalization of Urban-Rural Environmental Master Planning (UREMP) to Guide Environmentally Sustainable Urbanization in the People's Republic of China

A note on the outputs of this project

The Asian Development Bank Technical Assistance Project TA8537 (47061) PRC, Institutionalization of Urban-Rural Environmental Master Planning (UREMP) to Promote Environmentally Sustainable Urbanization in the People's Republic of China, delivered the following **four reports**.

Executive Report: Summary of UREMP in the PRC - Protecting China's Green Land from Urban Development, Urban Sprawl and Overdevelopment (this report) provides a comprehensive summary of UREMP and of the issues to be addressed in protecting China's Green Land in the context of continued rapid urbanization. The report provides a description of the methods and techniques to be used, recommendations for policies and for institutionalising urban-rural environmental master planning at various levels of government in the PRC, and lessons from successful examples of environmental protection in China and elsewhere.

Report Two: Technical Guidelines of UREMP provides technical details in the form of a manual and step-by-step guide for how to practically plan and implement UREMP, including approach, methods and techniques for mapping, analysing, assessing, zoning and evaluating Green Land within and surrounding urban areas where environmental assets may be at risk from development.

Report Three: Recommendations for Policies and Institutional Arrangements of UREMP provides details on procedures for setting up a legal framework and administrative regulations, and an institutional framework to enable UREMP to become an effective and operational instrument.

Report Four: Domestic Pilots and International Best Practice Cases of UREMP offers lessons from best practices in the PRC and elsewhere as a basis for possible solutions for protecting the PRC's Green Land, using theory, policies, institutional arrangements, methods and techniques from best practice cases.

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Abbreviations

ADB	Asian Development Bank
CAEP	Chinese Academy of Environmental Protection
DPSIR	Driving forces, Pressures, States, Impacts, Responses: see Terminology, below.
GIS	Geographic Information System
MEP	Ministry of Environmental Protection, PRC
NO_X	Nitric Oxide (NO) and Nitrogen Dioxide (NO_2) (measured in the atmosphere)
O_3	The molecule Ozone (measured in the atmosphere)
PM_{10}	Particulate Matter 10 micrometers or less in diameter (measured in the atmosphere)
$PM_{2.5}$	"Fine particles" 2.5 micrometers or less in diameter (measured in the atmosphere)
SO_2	The molecule Sulphur Dioxide (measured in the atmosphere)
UREMP	Urban-Rural Environmental Master Planning

Terminology

Note: Terms with a precise meaning in the context of this report, such as Green Land, Module and UREMP Plan, are capitalised throughout the report, and defined here.

bioregion A large, geographically distinct area of land with a unique overall pattern of natural characteristics including a particular climate, a local pattern of seasons, specific landforms and soils, watersheds, and populations of native plants and animals. Bioregions are mapped in Step 1, Module 1A.

biosubregion A bioregion will divide into a number of more uniform subregions, all of which are fully contained within the one bioregion. There is greater similarity in natural characteristics within than between each subregion. Bioregions and subregions are mapped in Step 1, Module 1A.

carrying capacity The maximum population size of a given biological species that a given environment can sustain indefinitely, for instance, the total human population that can be sustained on Earth. At smaller scales the term has diminishing relevance. In an urban region, for instance, the appropriate concept is the environment's maximal load. This concept is also reflected in the preferred alternative terms, *absorptive capacity* and *bearing capacity*.

DPSIR The DPSIR framework adopted by the European Environment Agency (building on the pressure-state-response model developed by OECD) for describing the cause-effect relationships between society and the environment. DPSIR stands for Driving forces, Pressures, States, Impacts, Responses.

ecosystem A complex of living organisms with their (abiotic) environment and their mutual relations. This definition applies to all hierarchical levels (from Earth's biomes down to a single water drop with its microorganisms). For the practical purposes of assessment and policy in a UREMP Plan, ecosystems have the scale of habitat/biotope or landscape. Ecosystems are mapped and assessed in Step 3, Module 3A.

ecosystem services and environmental services The direct and indirect benefits that ecosystems provide to humans and the biosphere. Ecosystem services can be classified into provisioning services (for example, food, fuel, fibre, medicine), regulating services (for example, purifying air and water, preventing soil erosion, reducing the spread of disease), cultural services (for example, education, recreation, inspiration, physical and mental health) and supporting services that underpin the other three categories (for example, nutrient cycling, soil formation, primary production). Ecosystem services are mapped in Step 3, Module 3A.

environment In these reports the term environment has the meaning given to it in Article 2 of the Environmental Protection Law of the People's Republic of China: the total body of all natural elements and artificially transformed natural elements affecting human existence

and development, which includes the atmosphere, water, seas, land, minerals, forests, grasslands, wetlands, wildlife, natural and human remains, nature reserves, historic sites and scenic spots, and urban and rural areas.

Green Land In these reports the term Green Land is used to refer to non-urban lands (therefore excluding urban parks, city lakes, etc.) that provide ecosystem services of all kinds, including natural areas, forests, wetlands, water bodies, farmland, recreational areas, buffer zones around infrastructure, coastal areas, etc. The land protected by the national general land use plan for 2006-2020, approved by the State Council in October 2008, can be considered to describe important aspects of Green Land: "cultivated land, garden land, forest land, grassland, water areas and unused land that has important ecological functions".

Module The method for preparing a UREMP Plan, as described in this report, includes 34 Modules, combined into eight Steps. The twelve Modules of Steps 1, 2 and 3 are essentially concerned with initiating the UREMP planning process: defining the UREMP Area, setting up shared map and data systems, and producing an agreed, holistic description of the environment of the UREMP Area. The next eighteen Modules analyse and value the many aspects of Green Land, the water environment and the air environment. There are five Modules related to environmental restoration, and finally one Module where all of the findings are integrated into the UREMP Plan. Each Module generates a specific set of maps and databases in the UREMP Atlas. While each Module is a set of specialised tasks related to particular issues or objectives, most must be finalised through negotiations involving the whole UREMP team, since decisions are being made about values and priorities affecting all aspects of the UREMP Area. Most Modules will require further work even after the initial UREMP Plan is completed, and must at all times be regarded as a work in progress. The Modules are listed in Table 1 in Chapter 2.

natural capital A term that encourages society to treat the natural environment as an asset with high capital value, since natural systems produce essential services including life support and quality-of-life services. Natural capital should be valued like other forms of capital when decisions are made, and not treated as if it is free and inexhaustible.

Step The method for preparing a UREMP Plan, as described in this report, includes eight Steps: (1) defining the UREMP Area, (2) setting up the map and data platform, (3) describing the overall environment of the UREMP Area, assessing the specific values of (4) Green Land, (5) water and (6) air in the context of urban and other development, identifying opportunities for (7) environmental restoration, and finally (8) integrating all of these findings into the UREMP Plan (see Table 1 in Chapter 2). While the eight Steps must largely be carried out in sequence they must also be considered in parallel, since the outputs from one Step will require other Steps to be revised; furthermore, most Steps will require further work even after the initial UREMP Plan is completed, and must at all times be regarded as a work in progress. Each Step contains a number of Modules.

"Three at the same time" means that measures to prevent and control environmental damage are *planned*, *constructed* and *implemented* at the same time as the main project is carried out.

UREMP Area The area, defined by agreed boundaries, for which a UREMP Plan is adopted, recognising that natural systems extend beyond jurisdictional borders, but also recognising that environmental protection measures must be adopted and implemented by existing jurisdictions.

UREMP Plan A planning instrument agreed by the relevant UREMP partnership and/or jurisdiction, and confirmed by the relevant People's Congresses for those jurisdictions, containing GIS maps and databases with red, yellow and green lines and corresponding objectives, evaluations, standards, rules and controls; the zones and controls are in a form that can be incorporated into provincial, municipal and other planning instruments and applied through the project approval processes of those planning instruments.

Executive Summary

The Asian Development Bank (ADB), in partnership with the Ministry of Environmental Protection of the PRC (MEP), supported project TA8537-PRC: *Institutionalization of Urban-Rural Environmental Master Planning (UREMP) to Guide Environmentally Sustainable Urbanization in the People's Republic of China*. The main outputs from this project are four reports, including this report, *Executive Report: Summary of UREMP in the PRC - Protecting China's Green Land from Urban Development, Urban Sprawl and Overdevelopment*. The ADB technical assistance (TA) project has been building on initial experiences from the MEP's program to develop assessment and planning methods for UREMP in selected pilot cities in the PRC starting in 2012. This Executive Report provides a comprehensive summary of UREMP, including a description of the methods and techniques to be used, recommendations for policies and for institutionalising urban-rural environmental master planning at various levels of government in the PRC, and lessons from successful examples of UREMP in the PRC and international best practices of urban-rural environmental protection, planning and management. This report is intended for senior government officials, government administrators on national, provincial and local levels, technical specialists, practitioners, stakeholders and members of the public, the thinking behind UREMP, the practical steps to prepare UREMP Plans, and the reforms needed to integrate spatial environmental protection plans with the other land use and urban development plans.

The context is the urgent need for protecting and integrating the planning of green land and open space systems into the urban and urban-rural development process in light of severe environmental loss, degradation, and pollution caused by the massive and rapid industrialization and urbanization in the PRC since the opening up and reform policies started in 1978. While undoubtedly this has been one of the greatest achievements in economic development in human history turning an agrarian society into an urban society and lifting hundreds of millions out of poverty, the toll on the environment has been very severe. Sprawling urban developments, polluting industries, and fossil fuel burning cities caused a vast loss of green land, soil, water and air pollution.

While the existing urban and land planning and management systems in the PRC have developed well during the high growth period, environmental protection and management need to urgently be prioritized and integrated with objectives of economic development. Green land provides essential ecosystems services that are needed and beneficial for ecological sustainability, and equally so for human health, and as productive resource and amenities for people. Ecological health in turn is essential for human health and the ecosystems services benefit the economy and the people.

However, there are already good laws, policies, and programs in the PRC promoting sustainable ecologically sound development including for example, (a) the national economic and social development plan requires pollution reduction and includes a general "four function zoning plan" with national level "environmental red lines" protecting priority landscape, (b) land use master planning contains requirements regarding the use of land with high ecological values, and (c) urban master planning targets significant increase of wastewater and solid waste treatment. However the status of the environment provisions of these plans is too low, the controls are weak, and more often economic and urban development goals are prioritized, at the expense of environmental protection. Clearly, protection and planning of the urban and rural environment must be set as highest priority and guide other plans like land use and transportation plans.

Environmental protection requires coordination and cooperation across disciplines and across administrative boundaries and needs among others to include the following.

- An environmental equivalent to economic and social targeting for sustainable development.
- A comprehensive spatially explicit environmental protection and planning instrument, including a technical platform, to compile, quantify and map all necessary information and environmental data to enable cooperation and decisions across administrative departments and across political levels.
- An integration and coordination of planning and management responsibilities and practice throughout and across administrative agencies removing the current fragmentation in environmental protection and management and harmonize different time frames of plans.
- Strengthened institutions and institutional coordination and cooperation improving the legal and regulatory framework and enforcement of environmental protection, planning and management laws and regulations.

With the revision of the Environmental Protection Law of 2014, the inclusion of the "four function zones" with environmental red lines and the development of UREMP Plans, environmental protection planning will be integrated and mainstreamed into national, regional and local planning procedures and practice coordinating across disciplines and boundaries.

The ADB TA developed a system of UREMP for implementation in city-clusters, city-regions and their urban-rural hinterlands including the following outputs: (i) technical guidelines with high operational value in the form of a step-by-step manual that can be followed by decision makers administrators and technical experts; (ii) policy recommendations and framework for institutionalization and responsibilities with practical suggestions on which agency and institution is responsible for what action and which planning instruments should be coordinated and harmonized; and (iii) Lessons learned from UREMPs carried out in pilot cities in the PRC, and lessons from international best practice cases.

Findings and results of the TA were highly relevant and it can be rated as highly successful. UREMP has been included in the 13th Five-Year Plan on the national level and in most provincial and city levels as "environmental red line," requesting all cities in the PRC to carry out such delineation as described in the UREMP technical guideline. A total of 31 cities have completed or are currently carrying out a UREMP. Instead of initially planned three, 13 pilot cities were trained and their UREMPs were completed, and in the case of Yichang, the People's Consultative Committee approved the first UREMP in the PRC. Several pilots included UREMP in their 13th FYPs and budgets were allocated for implementation.

(i) Technical Guidelines

One of the primary techniques for the protection of the environment will be the preparation of UREMP Plans, with three zones: red, yellow and green lines. Red line zones are drawn where environmental values are highest. Development is forbidden, and inappropriate development is removed. In yellow line zones all forms of land use and development are strictly controlled to protect ecosystems. Green line zones apply to remaining land, where development is allowed but still should be environmentally responsible and sustainable.

The specific objectives and methods of preparing a UREMP Plan are described in eight Steps. While the steps are generally carried out in the order presented, some Steps will take longer than others, and all Steps need to be reviewed when later Steps are completed. Within the eight Steps there are 34 technical Modules describing methods of analysis for specific aspects of environmental protection and planning. Individual Modules may be relevant to more than one of the Steps.

Step 1: Establish the UREMP Area and Partnership. There are five Modules for Step 1. The first three Modules primarily involve *description,* initially using available data and tools to map existing conditions

within and surrounding the region of the UREMP Plan: “Map the boundaries of bioregions and subregions”, “Map areas exposed to risk from urban and suburban development” and “Adopt objectives, controls and evaluation standards”. The remaining two modules use this information for negotiations and agreements: “Agree on the jurisdictions” and “Agree on the boundary of the UREMP Area”.

Step 2: Prepare agreed standards for the UREMP Atlas. This Step focuses on process and format rather than content. The UREMP Partners and neighbouring jurisdictions need to adopt shared standards for collecting and managing data, agree on ways to manage geographical information systems (GIS), and use a common format for maps. These standards are essential if the data collected by many agencies is to be accessible, comparable, integrated and kept up to date. Accordingly, the three Modules for completing Step 2 are “Adopt data standards’, “Adopt GIS standards” and “Adopt mapping standards and base maps”.

Step 3: Prepare an Ecosystem Zoning and Protection Map. The focus of this Step is on the Module “Map and assess ecosystems and landscapes”, so that the UREMP Planners map the value and vulnerability of each spatial unit outside cities, and document the development pressures on those areas. This allows the second Module “Indicative ecosystems protection zoning and mapping” to be completed, with the first of the red line maps.

Step 4: Prepare an Indicative Zoning Map for Green Land Protection. The first five Modules indicate the priorities: “Identify and map forest priority areas”, “Identify and map agricultural priority areas”, “Identify and map mineral resource priority areas”, “Identify and map soil conservation areas”, and “Identify and map priority hazardous areas”. The sixth Module, “Indicative Green Land protection zoning and mapping” generates the second red line map, integrating the complex and competing values of all Green Land areas.

Step 5: Prepare an Indicative Zoning Map for Water Quality Protection. There are six technical Modules: “Determine the scope of the water environment and spatial control units”, “Develop surface water quality models”, “Assess priorities for protecting rivers, lakes, wetlands and reservoirs”, “Assess priorities for flood risk management”, “Assess priorities for water source protection”, and “Assess priorities for the protection of riparian and coastal areas”. These are the basis for the seventh Module, “Indicative water quality protection zoning and mapping”, and the integration of these complex and competing values into the third red line map.

Step 6: Prepare an Indicative Zoning Map for Air Quality Protection. This Step applies the PRC’s well established air monitoring and regulating systems to UREMP. There are four technical Modules: “Assess priorities for microclimate protection areas”, “Develop a regional atmospheric flow model”, “Develop a regional pollution source model”, and “Develop a regional atmospheric absorptive model”. These are the basis for the fifth Module, “Indicative air quality protection zoning and mapping”, and the integration of these complex and competing values into the fourth red line map.

Step 7: Prepare an Indicative Zoning Map for Ecosystems Restoration. The four technical Modules are “Identify and map the potential for habitat and biodiversity regeneration”, “Identify and map the potential for water body and river restoration”, “Identify and map the potential for urban greening and open space”, and “Identify and map the potential for brownfield remediation”. These are the basis for the fifth Module, “Indicative environmental restoration zoning and mapping”, and the integration of these complex and competing values into the fifth red line map.

Step 8: Integrated Environmental Protection Zoning. To complete the one Module of Step 8, the teams of experts and officials of the UREMP Partners and neighbours integrate the foregoing five red line maps and agree on a comprehensive red line map for the UREMP Area. This final map gives access to the

layers of maps and data in the UREMP Atlas, to the values of the separate spatial units and the reasons for zoning, and specific policy measures to protect the environment. This is the basis for negotiations to ensure that these policy measures are implemented through land use and urban master plans.

(ii) Policy recommendations and institutional responsibilities of UREMP

A revision of the Environmental Protection Law of the PRC to include green land and environmental protection and provide a legal basis for UREMP is urgently needed. This may take the form of new provisions as national and provincial laws are revised; new procedures adopted by people's governments at all levels as planning is undertaken within the Thirteenth Five-year Plan; new technical controls to be included in UREMP Plans as the National Ecological Red Line Protection Plan is formulated; and finally through the issuing of departmental rules and national Instructions based on the experiences of the pilot cities.

One of the five fundamental *principles* of the Environmental Protection Law is *integrated governance*. Since a UREMP Plan may extend to large natural systems, and may involve a number of cities and the agencies of more than one province, *coordination* is essential. This will require, firstly, new structures that facilitate *internal* coordination within the city government, and secondly structures to facilitate communication, coordination and negotiation with provincial departments and the surrounding cities and counties.

The development and implementation of UREMPs will require major changes in *institutional cultures and professional practices*. If these changes are made and maintained, the resources available for environmental protection will be larger and stronger, natural systems will be managed holistically, and development will be controlled with greater authority and effectiveness. Two forms of institution building will be required: firstly, to enable governments to work together in the preparation of UREMP plans, using joint or compatible structures, procedures, IT platforms, etc; and secondly to facilitate collaboration between the diverse professions and disciplines required to fully incorporate environmental values into land use plans, master plans and urban and rural development plans.

Comprehensive, location-specific environmental protection planning, and integration with existing forms of spatial planning, will require new *management policies and procedures* relating to integrated spatial planning, location-specific standards, location-specific limits and caps, location-specific interventions, eco-compensation, risk management and ecological assets accounting.

In this light, significant *capacity building* will be required. The preparation of UREMP Plans should be overseen and guided by units staffed by qualified and experienced staff members in environmental planning agencies on provincial levels. These units should form an environmental planning steering committee, specially trained in UREMP.

(iii) Lessons from UREMP pilots in the PRC and from international best practice cases

A total of 31 pilot cities have started and several have already completed their UREMPs. The selection of the pilot cities was mainly based on four considerations: firstly, the regional distribution, which should take into account the different regions including the eastern, middle and western areas; secondly, the urban scale, which should take into account the cities of large, medium and small scale; thirdly, the urban economic development, which should take into account different economic development level; fourthly, types and development characteristics of city, which should take into account the different characteristics of cities.

In addition, the cities of Fuzhou, Yichang, Guangzhou and Weihai explored a series of practical trials in environmental system analysis, environmental spatial regulation, evaluation and management of resource capacity and improving environmental functions.

In general, the pilot cities demonstrated that an ecosystem services evaluation is possible and that this can result in a prioritization of areas by their importance for safeguarding the functioning of the green space. Specifically, Yichang Municipality also demonstrated that a formal approval procedure, in that case by the Municipal People's Congress, is a good precondition for implementation.

Some of the key strategies and international examples to protect the environment from urban expansion include: London's green belt, the Copenhagen finger plan, the Randstad in the Netherlands with its "green heart", and the urban growth boundary for the metropolitan region around Portland in Oregon, USA. Some key lessons that were applied in the policy recommendations came from EU, Germany, UK, Switzerland, and USA.

1. UREMP objectives and challenges

Objectives and challenges protecting the PRC's Green Land at risk from urban development and overdevelopment in urban-rural areas and in planned city clusters

1.1. The origin, urgent need and challenges for UREMP

Green Land – non-urban land that is in a relatively natural state, or used for forestry, farming, protection of resources, recreation, and the like – provides essential ecosystem services. There are *regulatory* services, such as habitat for wildlife and the conservation of biodiversity, production of oxygen, absorption of noise and pollutants in air and in water, lowering summer temperatures in urban areas, reduction of storm water and flooding, and many more. There are *provisioning* services, such as the supply of drinking water, agricultural products, and cultural and recreational opportunities. These services are of high importance for the economy and business, and essential for human wellbeing including health. The services of Green Land need to be protected for future generations. They are fundamental to human life, and urban green land also increases land values nearby. However during the last 38 years of opening up and reform policies, much green space has been lost to urban and industrial development and generally land extensive sprawling land development. Much open space has been exposed to degradation. Air, water, and soil have been polluted in the process. Now it is urgent to effectively protect the environment and green open space and open space systems to ensure ecologically sustainable development in the next phase of urbanization towards an estimated one billion urban people by 2030.

As a result, the PRC government spearheaded by the Ministry of Environmental Protection (MEP) requires that, the scarce resource of land should be protected and land should be used efficiently when developed, to ensure that natural, agricultural and other green land is protected. Ecosystems, sensitive and significant landscapes, forests, and farmland are precious and must not be disturbed. However, environmental protection in light of pressure from urbanisation, expanding infrastructures and other human activities, needs explicit mechanisms, institutional responsibilities, and legal instruments. Urban-Rural Environmental Master Planning (UREMP) is such an instrument that if applied throughout the country will make the next phase of the PRC's urbanization more environmentally sustainable. The result of the ADB technical assistance (TA) project is that UREMP is now included in the form of urban-rural environmental red lines in the national 13th Five Year Plan and in various provincial and municipal 13th Five Year Plans. Yichang, one of the pilot cities has formally approved its UREMP and designated budget resources for its implementation.

In July 2014, the Asian Development Bank and the Ministry of Environmental Protection launched the TA *Institutionalization of Urban-Rural Environmental Master Planning (UREMP) to Guide Environmentally Sustainable Urbanization in the PRC*. The TA is building on a MEP initiated pilot program that started in 2012 involving up to 24 cities. The pilot cities of Yichang, Weihai, Guangzhou and Fuzhou explored a series of practical trials, including in environmental system analysis, environmental spatial regulation, evaluation and management of resource capacity and improving environmental functions. The findings are summarised in this report, and reported in more details in *Report Four: Domestic Pilots and International Best Practice Cases of UREMP*. Three international experts and experts from the Chinese Academy for Environmental Planning, Beijing Normal University, Peking University, and MEP's Policy Research Center for Environment and Economy were engaged to carry out research for this TA. The conclusions of this phase were applied to overall urban environmental

planning for Yichang, Guangzhou, Weihai, Guiyang, Pingtan, Beihai and other cities, confirming the following findings.

- Establishment of UREMP is urgently needed for a healthy urbanization in the PRC.
- A breakthrough is required to overcome obstacles in governance, current planning practice and technical methods to establish a planning system for UREMP.
- Ecological Civilization and UREMP should be promoted simultaneously, with governance rules and technical guides that enable UREMP implementation during the 13th Five Year Plan period.

The primary planning system in the PRC, including National Economic and Social Development Plan, Major Function-Zone Planning, General Land Use Planning and General Urban Planning, has the following characteristics, which provide a model for the institutionalisation of UREMP.

- Legal status: regulations in the planning system require governments and society as a whole to follow these basic forms of planning.
- Established methods: the overall planning system, technical methods, content of plans and regulations, and layout specifications, spatial controls and development standards, have been established, enabling the planning system to provide strong guidance and controls.
- Administration: comprehensive procedures for implementation, including preparation, approval, evaluation and revision of plans, ensure orderly and effective regulation of development.

The existing planning and management system in the PRC is well-developed. Nevertheless it has to be strengthened to respond to environmental sustainability challenges. The following four fields have been identified, in which overcoming current problems would be particularly effective.

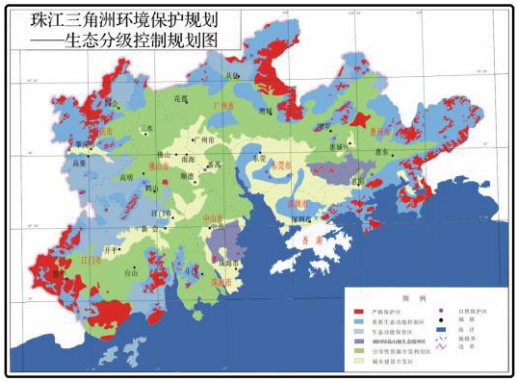
- There is no environmental sustainability target comparable to existing economic and social development targeting.
- There is no comprehensive spatially explicit environmental planning instrument and technical platform to systematically compile necessary information and prioritization of environmental topics for supporting decisions on different political levels.
- The management, implementation, control and evaluation of area-specific environmental goals policies and implementation instruments are scarce.
- Contents and competencies of environmental protection and management are fragmented in various sectors and allocated in different departments; time frames of plans are not always harmonized; this hampers integrated, effective, coordinated and cost-efficient solutions.

UREMP is to define aims, techniques, procedures, legal and administrative responsibilities to enable integrated and coordinated environmental protection and management in the PRC.

2. Technical methods for UREMP

A recommended step-by-step guide including institutional arrangements, comprehensive mapping, analysis, evaluation and the environmental zoning of land

2.1. Comprehensive mapping and ranking of land: red, yellow and green lines



The first mapping of an ecological red line for environmental protection was in the preparation of the *Pearl River Delta Environmental Protection Plan (2004-2020).* The plan had been initiated in 2003 by the State Environmental Protection Administration (which was replaced in 2008 by the MEP) and was enacted by the NPC of Guangdong Province. There were three zones or 'lines': a red line showed the areas under control, a green line showed the areas requiring improvement and a blue line showed the areas under environmental construction. This approach was developed by the Institute of Environmental Planning and became the prototype for China's General Environmental Planning and the idea of "space landing", although the current approach adopts red, yellow and green lines (zones) with new definitions.

In the red line zone, environmental values are highest and human activities of development, construction, expansion of production are forbidden and inappropriate land uses and buildings are removed. In the yellow line zone all forms of land use and development are strictly controlled to ensure, as far as possible, that ecosystems, which provide high biodiversity, wilderness and/or (other) valuable ecosystem services are not disturbed and cannot be reduced. The third zone is the green line zone, applying to all the remaining land. It should be subject to the MEP's requirements for all land, that land use should be economical and intensive, and that development should be environmentally responsible and sustainable.

Accordingly, the landscape and ecosystems including open and built up space must be analysed, assessed, mapped, zoned and ranked as to their ability to provide ecosystems services. Specific areas will be highly ranked for the ecosystems and economic services they provide. The analysis and evaluation must be sufficiently objective, quantifiable and rigorous to enable the highly ranked areas to be accurately delineated and to provide legal status for their appropriate protection.

Environmental challenges come in many forms, both in complexity and extent. Some may be addressed by regulations made by higher level governments. Some may be confined within one jurisdiction and may be resolved directly by that jurisdiction. Many will be managed within a UREMP of a single jurisdiction like municipality. If problems cannot be solved within one jurisdiction, or within the UREMP Area, or by higher-level regulation, partnerships must be formed amongst any jurisdictions that are within, or partially within the boundaries created by the specific environmental issues to address these adequately.

It is crucial that an appropriate digital platform be created, to enable the collection, integration, mapping and sharing of the data for every specific local UREMP Area, in order to share and integrate data between partners and on higher planning tiers.

Finally, environmental protection of Green Land (with priority in areas within cities and surrounding cities with high pressure from development) requires the delineation of red, yellow and green lines, and the adoption of explicit development controls, with maps, standards, land use criteria and procedures, to be incorporated in urban and regional strategies, master plans and detailed development plans. UREMP is intended to provide such environmental zoning instruments.

The approach, methods and techniques for this work are outlined in this section of the report, and in detail described in *Report Two: Technical Guidelines of UREMP*.

The specific objectives and methods of preparing a UREMP Plan are described in eight Steps. While the steps are generally carried out in the order presented, the UREMP process is not linear. There are two main reasons why the UREMP process will also be circular and iterative.

- Each Step will be influenced and informed by the outputs of the other Steps. It is therefore important to review and adapt earlier steps when later steps are completed.
- Pragmatically, there will not be adequate data to complete all the Steps as intended, and even if data may be available, there may not be sufficient time or resources to complete one or more Steps. It is therefore important to plan for and fund further work on specific Steps in the future.

Within the eight Steps there are 34 technical Modules describing methods of analysis and synthesis on specific aspects of environmental protection and planning. Individual Modules may be relevant to more than one of the steps. The Steps and Modules are listed in Table 2.1.

Table 2.1 Steps and Modules for UREMP zoning

8 Steps	34 Modules
Step 1: Establish the UREMP Area and Partnership	**Module 1A: Map the boundaries of bioregions and subregions** This is one of two essential first tasks: to describe and document the basic characteristics of the natural environment in the regions where a UREMP Area may be defined. Note: bioregions and subregions are higher-order divisions and may overlap the diverse ecosystems and landscapes mapped in Step 3.
	Module 1B: Map urbanized areas and areas exposed to risk from urban and suburban development and sprawl due to proximity and/or planning This is the second of the two essential first tasks: to *describe* and document urban and development pressure in the regions where a UREMP Area is to be defined.
	Module 1C: Document and adopt objectives, controls and evaluation standards and methods National and province-level legislation, controls, standards and methods enable UREMP planners to make environmental protection planning more effective at every level.
	Module 1D: Agree on the jurisdictions that might be included in the UREMP partnership This task involves consultation and negotiation with jurisdictions that may be partners in making the UREMP Plan, or may be partners on specific problems.
	Module 1E: Agree on the boundary of the UREMP Area This crucial preliminary task involves consultation and negotiation to determine the UREMP Area and the roles of any partner jurisdictions.
Step 2: Prepare agreed standards for the UREMP Atlas	**Module 2A: Adopt data standards and platforms**
	Module 2B: Adopt GIS standards and platforms
	Module 2C: Adopt mapping standards, base maps, methods and models
Step 3: Prepare an Ecosystem Zoning and Protection Map	**Module 3A: Map and assess ecosystems and landscapes** Document and map the state of the environment (values and sensitivity/vulnerability), and document and map pressures on the environment.
	Module 3B: Indicative ecosystems protection zoning and mapping The first red line map, integrating the complex and competing values of the ecosystems services assessed in Module 3A.
Step 4: Prepare an Indicative Zoning Map for Green Land	**Module 4A: Identify and map forest priority areas**
	Module 4B: Identify and map agricultural priority areas
	Module 4C: Identify and map mineral resource priority areas

Protection	**Module 4D: Identify and map soil conservation areas**
	Module 4E: Identify and map priority hazardous areas
	Module 4F: Indicative Green Land protection zoning and mapping The second red line map, integrating the complex and competing values of the Green Land areas assessed in Modules 4A, 4B, 4C, 4D and 4E.
Step 5: Prepare an Indicative Zoning Map for Water Quality Protection	**Module 5A: Determine the scope of the water environment and spatial control units**
	Module 5B: Develop surface water quality models
	Module 5C: Assess priorities for protecting rivers, lakes, wetlands and reservoirs
	Module 5D: Assess priorities for flood risk management
	Module 5E: Assess priorities for water source protection
	Module 5F: Assess priorities for the protection of riparian and coastal areas
	Module 5G: Indicative water quality protection zoning and mapping The third red line map, integrating the complex and competing values of the Water environment assessed in Modules 5A, 5B, 5C, 5D, 5E and 5F.
Step 6: Prepare an Indicative Zoning Map for Air Quality Protection	**Module 6A: Assess priorities for microclimate protection areas**
	Module 6B: Develop a regional atmospheric flow model
	Module 6C: Develop a regional pollution source model
	Module 6D: Develop a regional atmospheric absorptive model
	Module 6E: Indicative air quality protection zoning and mapping The fourth red line map, integrating the complex and competing values of the Air environment assessed in Modules 6A, 6B, 6C and 6D.
Step 7: Prepare an Indicative Zoning Map for Ecosystems Restoration	**Module 7A: Identify and map the potential for habitat and biodiversity regeneration**
	Module 7B: Identify and map the potential for water body and river restoration
	Module 7C: Identify and map the potential for urban greening and open space
	Module 7D: Identify and map the potential for brownfield remediation
	Module 7E: Indicative environmental restoration zoning and mapping The fifth red line map, integrating the complex and competing values of the areas assessed in Modules 7A, 7B, 7C, 7D and 7E.
Step 8: Integrated Environmental Protection Zoning	**Module 8A: Environmental protection zoning** The UREMP red line map, integrating the environmental protection zones and controls in the redline maps produced in Modules 3B, 4F, 5G, 6E and 7E.

2.2. Step 1: Establish the UREMP Area and Partnership

2.2.1. Basic questions for Step 1

The first question in its preparation is the extent of the UREMP planning area. For provincial planners, the answer could be, 'The province.' For municipal planners, the answer could be, 'The city.' This may be practical and may seem pragmatic as a first step from a governance and responsibility perspective. However, neither a province nor a city is typically delineating a single bioregion, or a full river basin, or a landscape unit, or a fishery, or another environmental system, that needs to be managed and protected as a whole.

The answer to that first question therefore depends on environmental science: what ecosystems are under most threat, and what bioregions must be managed in a holistic manner? It also depends on governance: what powers and skills are required, and which jurisdictions should be involved? For this reason, the essential first task in a UREMP planning project (subject to existing knowledge and data) is to *fully understand the region* where plans for environmental protection are going to be prepared, and to *engage with the jurisdictions* that might be involved in a UREMP Plan.

Thus the first objective of Step 1 is to *describe* and *document* the basic characteristics of the natural environment in the region likely to be chosen for the UREMP Plan. Based on such analysis, negotiations and compromises will be necessary. Bioregions are not absolute divisions. Bioregions are composite areas cutting across diverse ecosystems and landscapes, a balance of values arrived at through expert knowledge and judgement. Likewise, any potential combination of jurisdictions overlaps those bioregions. These boundary complexities make it essential that the UREMP project begin with a scientific overview of the environment of the possible UREMP Area, and engagement with the potential UREMP Partners. These tasks are the primary components of Step 1.

2.2.2. The purpose of Step 1

Two competing demands will determine the size and the specific boundaries of the UREMP Area.

- Natural systems such as watersheds, airsheds, forests, farmland, fisheries, etc., usually extend beyond the borders of cities and provinces. The impacts of urban development, and the diffusion of polluted air and water (for instance), affect areas well beyond the source. These systems cannot be managed independently by the multiple jurisdictions that they cover, and pressures on the environment cannot be lessened control of the source. Environmental protection and management must be defined geographically by natural systems rather than by political or administrative boundaries, as it requires a holistic and cooperative approach involving multiple jurisdictions.
- Despite these realities, actual planning and environmental protection authority belong to provinces, municipalities, counties and districts. Development control authority is not separate for a UREMP Area that includes multiple jurisdictions. Each jurisdiction will need to implement the UREMP provisions, and each may prefer a UREMP Area entirely within its borders.

While it may be easier to prepare and implement UREMP for single municipalities, as demonstrated by the pilot cities, municipalities cannot effectively protect only parts of natural systems. More significantly, UREMP protections are most urgently required for the larger urban regions, including the twenty city clusters prioritised by the national government (see the Appendix).

In terms of *urgency*, the implementation of UREMP should be focused on the city clusters and other large, rapidly expanding urban regions. In terms of *administrative feasibility*, UREMP can most readily be implemented in one province or one municipality. If the latter course is chosen, it is important to recognise that neighbouring UREMP Areas will need to be integrated in future, and that collaboration between jurisdictions, leading to partnerships, will be essential in all cases.

Partnerships should be formed at the beginning of a UREMP process, including on shared environmental data, mapping and decision-making systems to ensure harmonizing systems and mechanisms. By forming partnerships for joint environmental protection and management, provinces and municipalities would be implementing the principle of *integrated governance* mandated in Article 5 of the Environmental Protection Law of the PRC.

Step 1 has the following aims.

- Understand and map the extent and directions of urbanisation and development.
- Identify and map natural systems in which urbanisation is occurring, and pressures that development are imposing on those natural systems.
- Identify, document and map the responsibilities deferred to lower level jurisdictions by higher jurisdictions for management and development control, including enforcing environmental standards.
- Balancing these factors against administrative mechanisms for environmental protection, to gain agreement on the most appropriate boundaries for the UREMP Area.

Step 1 includes five Modules. The first three Modules primarily involve *description,* using available data and tools to map existing conditions within and surrounding the region where a UREMP Plan (or Plans) may be prepared. In Module 1A the bioregions and subregions are mapped and described. In Module 1B urban areas, and areas exposed to pressures from development, are mapped and described. In Module 1C the existing legal provisions that can be included in a UREMP Plan – environmental objectives, assessment principles, assessment methods, standards, limits and restrictions – need to be documented and, where applicable, mapped. Based on the outputs of the first three Modules, the fourth and fifth Modules involve *negotiations and decisions* concerning the roles of jurisdictions (if more than one) within the potential

UREMP Area. In Module 1D, discussions and negotiations are held between the jurisdictions that might join the UREMP partnership, or that might form partnerships to address specific environmental challenges. In Module 1E, the jurisdictions preparing a UREMP agree on the precise boundary of the area.

Module 1A: Map the boundaries of bioregions and subregions

Many classifications for spatial distributions within the biosphere, including for biological complexes, types of territories, land cover, and landscapes, exist generally in hierarchies from global down to single sites and elements. Ecosystem management has generated many overlapping schemes for stratifying the earth into progressively smaller areas of increasingly uniform environmental characteristics.

Key spatial concepts for UREMP include the following.

- **Bioregion**: Bioregions are large, geographically distinct areas of land with a unique overall pattern of natural characteristics including a particular climate, a local pattern of seasons, specific landforms and soils, watersheds, and populations of native plants and animals.
- **Biosubregion**: A bioregion will divide into a number of more uniform subregions, all of which are fully contained within the one bioregion. There is greater similarity in natural characteristics within than between each subregion. Bioregions and subregions are mapped in Step 1.
- **Ecosystem**: A complex of living organisms with their (abiotic) environment and their mutual relations. A practical approach to the 'spatial delimitation of an ecosystem' is to map a series of location of discontinuities: a useful ecosystem boundary is the place where a number of these relative discontinuities coincide. Mapping, assessment and policy in a UREMP relates to ecosystems on the scale of habitat/biotope or landscape. Ecosystems are mapped and assessed in Step 3.

Classifying space into bioregions and subregions using a pragmatic approach is essential.

- UREMP is an administrative activity for regulating human activity in the interests of protecting the environment: it is not primarily a research activity aimed at creating new knowledge, and to have immediate effect it must rely primarily on existing data.
- UREMP must be able to generate policy and practical measures for the regulation of human activity (primarily urban development) and should therefore avoid purist or exhaustive approaches to classification, and adopt *spatial units* relevant to *existing planning instruments* including urban and regional strategies, master plans and detailed development plans.

The outputs from Module 1A are maps and supporting information describing the bioregions and subregions in the potential UREMP Area and surroundings areas. This documentation should be done in a form that can be included in the UREMP Atlas and database (see Step 2).

Module 1B: Map urbanized areas and areas exposed to risk from urban and suburban development and sprawl due to proximity and/or planning

The aim of Module 1B is to map urbanized areas, potential areas of urbanization and future directions of urban, industrial, infrastructure and other development, based on land use maps, urban and regional strategies, urban-rural master plans, land use master plans, and other relevant data for all the areas considered in Module 1A.

The outputs from Module 1B are maps and supporting information describing present and future urbanisation and other development, and the pressures on the natural environment, in the potential UREMP Area and surroundings areas. This documentation should be done in a form that can be included in the UREMP Atlas and database (see Step 2).

Module 1C: Document and adopt objectives, controls and evaluation standards and methods

National and province-level legislation, controls, standards and methods govern the scope of UREMP Plans and provide UREMP planners with opportunities to make environmental protection planning more effective at every level.

The revised Environmental Protection Law of the PRC establishes the objectives and principles for all environmental protection planning. Section 1.2.2 above (including Tables 1.3 and 1.4) shows that the existing system of environmental standards and controls in the PRC creates a sound foundation for UREMP, and provides opportunities for effective local measures for environmental protection. Sections 1.3 and 2.1.5 of *Report Three: Recommendations for Policies and Institutional Arrangements of UREMP* provides detail on these matters.

The State Council sets pollutant emission targets to be implemented by provinces, autonomous regions and municipalities. MEP issues environmental quality standards with limits on the concentration of hazardous substances and the discharge of pollutants. These can be supplemented by standards adopted by governments above the level of municipality. Standards to be enforced by municipalities can be set by provincial governments in separate or joint UREMP Plans.

While there are many environmental policies on the pollution of water and air, not all ecosystem services are currently covered by standards. UREMP Plans with provincial partners will be able to establish local and regional quality standards and threshold values for all environmental media. Where national total-amount limits have been set, these UREMP Plans will also be able to scale down the targets to lower levels including provinces, districts and local industries. UREMP Plans with provincial partners will be able to extend total-amount control policies to urbanization rates, green-house-gas emissions, nitrate surplus, no-net-loss of biodiversity and organic soil, no-net-loss of farmland and forest, etc.

All these and others define the potential scope and powers of a UREMP Plan as well as its limits. The objectives, assessment principles, assessment methods, standards, limits and restrictions, to be applied in a UREMP Plan, need to be documented and, where applicable, mapped.

The outputs from Module 1C are documents, data and maps to facilitate the preparation of the UREMP Plan in its most effective form. This documentation should be done in a form that can be included in the UREMP Atlas and database (see Step 2).

Module 1D: Agree on jurisdictions and UREMP partnership

Where the proposed UREMP Area covers multiple jurisdictions, the aim of Module 1C is to form effective partnerships among the provinces, municipalities, counties, districts and agencies within the proposed area. To organize the process of a UREMP, partnership agreements need to be agreed, a steering committee and working groups need to be established, roles and responsibilities need to be negotiated, and a work plan to effectively carry out a UREMP needs to be adopted. Options for legal frameworks and institutional arrangements are discussed in *Report Three: Recommendations for Policies and Institutional Arrangements of UREMP.*

Achieving *integrated governance* will require cross-jurisdiction consultations and negotiations under the guidance of environmental protection experts and with observation and leadership from higher level governments to set an adequate extent and scope for the proposed UREMP Plan.

Where jurisdictions do not join a UREMP partnership, they may still be needed in partnerships to address specific environmental problems.

The jurisdictions within the UREMP Area will need to agree to translate the resulting UREMP environmental protection zones into their environmental protection plans, informing their master development plans, land use plans, housing programs, infrastructure programs and urban design plans.

The outputs from Module 1D are enduring *agreements* and decision making *structures* and processes to prepare and implement the UREMP Plan. Documents and data should be included in the UREMP Atlas and database (see Step 2).

Module 1E: Agree on the boundary of the UREMP Area

The aim of Module 1E is to agree on a boundary of the study area for the UREMP among the jurisdictions that formed the UREMP partnership.

On the basis of the mapping of natural systems and present and future urban impacts, and on the basis of the agreements reached in Module 1D, the precise boundaries of the UREMP Area are defined, confirmed, and included in the UREMP Atlas (see Step 2).

2.2.3. Example: Determining the boundary of research for the Fuzhou UREMP Plan

Taking into account the pattern of urban areas of Fuzhou, the location of the subregions of the four bioregions shared by Fuzhou and neighbouring cities, the pollution spread offshore by the main river through Fuzhou, and the distribution of atmospheric pollutants coming from the northeast beyond the city and spreading southwest from the city, the UREMP team defined the areas for comprehensive research as being the whole of Fuzhou and its offshore areas, together with Ningde to the north and Putian and Quanzhou to the south, all in the Province of Fujian. An overview of the Fuzhou UREMP Plan is given in Chapter 4 of this report.

The Fuzhou UREMP Plan is described in detail in *Report Four: Domestic Pilots and International Best Practice Cases of UREMP*.

2.3. Step 2: Prepare agreed standards for the UREMP Atlas

Step 2 focuses on process and format: shared standards for collecting and managing data, agreed ways to manage geographical information systems (GIS), and common formats for maps. These standards are essential if the data collected by many agencies is to be accessible, comparable, integrated and maintained and to be integrated into the UREMP Atlas.

The UREMP Atlas is a living document available online, and a system of evolving digital and intranet based databases, owned and maintained by the agencies which collect and update data and maps, with access rights assigned to contribute, edit and analyse to concerned agencies and institutions according to the protocols and procedures agreed by the UREMP partnership. This Atlas will be instrumental for linking UREMP and providing inputs to other planning processes like land use planning. It is intended to support the management platform for multi-level shared application services, business flow and spatial data integration. An example for an environmental Atlas is the Berlin Environmental Atlas openly available on the internet allowing the interactive creation of maps varying parameters.

Module 2A: Adopt data standards

The objective of Module 2A is to facilitate shared environmental data management and agree on data standards and protocols among any and all governments and agencies within the UREMP Area. Achieving interoperability and the harmonization of data will be challenging and requires significant commitment of time and resources, driven by a high-level interagency task force. The known rule, however, is that this work needs to commence at the beginning of the UREMP process, and needs to be sustained over the entire life of the UREMP preparation and maintenance periods. In order to collect data more efficiently, the local EPA should appoint a senior officer to collect data and to connect with other bureaus. A mayor or vice mayor administering EPA in a local city should hold a meeting for UREMP, to mobilize other bureaus to provide key information for UREMP.

Metadata should indicate the source, accuracy and timeliness of data. Maps should: (i) comply with "1980 Xi'an coordinate system"; (ii) be based on the "1985 national elevation datum"; and (iii) use the Krueger Gauss projection; 3° zoning is preferred. Spatial data should have a scale of at least 1:100,000 and be provided in vector format. Images should be vectored by GIS with high resolutions. This data should be accessible to and maintained by the relevant agencies, including EPA, Planning Bureaus, Land and Resources Bureaus and other planning departments.

Module 2B: Adopt GIS standards

The objective of Module 2B is to develop and agree on a common GIS system and platform and base mapping system that will serve as the main tool for spatial analysis and mapping. A robust GIS system and platform will be critical for the effective UREMP development and maintenance. The roles and responsibilities of data coordinator, data integrator, data provider (EPA, bureau of land and resources, planning bureau, water conservancy bureau, forestry bureau, tourism bureau, oceanic bureau, etc.) and data user/consumer (including project proponents and the public) will need to be defined and issues of content need to be agreed upon. Data users have the right to query the quality and timeliness of data. Confidentiality agreements may be required.

The data categories should be, at a minimum, land use (vector), remote sensing images (vector), digital elevation models (vector), soil types (vector), soil properties (local government records), key risk sources (Excel database of coordinates and risks), boundaries of water bodies (vector, and text of regulations), boundaries of biodiversity and habitat protection areas (vector, and text of regulations), brownfield sites (vector, and Excel database of coordinates and data), populations of administrative divisions, boundaries of flood control areas (vector, and capacity data), air quality (vector, and detailed atmospheric data for ten years), meteorological disasters (vector, and detailed historical data) and geological hazards (vector, and detailed historical data).

Module 2C: Adopt mapping standards and base maps

The aim of Module 2c is to provide guidelines for creating and presenting basic and thematic maps, a style for the map legends, and a format for the map layout.

From the experience of pilot cities, there are 72 parameters that need to be mapped, including 25 descriptive (status) maps, 16 analytical maps and 31 policy maps. Of these, 31 are fundamental and must be prepared initially, while 41 are recommended and may be prepared over time. A list of these maps is in *Report Two: Technical Guidelines of UREMP.*

Protocols and standards need to be agreed concerning map formats (base maps, maps of bioregions, ecosystems, land use, soils, atmospheric environment, water environment, etc.) and styles (including figure title, figure surface, figure boundary, compass, proportion, scale, legend, signature, date of preparation, figure number, etc.) and annotations (including county name, township, government residences, roads, railways, airports and ports, water facilities, rivers, lakes and reservoirs, nature reserves and scenic spots, elevation values, font and word size, annotation word direction, annotation arrangement and annotation word interval). UREMP maps should have a clear and artistic layout. Contents should be complete, accurate and legible. The mapped information should include the full range of planned use, surrounding land, and other planning content according to the specification.

2.4. Step 3: Prepare an Ecosystem Zoning and Protection Map

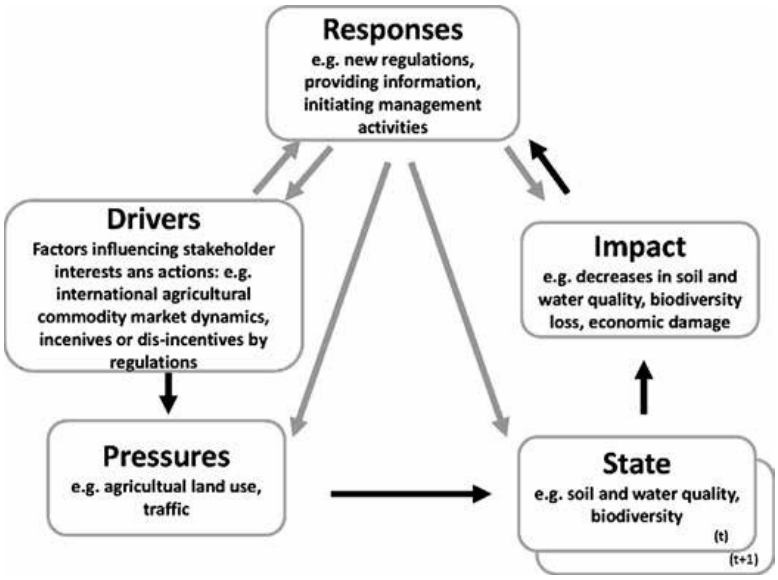
The challenge for governments in protecting the environment, as ultimate basis on which life depends, is to understand the relationships between the state of the environment and human impacts on the environment, that is, to understand causes and the effects.

As Albert et al (2016) point out, one of the most widely used frameworks for managing human impacts on the environment is the Driving forces, Pressures, State, Impacts and Responses (DPSIR) model originally proposed by Smeets and Weterings in a report to the European Environmental Agency in 1999. DPSIR represents a framework for studying cause-effect relationships between socio-economic activities and the environment.

Figure 2.1 The DPSIR model

The grey arrows represent the potential paths of influence by planning.

Source: Albert et al (2016), adapted from Smeets and Weterings (European Environment Agency 1999).



Albert et al. argue that '*Environmental indicators* are required for *all elements of this causal chain* in order to meet the information needs of policy makers' (2016, page 101, emphasis added).

In relation to *environmental indicators*, practice has varied significantly. Environmental indicators may measure natural capital, biodiversity, landscape integrity and many other variables. However, particularly since the UN's Millennium Ecosystem Assessment of 2001-2005 and the TEEB study (The Economics of

Ecosystems and Biodiversity project commissioned by G8+5 in 2008 and led by banker Pavan Sukhdev) the focus has been on *assessing ecosystem services*.

Ecosystem or environmental services (ES) are defined as direct and indirect benefits that ecosystems provide to humans and the biosphere. To provide a structure for overlapping concepts, ecosystem services can be classified into provisioning services (e.g. food, fuel, fibre, medicine), regulating services (e.g. purifying air and water, preventing soil erosion, reducing the spread of disease), cultural services (e.g. education, recreation, inspiration, physical and mental health) and supporting services that underpin the other three categories (e.g. nutrient cycling, soil formation, primary production).

In further developing the concepts of ecosystem services, distinctions have recently been made between ecosystem services that are 'offered' by ecosystems and those that are actually 'utilized' by humans (Albert et al., 2016), and in a similar distinction, between ecosystem service potentials, ecosystem service flows, and ecosystem service demands (Burkhart et al., 2014). Nevertheless, these and other experts recognise that, notwithstanding the imperative to protect the environment, it is unlikely that the concept of ecosystem services will be fully mainstreamed in planning instruments in the short term, considering the limits of time, funding and data. Countries may take different routes to protecting the environment through regulatory planning, possibly including the following options:

- retrofitting existing plans and programs with considerations of ecosystem services;
- incrementally integrating assessments of ecosystem services in existing planning procedures;
- environment-led approach embedding ES considerations at early planning stages; and
- ecosystem approach-based model that fundamentally alters planning procedures toward better considering ES and their values in decisions.

The authors also acknowledge that it is not yet clear if investing more resources in acquiring additional ecosystem services information will actually yield a better consideration of environmental aspects in planning (Albert et al., 2016, p 112). Burkhart et al. (2014) consider a typical (though hypothetical) European landscape, enabling them to elaborate the ecosystem services into eleven regulating services, fourteen provisioning services, and six cultural services, as listed in Table 2.2.

Table 2.2 Ecosystem services applicable to a typical European landscape (Burkhart et al., 2014)

Regulating services	**Provisioning services**	**Cultural services**
Global climate regulation Local climate regulation Air quality regulation Water flow regulation Water purification Nutrient regulation Erosion regulation Natural hazard regulation Pollination Pest and disease control Regulation of waste	Crops Biomass for energy Fodder Livestock (domestic) Fibre Timber Wood Fuel Fish, seafood and edible algae Aquaculture Wild foods and resources Biochemicals and medicine Freshwater Mineral resources* Abiotic energy sources*	Recreation and tourism Landscape aesthetics and inspiration Knowledge systems Religious and spiritual experience Cultural heritage and cultural diversity Natural heritage and natural diversity * Abiotic outputs from natural systems (after CICES); often not acknowledged as ecosystem services, but of high relevance for policy decisions and land use/resource management.

The authors use a matrix in their analysis to evaluate these possible ecosystem services for each of 44 land cover types or classes, as listed in Table 2.3.

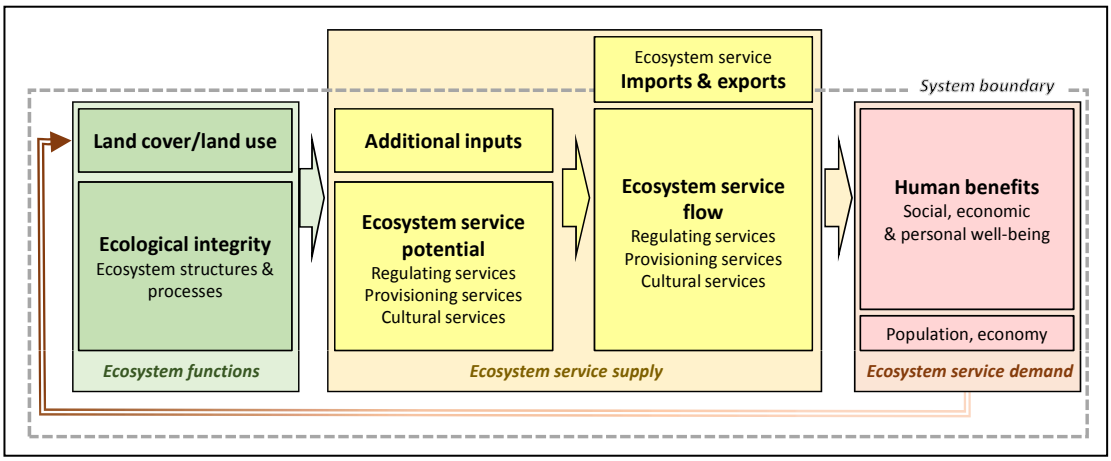
Table 2.3: **Land cover types applicable to a typical European landscape** (Burkhart et al., 2014)

Land cover		
Continuous urban fabric Discontinuous urban fabric Industrial or commercial units Road and rail networks Port areas Airports Mineral extraction sites Dump sites Construction sites Green urban areas Sport and leisure facilities Non-irrigated arable land Permanently irrigated land Ricefields Vineyards	Fruit trees and berries Olive groves Pastures Annual and permanent crops Complex cultivation patterns Agriculture & natural vegetation Agro-forestry areas Broad-leaved forest Coniferous forest Mixed forest Natural grassland Moors and heathland Sclerophyllous vegetation Transitional woodland shrub	Beaches, dunes and sand plains Bare rock Sparsely vegetated areas Burnt areas Glaciers and perpetual snow Inland marshes Peatbogs Salt marshes Salines Intertidal flats Water courses Water bodies Coastal lagoons Estuaries Sea and ocean

From this understanding of the landscape, Burkhart et al. (2014), like Albert et al. (2016), recognise specific characteristics in ecosystem services. They distinguish between *potential* ecosystem services and the actual *flows* of ecosystem services, they identify ecosystem service *demand*, and they first consider *ecosystem functions*, as indicated in Figure 2.2.

Figure 2.2 Conceptual model that relates to the DPSIR framework and integrates the concepts of ecosystem functions, ecosystem service supply (distinguishing between potential and flow) and ecosystem service demand.

Source: Burkhard, B. et al. 'Ecosystem Service Potentials, Flows and Demands – Concepts for Spatial Localisation, Indication and Quantification', Landscape Online Volume 34, pages 1-32, 2014, page 6.



The spatial application of these concepts calls for the mapping of both service providing units and service benefiting areas. The former includes the total collection of organisms, their abundance, phenology, distribution and trait attributes required to deliver certain ecosystem services as well as abiotic components (water bodies, soil units) hosting the service supplying ecosystems. The service benefiting areas are complementary to service providing units, but in contrast they do not relate primarily to ecosystems or geobiophysical units but to beneficiaries such as urban areas or rural settlements, likely to be defined as administrative and/or planning units (Burkhart et al., 2016, pp 6-7).

In mapping the provision of ecosystem services, planners should identify service providing units or areas affected by related processes (floodplains, catchments). Hotspots (and coldspots as their opposite) of ecosystem service supply are special types of service providing units. They can be either small local point sources or larger sources within larger service providing units. Times of particularly high ecosystem service supply, for example due to seasonal variations, can be identified as hot moments. It is highly relevant for landscape management to identify spatial hotspots and temporal hot moments of ecosystem service supply and demand (Burkhart et al., 2016, pp 6-7).

In undertaking this mapping, while the demand side may be administrative and/or planning units, the supply of ecosystem services should be identified as ecosystems or natural areas, rather than administrative units, which often mark artificial system boundaries (Burkhart et al., 2014, p 6).

Burkhart et al. (2014) present a series of matrices in which ecosystem services are related to land cover types, all of them showing the conditions in Europe in summer prior to harvest. The matrices assign ecosystem services values to (i) potentials, (ii) flows, (iii) extent of utilisation (potential minus flow), (iv) level of demand (mainly generated by land cover types with human populations such as urban and agricultural areas) and (v) undersupply and oversupply (flow minus demand). This later analysis is essential if global supply-demand budgets are to be reduced to zero in the long-term and a continued depletion of natural capital is to be avoided. Table 2.4 presents extracts from the first two matrices, to show ecosystem services potentials and ecosystem services flows for a set of six related land cover types.

Table 2.4 An example of an evaluation in a hypothetical typical European landscape (in summer, before the harvest period), using a small sample of six related ecosystems

Source: Combined extracts from Figures 4 and 5 in Burkhard, B. et al. 'Ecosystem Service Potentials, Flows and Demands – Concepts for Spatial Localisation, Indication and Quantification', Landscape Online Volume 34, pages 1-32, 2014, pages 15-16.

		Regulating services	Global climate regulation	Local climate regulation	Air quality regulation	Water flow regulation	Water purification	Nutrient regulation	Erosion regulation	Natural hazard regulation	Pollination	Pest and disease control	Regulation of waste	**Provisioning services**	Crops	Biomass for energy	Fodder	Livestock (domestic)	Fibre	Timber	Wood Fuel	Fish, seafood and edible algae	Aquaculture	Wild foods and resources	Biochemicals and medicine	Freshwater	Mineral resources*	Abiotic energy sources*	**Cultural services**	Recreation and tourism	Landscape aesthetics and inspiration	Knowledge systems	Religious and spiritual experience	Cultural heritage and cultural diversity	Natural heritage and natural diversity
Ecosystem service **potential**	Ann + perm crops		1	2	1	1	0	1	2	1	1	2	2		4	2	4	1	5	0	0	0	0	1	1	0	0	2		1	1	2	0	3	0
	Comp cult patterns		1	2	1	1	0	1	1	1	2	3	2		4	2	2	1	4	0	1	0	0	1	2	0	0	1		2	2	2	0	3	0
	Ag & nat vegetation		2	3	2	2	2	2	2	1	2	3	2		3	3	2	2	4	1	1	0	0	2	1	0	0	1		2	2	3	1	3	3
	Agro-forestry areas		2	2	2	2	2	2	3	1	3	3	3		2	3	2	3	2	3	3	0	0	2	1	0	0	0		2	2	2	0	3	2
	Broad-leaved forest		5	5	5	3	5	5	5	4	4	4	4		0	1	1	0	1	5	5	0	0	5	3	0	0	0		5	5	5	3	4	5
	Coniferous forest		5	5	5	3	5	5	5	4	4	4	4		0	1	1	0	1	5	5	0	0	5	3	0	0	0		5	5	5	3	4	4
Ecosystem service **flow**	Ann + perm crops		1	2	1	2	0	2	2	1	2	2	2		0	0	0	0	0	0	0	0	0	0	0	0	0	0		1	1	1	0	2	0
	Comp cult patterns		1	2	1	2	0	2	1	1	3	3	2		0	0	1	0	0	0	0	0	0	0	1	0	0	0		2	2	1	0	2	0
	Ag & nat vegetation		1	3	2	2	1	2	2	1	2	3	2		0	0	1	0	1	0	1	0	0	0	1	0	0	1		2	2	2	1	2	1
	Agro-forestry areas		1	2	2	2	1	1	3	1	2	3	3		0	0	0	1	1	1	1	0	0	0	1	0	0	0		2	2	1	0	2	1
	Broad-leaved forest		4	5	5	3	4	5	5	3	1	4	4		0	1	1	0	1	1	1	0	0	1	1	0	0	0		4	4	4	2	2	4
	Coniferous forest		4	5	5	3	4	5	5	3	1	4	4		0	1	1	0	1	1	1	0	0	1	1	0	0	0		4	4	4	2	2	3

* Abiotic outputs from natural systems (after CICES); often not acknowledged as ecosystem services, but of high relevance for policy decisions and land use/resource management.

The relevant section on Step 3 in *Report Two: Technical Guidelines of UREMP* (Section 4.3) has an extended discussion of ecosystem services and related concepts, and describes techniques being used to identify and value ecosystem services. In the next section of this present report, the summary guideline for Module 3A, below, it is assumed that a minimum input for a UREMP Plan will be the mapping and assessment of ecosystems and landscapes, to the extent that time, resources and data allow.

The mapping and assessment of ecosystems and landscapes is a precondition for assessing and valuing ecosystem services, even if, as suggested above, 'no final solution for highly complex ecosystem service assessments has been found yet.'

While a solution for ecosystem service assessments is developed in the scientific institutions of the world, UREMP planners should adopt the following approach.

1 It is essential that ecosystem services considerations are prioritized at the beginning of a UREMP:
- After developing an understanding of the essential environment characteristics of the potential UREMP Area and agreeing to the composition of any UREMP Partnership and the precise boundaries of the UREMP Area (Step 1);
- and after establishing a mapping and data platform (Step 2);
- the UREMP planners must broadly identify the ecosystems that provision and regulate the environmental benefits received by human society, and provide cultural benefits.

2 In the long run, it is essential that UREMP planners:
- As a baseline, where data is available, document the *characteristics* of the UREMP Area, in the process drawing on, and revising, the findings in Step 1, and enabling the application of the DPSIR approach (see Figure 2.1, above).
- Document and map the *driving forces* affecting the environment (interests, motivations, market forces, regulations, traditional practices, etc.).
- Document and map the *pressures* on the environment (development and other pressures, such as urban expansion, infrastructure, vegetation clearing, mining, traffic, sealing of the surface, and pollution load, as initially identified in Step 1).
- Where data is available, document and map the *state* of the environment – values, sensitivity, vulnerability – for critical ecosystem services.
- Where data is available, assess the *impact* of the identified pressures on the identified ecosystem services.
- In all cases, broadly identify the *responses* that are necessary to reduce impacts and reverse the loss of ecosystem services.

3 As shown above, the theory, techniques and practice of valuing ecosystem services is on the cutting edge of science and practice. UREMP is a major (and globally significant) initiative to protect the environment, and must take advantage of environmental protection strategies that are simple, tested, and feasible. Initially, assessments may be constrained by unfamiliarity, and shortages of time, funding and data. Nevertheless, it is essential that this work begins, so that it can continue to improve and evolve with the institutionalisation of UREMP.

4 Steps 4, 5 and 6 take these initial investigations much further. Green Land takes a number of forms and each has its own challenges in relation to sustainability and the protection of ecosystem services (whether or not the ecosystem services have been accurately identified and valued). Step 4 is concerned with environmental protection related to Green Land, and applies the methods adopted and developed in the PRC. Likewise Step 5 is concerned with environmental protection related to water and applies the PRC's comprehensive standards and methods for managing water resources to UREMP. Step 6 applies the PRC's well established air monitoring and regulating systems to UREMP.

The relevant section on Step 3 in *Report Two: Technical Guidelines of UREMP* (Section 4.3) has an extended discussion of the present state of the art in understanding and protecting ecosystems services, and an exploration of the regulatory techniques available for Module 3A, Mapping and assessing ecosystems services.

Module 3A: Map and assess ecosystems and landscapes

Module 3A is a critical phase in the UREMP planning process when the entire UREMP Area is closely examined and understood.

During this Step the UREMP Area is studied and divided into at least two kinds of bio-geographic classifications, for *ecosystems* and for the *landscape*. The classification systems must be relevant to the specific region and to the ultimate purposes of (i) protecting ecosystems that threatened by development, and (ii) achieving protection through regulations implemented in local and provincial planning instruments.

Module 3A is a task for everyone in the UREMP team and for additional experts. It is essential that the classifications chosen for ecosystems and landscapes are agreed across disciplines and by planners and policy makers. The classifications will later determine the usefulness of the spatial division of the area into small units, and the usefulness of how those units are assessed and ranked.

The UREMP Area has already been divided into *bioregions* and *subregions*, in Step 1. Bioregions, and the subregions into which they are divided, cover all of the land of the UREMP Area. They may be relatively large areas, such as a coastal plain, a mountain range or a river basin. The will include within them the cities, towns, farms, ports and other human uses of the land. Understanding this underlying bio-geographic structure of the potential UREMP Area is essential for establishing a UREMP boundary that makes integrated and holistic management of the environment possible.

Now, in Module 3A, the distribution of specific *ecosystems* that are found in those bioregions are mapped and assessed. These ecosystems may be extensive, or they may be fragmented, or found in scattered areas. They may still represent much of what once existed, or they may be only remnant areas. They may be in good condition, or they may be disturbed and incomplete. Identifying these areas and assessing their state and therefore their significance is an essential step in their protection. The result is a series of maps and databases that map and assess the significant ecosystems, in patches, belts, fields, forests, rivers and water bodies, large and small.

The UREMP Area must also be understood in terms of land cover or landscape units, some extensive, some as small as single sites, according to a classification that is appropriate to the region and the context of the UREMP Plan. The classification focuses on broad land use and land cover, ecological function, value to humans and natural systems, visual qualities, etc., and the ultimate implementation of protection measures through provincial and local planning instruments. The landscape classes adopted for the UREMP Plan are primarily concerned with areas outside urban and developed areas: while all parts of the UREMP Area are included in one or more of the landscape classes, most of the detailed mapping is on the Green Land. The result is a series of maps and databases that map and assess the landscape attributes of the UREMP Area.

An ecosystem is usually defined as a complex of living organisms with their environment and their mutual relations. Although this definition applies to all hierarchical levels (from Earth's biomes down to a single water drop with its microorganisms), for the practical purposes of mapping and assessment, an ecosystem is here considered at the scale of habitat, site or biotope – as if the scales of the (vector) maps are from 1:100 000 up to 1:20 000.

A practical approach to the 'spatial delimitation of an ecosystem' is to build up a series of overlays of significant factors, mapping the location of discontinuities, such as in the distribution of organisms, the biophysical environment (soil types, drainage basins, depth in a water body), and spatial interactions (home ranges, migration patterns, fluxes of matter). A useful ecosystem boundary is the place where a

number of these relative discontinuities coincide. Ecosystems within each category share a suite of biological, climatic, and social factors that tend to differ across categories. These might include the following.

- species composition;
- surface cover in terrestrial ecosystems (type of vegetation) or water type in aquatic ecosystems (fresh water, brackish water, salt water);
- climatic conditions;
- geophysical conditions;
- dominant use by humans;
- resource management systems and institutions.

Generally, there is greater similarity *within* than *between* each ecosystem type in relation to the above factors.

Ecosystem mapping is the spatial delineation of ecosystems following an agreed ecosystem typology, which strongly depends on mapping purpose and scale. The mapping of related systems – land cover and landscape units – are carried out in Module 3A.

In the context of a UREMP Plan, the primary reason for mapping ecosystems is to provide a basis for assessing the status and health of ecosystems, for assessing the pressures on ecosystems, and for ranking the level of protection needed for ecosystems across the UREMP Area. The analysis then allows policy measures to be developed for protecting ecosystems already affected by, or threatened by, urban and other development.

One aspect of the status of an ecosystem is the extent of the loss of that ecosystem, compared to a baseline condition, at some time in the recent or more distant past. The *proportion* of an ecosystem that remains intact will depend on the size of the territory within which that ecosystem is represented: the whole country, an extensive region within the country, the UREMP Area, etc. An example of a method for assessing ecosystems is shown in Table 2.5.

Table 2.5 Assessing the status of an ecosystem (illustrative only)

Natural extent remaining	Status
80-100%	Least threatened
60-80%	Vulnerable
Above target	Endangered
Below target	Critical

The thresholds shown in Table 2.5 – 80%, 60% – should be based on the best available science. The threshold beyond which an ecosystem becomes critically endangered can vary significantly (for instance from 15% to 40%) depending on the ecosystem: the more species-rich the ecosystem, the higher the threshold. This lowest threshold is also known as the biodiversity target. It represents the minimum proportion of each ecosystem that should be included in protected areas.

Assessing an ecosystem may require monitoring specific indicators (for instance, water quality, biodiversity, erosion). Based on standardized sampling programs and/or expert opinion, the indicators may be given qualitative scores on an ordinal scale of 1 (poor) to 5 (good), offering a profile related to the condition or state of the ecosystem, either regionally or in specific subareas (Table 2.6).

Table 2.6 Assessing the state of an ecosystem (illustrative only)

	Year 1	Year 2	Year 3	Year 4…
Indicator A	[Score 1-5]	[Score 1-5]	[Score 1-5]	
Indicator B	[Score 1-5]	[Score 1-5]	[Score 1-5]	
Indicator C	[Score 1-5]	[Score 1-5]	[Score 1-5]	
Indicator D	[Score 1-5]	[Score 1-5]	[Score 1-5]	
Indicator E	[Score 1-5]	[Score 1-5]	[Score 1-5]	

A landscape is a mosaic of areas that have relatively homogeneous characteristics internally, and differ from the characteristics of their surroundings. These areas, or landscape units, are used to stratify landscapes according to such measures as structure, function, value, rate and direction of change, and the interactions between units. While landscape units are usually shown on maps as having discrete boundaries – collectively making up the entire landscape – the transition from one unit to a neighbouring unit can be gradual and indistinct (in which case a gradient threshold can be set to mark the border between the two units). The size of a landscape unit can vary from a farm or a forest or a town down to a single site. For the practical purposes of UREMP mapping and assessment, landscape units are classified and defined as if the scales of the (vector) maps are from 1:100 000 up to 1:20 000.

The predominant vegetation or biology of the land is often classified as a type of land cover. The top level of a land cover classification might include the following categories.

- woodland and forest
- heathland and shrub
- grassland
- cropland
- sparsely vegetated land
- construction land
- wasteland
- wetlands
- river and lake
- marine

Alongside such a classification, landscape units may be classified according to their functions and relationships. Such a classification might include the following categories at the highest levels.

- geology and geomorphology
- soils (types, soil landscapes, specific attributes, etc)
- habitats (types, connectivity, etc)
- water (sources, retention, etc)
- air (qualities, composition, flows, etc)
- climate regulation
- visual landscape (landscape character, impairments, vistas, etc)

The outputs of Module 3A take a number of forms. There are one or more maps in the GIS showing a large number of spatial units corresponding to specific ecosystems. Each ecosystem is likely to be divided into subareas depending on the *status* and *state* of that subarea of the ecosystem, on the *pressures* to which that subarea is subject, on the ranking of the significance of the subarea, and on the measures (the *response*) that are needed to protect the subarea. There are also one or more maps in the GIS showing a large number of defined areas corresponding to landscape units and areas with specific values.

The boundaries of these defined spatial units are likely to follow natural systems, such as watercourses, ridgelines, wetlands, and forest edges. If these boundaries can be merged with human-use boundaries such as those of infrastructure, land parcels, institutions or regulatory zones, the implementation of policies and controls will be facilitated.

For all of these areas there is a database with information on the attributes, values, significance and ranking of each of those areas, the reasons for the ranking of the area, and the policy measures that are appropriate to protect the area's values.

Module 3B: Indicative ecosystems protection zoning and mapping

The **output** of Module 3B is the first of the series of *indicative zoning maps* showing red, yellow and green lines (zones). This map, and the others from Steps 4, 5, 6 and 7, are called 'indicative' because they each show these protection zones in relation to a single set of parameters. At this stage, the indicative protection zones show a ranking, and a set of policy measures, that need to be reconciled and negotiated before they can be integrated into the final UREMP protection zoning map that is the output from Step 8.

Within Module 3B, the same reconciliation and negotiation needs to take place to integrate the outputs of Module 3A. This is a task that needs to involve the whole UREMP team, since decisions are being made about values, ranking, priorities and regulations. It also should involve representative of neighbouring UREMP teams (if neighbouring teams exist) or alternatively representatives of neighbouring provinces and local governments, since natural systems exist (and need protection) on both sides of all UREMP boundaries.

When the layers of spatial information from Module 3A are combined to produce a new set of defined areas zoned red, yellow and green, the data underlying the ranking of each area needs to remain associated with that area. In other words, red, yellow and green protection zones are not uniform. They comprise many sub-areas based on competing values and competing policy responses, which must be capable of being explained and justified. Likewise, being zoned red, yellow or green does not carry with it a single set of opportunities and constraints. Any subarea of these zones may be subject to a set of regulations that are specific to that subarea, and that must be capable of being explained and justified.

The output of Module 3B is an indicative ecosystems protection zoning map and databases relating to ecosystems and landscape units in the UREMP Area. This becomes critical input to the preparation of the UREMP integrated environmental protection zoning map in Step 8.

2.4.1. Example: Ecological functions of the Yichang administrative area

At a high level and large scale, the Yichang administrative area performs the following nationally-significant functions: as an important nodal region, Yichang functions to maintain the ecological conditions of the Yangtze River basin; as a transitional zone from the Qinling and Dabashan Mountains to the Jianghan Plain, Yichang is a typical example of a complex ecological environment with strong environmental sensitivity; Yichang plays an important role in guaranteeing ecological environmental security of the Three Gorges Reservoir Region and western areas of Hubei Province; Yichang functions as a gene bank to preserve certain endangered species of China; and Yichang is a crucial area to protect species abundance, safeguarding national species security. An overview of the Yichang UREMP Plan is given in Chapter 4 of this report.

The Yichang UREMP Plan is described in detail in *Report Four: Domestic Pilots and International Best Practice Cases of UREMP*.

2.4.2. Example: Valuing environmental services in Xiamen

In Xiamen, digital maps were used to define (i) a forest ecosystem divided into "general woodlands" (including general forests, timber forests, shrubberies, open forests, small area woodlands, and scenic beauty forests) and "economic forests" (orchards, tea plantations, etc.); (ii) a grassland ecosystem

(including grasslands, nursery gardens, flower beds, cities, other types of green space, farms, forest farms, and pastures); (iii) a farmland ecosystem (irrigable lands, dry lands, economical crop lands, vegetable fields, etc.) and (iv) a wetlands ecosystem (shallow water areas, tidal flats, estuarine waters, river systems, ponds, etc.). For each type, there was an estimate of its economic value, both direct (value of production) and indirect, including the value of water conservation, soil conservation and cultivation, carbon sequestration and oxygen production, and air purification. For these indirect economic services, various quantitative calculations were used to generate an index scale for each (generally as a function of the distance from the city) to enable combined high-to-low values to be mapped. As a broad finding, the environmental planners concluded that the highest priority is to strengthen wetland protection and planning in Maluan Bay and other seriously polluted areas that impact on the urban ecological balance.

A description of the Xiamen projects is given in *Report Two: Technical Guidelines of UREMP*.

2.4.3. Example: Ecological Function Zoning in Xiamen

For the coastal areas and neighbouring sea areas of Xiamen, the Arcview platform was used to map natural, economic and social characteristics, and then rank them according to certain standards, to produce a combined five-level scale of ecological suitability. The whole of Xiamen was assessed for environmental sensitivity, and as a result divided into three levels of suitability for development: suitable, basically suitable, and unsuitable. Areas for environmental protection were divided into three zones: ecological management and protection districts, ecological buffer zones, and ecological reconstruction areas. By considering ecological vulnerability, ecological service values, and the existing ecological function zoning, 36 ecological function zones were defined: three at the first level, eight at the second level, and 25 at the third level.

A description of the Xiamen projects is given in *Report Two: Technical Guidelines of UREMP*.

2.4.4. Example: Defining the landscape ecological security pattern of Xiamen

The extensive forest and sea areas of Xiamen provide existing and potential sources of native species diffusion and maintenance, and provide stability to the entire ecosystem. The evaporation characteristics of the forests were mapped by estimating the atmospheric surface resistance. Buffer areas (orchards and farmlands around forest areas, and urban to rural transitional areas) and radiating strips (for instance along ridges) were mapped. Since corridors connecting forest sources provide stability to the ecological system, places such as valleys and other potential channels for ecological flows were mapped. By combining these maps and giving comprehensive consideration to the landscape of Xiamen, the security pattern was mapped as “one nucleus, four areas, eight groups, three corridors, seven ecological isolation belts and ten landscape strategic points.”

A description of the Xiamen projects is given in *Report Two: Technical Guidelines of UREMP*.

2.5. Step 4: Prepare an Indicative Zoning Map for Green Land Protection

Module 4A: Identify and map forest priority areas

“Forest areas” include not only woodlands and areas with trees but also areas with bamboos or shrubs and coastal areas with mangroves, and may include slashes where these plants have been harvested or cleared. For the purposes of UREMP the term excludes green space inside urban areas, forests within the range of railway or highway construction, and forests that have been planted or retained to protect the dikes of rivers and canals.

Forest areas provide many environmental, social and economic benefits beyond the production of forest products and the provision of habitat, including the absorption of pollutants and carbon dioxide, the

production of oxygen, the regulation of water, and recreational contact with nature. The objectives of Module 4A are to identify and map the type, diversity, character, ecosystem values and landscape characteristics of forests in the UREMP Area.

This begins with the mapping of these attributes, and many more, in forest lands. Methods include the following.

- Sample plot surveys are carried out to measure species abundance, frequency, shade density, coverage, and structure/growth form. Using the conventional sample plot method to measure coenology ("plant sociology") it is possible to quantify these variables across the UREMP Area.
- Data on rainfall, slope/terrain, soils, etc., are used to assess the ecosystem value of the forest areas in reducing erosion.
- Characteristics of the soil, vegetative cover, rainfall and wind conditions are used to measure the value of the forest areas in reducing sand loss through wind-blown erosion.
- A water flow decomposition model based on precipitation and evapotranspiration can be used to estimate the level of water conservation (water source regulation) and thus the regulation of surface flow, provision of groundwater, mitigation of seasonal fluctuations in river flows, reduction of flooding and protection of water quality.

These and/or other measures are assessed, ranked and combined, using both rules and expert judgement, to obtain an integrated assessment of the forest areas of the UREMP Area.

Thus the **outputs** from Module 4A are maps analysing the ecosystem values of discrete, mapped forest locations across the UREMP Area, with databases in the GIS relating to the significance, values and ranking of each location, and the policy measures that are appropriate to protect the location's values. These maps have immediate and direct implications for the red, yellow and green lines of the Green Land zoning and protection map produced in Module 4F.

Module 4B: Identify and map agricultural priority areas

Agricultural priority areas include cultivated fields (long-cultivated, newly-developed, reclaimed, consolidated, and fields in fallow rotation); vegetable crops interplanted with fruit trees, mulberry trees or other kinds of trees; and crops on cultivated beach land and tidal marsh where there is an annual harvest. Agricultural priority areas include fixed ditches, channels, roads and ridges whose width is less than 1.0 meter in south China and 2.0 meters in North China, as well as land for temporary planting of herbal drugs, grass sod, flowers, seedling, etc.

Agriculture – whether for grain, fiber, fruit, vegetable, flower, poultry, fish or livestock production – provides substantial environmental, social and economic benefits, and food security, and at the same time may lead to pollution of air, water and soils.

This Module has the following aims.

- Identify, map and assess the benefits and the environmental effects of agriculture across the UREMP Area and beyond.
- Provide policy advice applying to different types of agricultural priority areas, to maximise the benefits, to optimise the environmental effects, and to enable decisions about land allocation and development controls to be based on long-term, holistic strategies.

The benefits of agricultural production can be estimated from the current prices of agricultural products, or the mean prices of recent years. The positive and negative environmental effects of agriculture on soils, water and air can be estimated by calculating the full market costs of rehabilitating the land. When this is

not feasible, a systematic process using experts and appraisers can arrive at an estimate of the cost of rehabilitation.

The **outputs** from Module 4B are maps of agricultural locations across and beyond the UREMP Area, with databases in the GIS relating to the significance, values and ranking of each location, and the policy measures that are appropriate to protect the location's values. These maps have immediate and direct implications for the red, yellow and green lines of the Green Land zoning and protection map produced in Module 4F.

Module 4C: Identify and map mineral resource priority areas

Mineral resources may include both high-value ores and essential low-value material such as rock and sand. Extracting these resources may create extensive waste around the operation and may generate positive and negative externalities. Thus the objectives of this module are to assess and map the presence of mineral resources in and beyond the UREMP Area, to estimate the future economic values of the resources, to estimate the scale of externalities now and in the future, and to identify opportunities to protect non-urban Green Land, either by avoiding the negative effects of mining, or by maximising some of the positive effects of mining (for example, buffer zones, screening, rehabilitation, environmental offsets, and eco-compensation).

Indicators of mineral resource externalities include the following:

- reserve-production ratio (%)
- rate of recovery (%)
- ore dressing recovery rate
- mineral resource integrated utilization efficiency (ton/10,000 yuan)

GIS technology is adopted to analyze each indicator in the mineral resource locations, and the results are combined, using both rules and expert judgement, into integrated externality indicators for each location.

The **outputs** from Module 4C are maps of mineral resource locations across the UREMP Area, with databases in the GIS relating to the opportunities to protect non-urban Green Land from, or with, mining activity. These maps have immediate and direct implications for the red, yellow and green lines of the Green Land zoning and protection map produced in Module 4F.

Module 4D: Identify and map soil conservation areas

Valuable soils disappear under urban development, but just as significantly valuable soils are lost due to contamination, erosion, salinization, desertification and similar processes of overuse and neglect. Such processes can be reversed if the soils are highly valued. Accordingly, the objectives of Module 4D are as follows.

- To assess and map the locations where soils are being lost and at risk of erosion, salinization, desertification or other destructive processes, in the UREMP Area and beyond.
- To provide comprehensive and credible input to planning decisions about the directions and nature of urban development and the distribution of land uses in the UREMP Area, so that high-value soil areas are fully protected from urban development, urban sprawl and overdevelopment.

The sensitivity of soils to various destructive processes can be estimated by calculating indexes of sensitivity, including the following examples.

- soil erosion sensitivity index (based on assigning an R value for rainfall erosivity, assessing the soil texture, calculating the degree of topographic relief (waviness), assessing the surface conditions (vegetation cover));
- soil salinisation sensitivity index (based on humidity, wind patterns, soil texture and vegetation cover);
- soil desertification sensitivity index (based on soil type, soil thickness and vegetation cover).

GIS technology is adopted for analyzing the sensitivity of individual impact factors. The impact factors are overlaid and integrated according to certain rules, to generate an integrated sensitivity distribution map. Sensitivity levels are assessed and zoned, and these areas can be divided into different levels.

The **outputs** from Module 4D are maps of locations of significant soils being destroyed or at risk, across the UREMP Area, with databases in the GIS relating to the significance, values and ranking of each location, and the policy measures that are appropriate to protect the location's values. These maps have immediate and direct implications for the red, yellow and green lines of the Green Land zoning and protection map produced in Module 4F.

Module 4E: Identify and map priority hazardous areas

Some areas of Green Land are constrained by being prone to earthquake, volcanic eruption, landslip, mudslide, rockfall, inundation, subsidence, and other hazards, including human-made hazards. The objective of Module 4E is to identify, map and assess such locations across the UREMP Area and beyond.

Natural hazards (including those listed above) and human-made hazards (such as those resulting from excavations, infrastructure, and mining) can threaten the values of Green Land. In some situations, hazards of these kinds can also serve to protect Green Land, by making urban and other forms of development costly or impossible. These positive and negative impacts on Green Land are included in the mapping and analysis.

Natural disaster risk assessment is a complicated and difficult process as the causes of quite a few natural disasters are still unknown. In such cases, an advisable practice is to grade natural disasters and consequences by risk and vulnerability. The most common approach is to grade the *probability*, from 'minimal' to 'very likely' (sometimes from 'rare' to 'certain'), and to grade the *severity* of the impact from 'low' to 'high' (sometimes from 'negligible' to 'catastrophic'). This approach is illustrated in Table 2.7, and can contribute to the ranking and management of hazardous locations.

Table 2.7 Risk matrix (illustrative only)

			Severity of consequences			
			Low	Relatively low	Medium	High
			4	3	2	1
Probability	Minimal	4	**16**	**12**	**8**	**4**
	Unlikely	3	**12**	**9**	**6**	**3**
	Likely	2	**8**	**6**	**4**	**2**
	Very likely	1	**4**	**3**	**2**	**1**

The **outputs** from Module 4E are maps of hazardous locations across the UREMP Area, with databases in the GIS relating to the nature of the hazard, the probability, the potential severity of the consequences, the risk level and ranking of each location, the negative and positive impacts on significant Green Land,

and the policy measures that are appropriate to manage the risk and/or to protect Green Land. These maps have immediate and direct implications for the red, yellow and green lines of the Green Land zoning and protection map produced in Module 4F.

Module 4F: Indicative Green Land protection zoning and mapping

The output of Module 4F continues the series of *indicative zoning maps* showing red, yellow and green lines that began with the output of Module 3E.

The map produced in Module 4F, like the others from Steps 3, 5, 6 and 7, is called 'indicative' because it shows protection zones in relation to a single set of parameters, in this case relating to Green Land. The Green Land protection zones show a ranking, and a set of policy measures, that need to be reconciled and negotiated before they can be integrated into the final UREMP protection zoning map that is the output from Step 8.

Within Module 4F, the same reconciliation and negotiation needs to take place to integrate the outputs of Modules 4A, 4B, 4C, 4D and 4E. This is a task that needs to involve the whole UREMP team, since decisions are being made about values, ranking, priorities and regulations. It also should involve representatives of neighbouring UREMP teams (if neighbouring teams exist) or alternatively representatives of neighbouring provinces and local governments, since natural systems exist (and need protection) on both sides of all UREMP boundaries.

When the five collections of spatial data from Modules 4A, 4B, 4C, 4D and 4E are overlaid and combined, to produce a new set of defined areas zoned red, yellow and green, the data underlying the ranking of each area needs to remain associated with that area. In other words, red, yellow and green protection zones are not uniform. They comprise many sub-areas based on competing values and competing policy responses, which must be capable of being explained and justified. Likewise, being zoned red, yellow or green does not carry with it a single set of opportunities and constraints. Any sub-area of these zones may be subject to a set of regulations that are specific to that sub-area, and that must be capable of being explained and justified.

The output of Module 4F is an indicative Green Land protection zoning map and databases relating to specific types of Green Land in the UREMP Area. This becomes critical input to the preparation of the UREMP integrated environmental protection zoning map in Step 8.

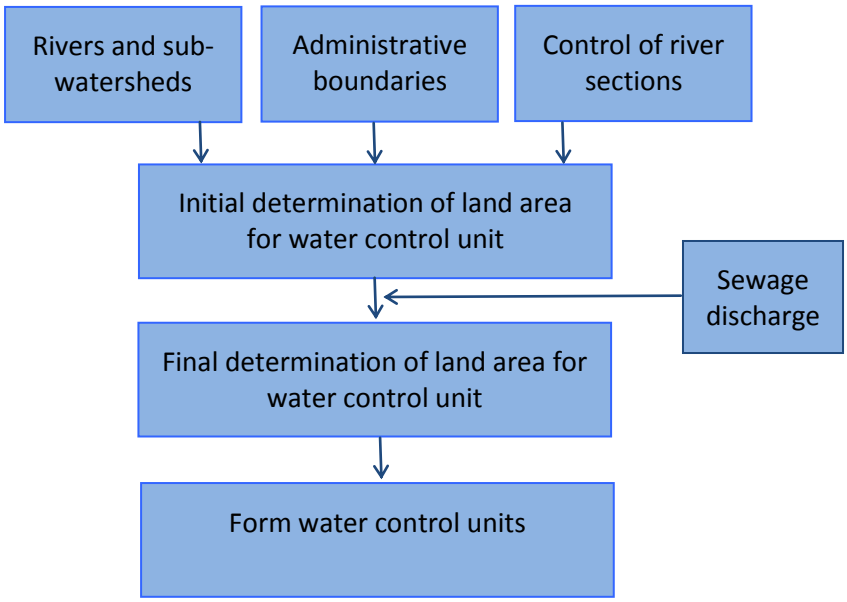
2.6. Step 5: Prepare an Indicative Zoning Map for Water Quality Protection

Module 5A: Determine the scope of the water environment and spatial control units

In managing and protecting the water environment and water resources, the spatial unit equivalent to ecosystem (or landscape unit, or forest) is the *water control unit*. Dividing the UREMP Area (and beyond) into water control units is based on the following principles.

- Spatial units should reflect the functional requirements of water conservation areas and special species protection.
- Spatial units should correspond to natural water systems, so that the natural catchment characteristics and the artificial pipe network should determine their scope.
- Spatial units should facilitate management feasibility and operability. Considering that the county is the grassroots administrative unit for environmental data survey and statistics, water control units should consist of a county or a group of counties.

Figure 2.3 Delineating the water control units



The outputs of Module 5A are maps and databases in the GIS defining the water control units, describing their characteristics and explaining the reasons for the chosen boundaries. As an example, the water control units of Guangzhou are shown in Map 2.1.

Map 2.1 Water control units in Guangzhou

Module 5B: Develop surface water quality models

One-dimensional (linear) and two-dimensional (areal) water quality models can be adopted in the measurement and calculation of environmental capacity, with uneven coefficients introduced to rectify the measurement and calculation of water environmental capacity. For cities with insufficient data, the runoff volume method can be used for evaluation and calculation of water environmental capacity.

The findings from practical exploration are that different evaluation units and calculation methods can be adopted, based on the availability of data and the characteristics of the urban water environment. This was the case in the pilot cities, as shown in Table 2.8.

Table 2.8 Control units and calculation methods in four pilot cities

	Fuzhou	Yichang	Guangzhou	Weihai
Evaluation scope	16 control units (combining water-collecting area and functional area of water environment)	375 control units (combining water-collecting area and functional area of water environment)	120 control units (combining water-collecting area and functional area of water environment)	43 reaches (combining water environment functional area of main rivers and actually monitored sections)
Foothold	Control unit	Control unit	Control unit	Reach
Measurement and calculation method for environmental capacity	1D model and 2D model based on classification, and uneven coefficient was introduced for correction.	Runoff volume method	1D model and 2D model based on classification	Runoff volume method
Measurement and calculation method for pollution load	Non-point source: experience coefficient method; Point sources: investigation and statistical method	Area pollution source: experience coefficient method; Point sources: investigation and statistical method	Area pollution source: experience coefficient method; Point sources: investigation and statistical method, to each pollution outlet	Area pollution source: experience coefficient method; Point sources: investigation and statistical method

Module 5C: Assess priorities for protecting rivers, lakes, wetlands and reservoirs

Module 5C begins with an assessment of the sensitivity of surface water environment function zones and control units. Sensitivity varies from high (for instance, rare species protection areas, fish spawning areas and other nature reserves, forest parks and other important habitats protection areas, water sources and swimming areas), are used to moderate (for instance, fisheries), to general (for instance, industrial and agricultural water bodies, and recreational landscapes).

A critical issue is the absorptive (or load bearing) capacity of these waters. At present, there is no unified and mature research method for estimating the absorptive capacity of a water resource. Domestic research methods mainly include the background analysis method (limited to the static history background), the conventional trend method (ignores the correlation between the load bearing factors), the comprehensive evaluation of indicators (a convenient method for preliminary comprehensive evaluation), the systematic analysis method, the system dynamics method and the multi-objective decision making method.

The **outputs** from Module 5C are maps of water function zones and water control units and specific locations within these units, with databases in the GIS relating to the significance, sensitivity, absorptive capacity and ranking of each location, and the policy measures that are appropriate to protect the location's values. These maps have immediate and direct implications for the red, yellow and green lines of the Green Land zoning and protection map produced in Module 5G.

Module 5D: Assess priorities for flood risk management

An index of the importance of flood risk management can be calculated from data on precipitation, the size of the water body relative to the control unit, the maximum water level, the minimum water level, and the elevation of the control unit.

The **outputs** from Module 5D are maps of water control units and specific locations within these units, with databases in the GIS relating to the risk of flooding and the policy measures that are appropriate to

manage the risk. These maps have immediate and direct implications for the red, yellow and green lines of the Green Land zoning and protection map produced in Module 5G.

Module 5E: Assess priorities for water source protection

An assessment is made of the significance and importance of the different types of water bodies in the water environment function zones across and beyond the UREMP Area. This enables priorities to be established, primarily through expert evaluations.

The **outputs** from Module 5E are maps of water function zones and specific locations within them, with databases in the GIS relating to the importance of protecting the water quality at each location, and the policy measures that are appropriate to achieve this. These maps have immediate and direct implications for the red, yellow and green lines of the Green Land zoning and protection map produced in Module 5G.

Module 5F: Assess priorities for the protection of riparian and coastal areas

An assessment is made of the priority areas for protecting river banks and riparian vegetation, based on domestic and international empirical data on the minimum widths for sustaining riparian vegetation. By combining this data with the nature of the riparian water environment function zone, the water quality objectives and the rate of soil erosion, the fragility of the riparian environments can be mapped, assessed and ranked. The fragility of coastal areas can be assessed by measuring the effects, over many years, of sea level rise and storm surges, and specifically the width of the erosion zone.

The **outputs** from Module 5F are maps of specific locations where the riparian and coastal environment is fragile, with databases in the GIS relating to the significance, fragility and ranking of each location, and the policy measures that are appropriate to protect the location's values. These maps have immediate and direct implications for the red, yellow and green lines of the Green Land zoning and protection map produced in Module 5G.

Module 5G: Indicative water quality protection zoning and mapping

The output of Module 5G continues the series of *indicative zoning maps* showing red, yellow and green lines that began with the output of Module 3E.

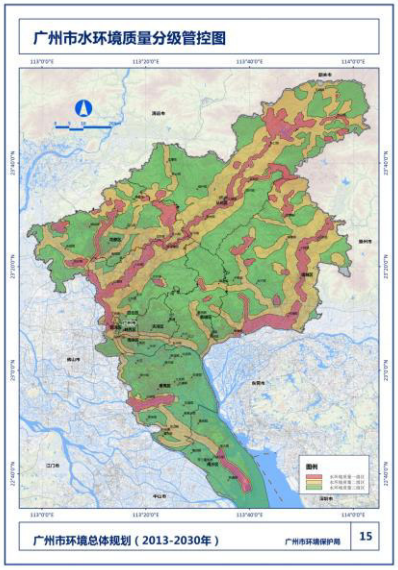
The map produced in Module 5G, like the others from Steps 3, 4, 6 and 7, is called 'indicative' because it shows protection zones in relation to a single set of parameters, in this case relating to water conservation and quality. The water priority areas show a ranking, and a set of policy measures, that need to be reconciled and negotiated before they can be integrated into the final UREMP protection zoning map that is the output from Step 8.

Within Module 5G, the same reconciliation and negotiation needs to take place to integrate the outputs of Modules 5A, 5B, 5C, 5D, 5E and 5F. This is a task that needs to involve the whole UREMP team, since decisions are being made about values, ranking, priorities and regulations. It also should involve representatives of neighbouring UREMP teams (if neighbouring teams exist) or alternatively representatives of neighbouring provinces and local governments, since natural systems exist (and need protection) on both sides of all UREMP boundaries.

When the five collections of spatial data from Modules 5A, 5B, 5C, 5D, 5E and 5F are overlaid and combined, to produce a new set of defined areas zoned red, yellow and green, the data underlying the ranking of each area needs to remain associated with that area. In other words, red, yellow and green protection zones are not uniform. They comprise many sub-areas based on competing values and competing policy responses, which must be capable of being explained and justified. Likewise, being

zoned red, yellow or green does not carry with it a single set of opportunities and constraints. Any sub-area of these zones may be subject to a set of regulations that are specific to that sub-area, and that must be capable of being explained and justified. An example of red, yellow and green lines for protecting water quality is shown in Map 2.2.

Map 2.2 Environmental protection zoning for water quality in Guangzhou



The output of Module 5G is an indicative water protection zoning map and databases relating to specific water environments in the UREMP Area. This becomes critical input to the preparation of the UREMP integrated environmental protection zoning map in Step 8.

2.6.1. Example: Approaches used in estimating absorptive/load bearing capacity for water

The UREMP pilot cities used slightly different approaches in estimating the absorptive (or load bearing) capacity of the water environment – see Module 5C above. The approaches and methods are summarised in Table 2.9.

Table 2.9 Approaches to estimating absorptive capacity used by four pilot cities

	Fuzhou	Yichang	Guangzhou	Weihai
Scope	Whole city	Whole city	Whole city	Whole city
Approach	Analysis on balance of water supply	Analysis on balance of water supply	Analysis on balance of water supply	Analysis on balance of water supply
Evaluation methods	A multi-objective indicator system for carrying capacity of water resources was established, and it combines the indicator evaluation and analytic hierarchy process.	Based on average quantity of water resources in many years of all districts and counties, population bearing capacity of water resources was calculated	Quantitative calculation of gap between the water resource capacity and the actual water consumption	Quantitative calculation of gap between the water resource capacity and the actual water consumption
Calculation results	Carrying capacity index of water resources of all districts and counties	Limit population for bearing capacity of water resources of all districts and counties	Gaps of water resource capacity and water demand of all districts and counties	Gaps of water resource capacity and water demand of all districts and counties
Policy direction	Advice for water resource allocation	Strictly implement management of red lines for development and utilization of water resource and the utilization efficiency of water resource; carry out industrial restructuring based on water consumption characteristics of industry.	Plan for water resource prediction and allocation	Guidance on red lines for development and utilization of water resource and the goal of utilization efficiency of water resource; guidance for industrial restructuring

An overview of the UREMP Plans for Fuzhou, Yichang, Guangzhou and Weihai is given in Chapter 4 of this report.

The UREMP Plans for Fuzhou, Yichang, Guangzhou and Weihai are described in detail in *Report Four: Domestic Pilots and International Best Practice Cases of UREMP*.

2.6.2. Example: From absorptive capacity to targets and controls in Fuzhou

The Fuzhou UREMP planners determined that measuring runoff volumes requires relatively little data compared with calculations based on cross sections, and can directly give an efficient estimate of the total capacity of the entire water system. All sub-watersheds were classified as saturated (pollution discharge is 1.5 times the absorptive capacity), balanced (discharge is between 0.8 and 1.5 times the capacity) and surplus (up to 0.8 times the capacity). Management measures included changing the guidelines for regulating industrial establishments, with new policies in overloaded areas for (i) replacing small units with large ones, (ii) substituting materials with less polluting materials, and (iii) reducing pollution by "replacing project with half pollution". Management measures also included setting new targets: in overloaded areas, the discharge of pollutants is to be halved by 2020; in these areas and in balanced areas, the discharge of pollutants should be limited to 90% of the absorptive capacity; and in other areas, in principle, the discharge of pollutants should not increase above present levels. In these ways, targets were set for all watersheds for 2020 and 2030. An overview of the Fuzhou UREMP is given in Chapter 4 of this report. It is described in detail in *Report Four: Domestic Pilots and International Best Practice Cases of UREMP*.

2.7. Step 6: Prepare an Indicative Zoning Map for Air Quality Protection

The intense use of energy in urban areas – for transport, heating, cooling, lighting, communication, infrastructure, etc. – adds to the air pollution generated by manufacturing and processing industries and generated by intense uses of land including agriculture. At the same time, the loss of Green Land, including land used for agriculture, reduces the sinks for pollutants (capacity for absorption).

The analysis requires the study and modelling of the three-dimensional wind field across the UREMP Area and of course beyond it (since air pollutants are carried across jurisdictional boundaries), the topography, the sources of such gases as sulphur dioxide, nitrogen oxides and ozone, the sources of particulates that people might breathe, and the sensitivities of receptors (people and biosystems) affected by the pollutants. The results are modelled, combined and analysed on a grid across the area, generating cells with different degrees and types of air pollution, and different measures for managing emissions and controlling development.

Module 6A: Assess priorities for microclimate protection areas

Pollutants are concentrated in areas of high emissions and/or low capacity for absorption or clearance (areas of air pollution fragility), such as valleys. The first step in managing urban expansion in order to protect air quality is to locate where air pollutants are concentrated. In Module 6A, these areas of fragility are mapped and assessed.

The **outputs** of Module 6A are maps and databases in the GIS defining the areas with high levels of sulphur dioxide, nitrogen oxides, ozone, respirable particulates, and other pollutants.

Module 6B: Develop a regional atmospheric flow model

To explain the observed concentration of air pollutants, it is necessary to simulate atmospheric conditions (in three dimensions) and to simulate the dispersion and transformation of pollutants, through the use of sophisticated models.

Chinese air quality experts use a number of international applications to generate these models based on data relating to wind, terrain, land use, and air composition and characteristics. The data is drawn from weather stations, air monitoring stations, land use information, etc. The spatial units can reflect administrative boundaries (for instance, counties) but more often the model is based on a 1 km by 1 km grid. (In more remote places the 1 km by 1 km cells may be aggregated into a 3 km by 3 km grid or a 9 km by 9 km grid.) A well-calibrated model based on good data can be used to accurately predict (i) levels of air pollutants across the UREMP Area and beyond in response to seasonal conditions and weather events, (ii) levels of air pollutants resulting from expanding urbanisation, industrial development and loss of Green Land, and (iii) improvements to be gained from emission reductions and additions to Green Land.

The pilot cities used slightly different approaches in applying atmospheric flow models, as shown in Table B2.6a. From this experience it is recommended (subject to practical considerations based on the quality of the data, the nature of air pollution and the urban scale) that the models CALPUFF and CMAQ should be used in combination, that the resolution should be a 1 km grid, and that the analysis should include sulphur dioxide, nitrogen oxides, ozone and fine particles with a diameter of 2.5 μm or less (SO_2, NO_X, O_3 and $PM_{2.5}$).

Table 2.10 Models and methods used in atmospheric analysis by four pilot cities

	Fuzhou	Yichang	Guangzhou	Weihai
Model	CALPUFF	CALPUFF	CMAQ	CALPUFF/CMAQ
Evaluation method	Concentration vulnerability, layout sensitivity and receptor importance	Concentration vulnerability, layout sensitivity and receptor importance	Concentration vulnerability, layout sensitivity and receptor importance	Concentration vulnerability, layout sensitivity and receptor importance
Evaluation accuracy	Concentration vulnerability: 3 km * 3 km; layout sensitivity: 3 km * 3 km	Concentration vulnerability: 3 km * 3 km; layout sensitivity: 3 km * 3 km	Concentration vulnerability: 1 km * 1 km; layout sensitivity: 3 km * 3 km	Concentration vulnerability: 1 km * 1 km; layout sensitivity: 3 km * 3 km
Evaluation object	SO_2	SO_2	NO_X $PM_{2.5}$ O_3	SO_2

Module 6C: Develop a regional pollution source model

The spatial distribution of areas most affected by air pollution, and the location of the sources of air pollution, are crucial inputs to measures to protect the environment. The places most sensitive to air pollution, whether densely populated urban areas or high-value Green Land that is susceptible, for instance, to acid rain, are mapped and assessed, using the 1 km by 1 km grid.

At the same time, data on the source and distribution of air pollutants is essential. Using the same grid, major emitters are identified, virtual sources are established in each grid, and the atmospheric and weather models are used to map the likely patterns of air pollution under different conditions.

Module 6D: Develop a regional atmospheric absorptive model

Taking the national class II air quality standards as the benchmark, formulae are calculated to relate levels of emission to the rates of compliance with the national standards. This can be utilised for estimating the

necessary atmospheric environmental capacity to achieve targeted compliance rates. From the experience of calculating atmospheric environmental capacity in the pilot cities, the use of the WRF-modified A-value method and multi-source simulation method of CMAQ model are recommended (see Section 2.6.1 below).

The **outputs** of Module 6D are maps and databases in the GIS that identify locations with critical, serious and medium levels of pollutants exceeding the atmosphere's environmental capacity, and the necessary policy measures, including stringent controls on emissions and development, to improve air quality.

Module 6E: Indicative air quality protection zoning and mapping

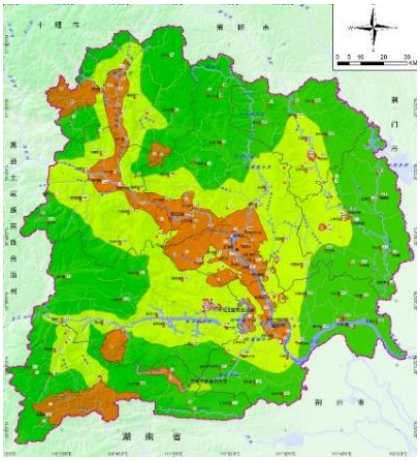
The output of Module 6E continues the series of *indicative zoning maps* showing red, yellow and green lines that began with the output of Module 3E.

The map produced in Module 6E, like the others from Steps 3, 4, 5 and 7, is called 'indicative' because it shows protection zones in relation to a single set of parameters, in this case relating to air quality. The air quality priority areas show a ranking, and a set of policy measures, that need to be reconciled and negotiated before they can be integrated into the final UREMP protection zoning map that is the output from Step 8.

Within Module 6E, the same reconciliation and negotiation needs to take place to integrate the outputs of Modules 6A, 6B, 6C and 6D. This is a task that needs to involve the whole UREMP team, since decisions are being made about values, ranking, priorities and regulations. It also should involve representatives of neighbouring UREMP teams (if neighbouring teams exist) or alternatively representatives of neighbouring provinces and local governments, since natural systems exist (and need protection) on both sides of all UREMP boundaries.

When the five collections of spatial data from Modules 6A, 6B, 6C and 6D are overlaid and combined, to produce a new set of defined areas zoned red, yellow and green, the data underlying the ranking of each area needs to remain associated with that area. In other words, red, yellow and green protection zones are not uniform. They comprise many sub-areas based on competing values and competing policy responses, which must be capable of being explained and justified. Likewise, being zoned red, yellow or green does not carry with it a single set of opportunities and constraints. Any sub-area of these zones may be subject to a set of regulations that are specific to that sub-area, and that must be capable of being explained and justified. An example of an air quality protection zoning map is shown in Map 2.3.

Map 2.3 Air quality protection zoning map for Yichang



The air quality protection zoning map for Yichang illustrates another critical aspect of the UREMP process for protecting Green Land. Some of the most serious areas of pollutant overload in Yichang are on the boundaries of the city, and may only be addressed through joint research, monitoring and action by neighbouring governments. This is best achieved by a UREMP partnership that effectively covers the extent of the natural systems that need to be protected and managed.

The **outputs** of Module 6E are an indicative air quality protection zoning map and databases relating to specific locations in the UREMP Area. This becomes critical input to the preparation of the UREMP integrated environmental protection zoning map in Step 8.

2.7.1. Example: Approaches used in estimating absorptive/load bearing capacity for air

The UREMP pilot cities used slightly different approaches in estimating the absorptive (or load bearing) capacity of the air environment – see Module 6D above. The approaches and methods are summarised in Table 2.11.

Table 2.11 Approaches to estimating air absorptive capacity used by four pilot cities

	Fuzhou	Yichang	Guangzhou	Weihai
Air model	CALPUFF	CALPUFF	CMAQ	CALPUFF/CMAQ
Meteorological model	WRF	WRF	MM5/WRF	WRF
Calculation method for environmental capacity and bearing rate	Use WRF-modified A-value method to calculate capacity and bearing rate of SO_2, NOX and PM_{10}	Use WRF-modified A-value method to calculate capacity and bearing rate of SO_2, NOX and PM_{10}	Use multi-source simulation method in CMAQ model to calculate capacity and bearing rate of NOX and $PM_{2.5}$	Use WRF-modified A-value method to calculate capacity and bearing rate of SO_2, NOX and PM_{10}; use multi-source simulation method of CMAQ model to calculate capacity and bearing rate of $PM_{2.5}$

An overview of the UREMP Plans for Fuzhou, Yichang, Guangzhou and Weihai is given in Chapter 4 of this report.

The UREMP Plans for Fuzhou, Yichang, Guangzhou and Weihai are described in detail in *Report Four: Domestic Pilots and International Best Practice Cases of UREMP*.

2.7.2. Example: Air quality protection zoning in Yichang

In formulating air quality protection policies for Yichang, the environmental planners first simulated the wind field for the whole administrative area of Yichang at a resolution of three kilometres, then used terrain data to simulate atmospheric flows at a resolution of one kilometre, emphasising wind directions and speed. The sensitivity of the spatial distribution of pollution sources was quantified using the CALPUFF model, to identify locations with higher affected scope and degree under equal pollution emission. The transmission and concentration of air pollution were quantified using the CALPUFF model, to identify locations where pollution was likely to be concentrated. Finally, the receptors were mapped in relation to land use and built-up areas, to estimate the affects on people's health. This spatial analysis enabled the planners to divide the whole administrative area of Yichang into red line, yellow line and green line zones. An overview of the Yichang UREMP Plan is given in Chapter 4 of this report.

The Yichang UREMP Plan is described in detail in *Report Four: Domestic Pilots and International Best Practice Cases of UREMP*.

2.8. Step 7: Prepare an Indicative Zoning Map for Ecosystems Restoration

The most important cause of species decline and extinction is habitat loss and urban and rural ecological degradation. Step 7 provides guidelines for arresting and reversing these processes. Effective measures range from large-scale landscape restoration, the revegetation of degraded habitats and the rehabilitation of river banks and water bodies, to enriching the biodiversity of urban green spaces and the decontamination of brownfield sites.

Step 7 comes at the end of series of UREMP processes which map and analyse locations in the UREMP Area and beyond, focusing on bioregions, ecosystems, landscapes, the condition of the land, the state of the water environment and the state of the atmosphere. Those investigations will have discovered locations where techniques of environmental restoration may be able to contribute significantly to environmental protection. In any event the findings of earlier investigations should be revisited to identify locations for landscape restoration, revegetation, rehabilitation, biodiversity enrichment and reuse of brownfield sites. In all cases, outcomes are enhanced if systematic steps are taken, including the following.

- Precise identification of the land and its boundaries, supported in the GIS with high resolution aerial photography and data on soils, topography, drainage and relevant aspects of the surrounding landscape.
- Identification of the ownership, control and management of the land and in some cases the surrounding land: all stakeholders need to understand the goals and methods proposed for the restoration program.
- Identification of the specific needs for restoration: the history of the uses of the site, the consequences of those uses, the potential outcomes of restoration, and the benefits of those outcomes (economic, cultural, aesthetic, educational, scientific, and ecological such as greater biodiversity, food chain support, and ecosystem services).
- Defining each restoration goal with a succinct and carefully crafted statement, to guide the program, to avoid conflicts of interest, and to be the basis for project evaluation.

Specific terms used in Step 7 include the following.

- **Urban and rural ecosystem restoration** is the assisted recovery of a degraded urban and rural ecosystem.
- **Habitat restoration** provides suitable environments and resources for a target species or group of species that are currently in decline due to past habitat clearance or degradation.
- **Brownfield sites** are sites previously used for commercial, industrial, transport and other purposes that are available for *reuse*, subject to the identification, containment and removal of contaminants and environmental hazards.

Module 7A: Identify and map the potential for habitat and biodiversity regeneration

Biodiversity is primarily sustained through the active protection and management of existing biodiverse areas. Biodiversity is also sustained through the active restoration of plant and wildlife communities in areas where biodiversity has been degraded or even lost. Amongst the most important areas for restoration are those that are close to, or form part of, or provide links between, areas of high environmental value, and those where the survival of remnant ecosystems is threatened by urban expansion and other forms of development. These areas will have been identified, assessed and mapped in Steps 1, 3, 4, 5 and/or 6, and the objective of Module 7A is to assess, map and rank locations where biodiversity restoration can contribute significantly to the protection of the environment of the UREMP Area.

The **outputs** of Module 7A are maps and databases in the GIS defining each location where biodiversity restoration is a priority, describing its specific characteristics as listed above at the beginning of this Step, stating the goals of biodiversity restoration at that location, and explaining the reasons for the chosen boundaries.

Module 7B: Identify and map the potential for water body and river restoration

In urban and rural areas many waterways (rivers, streams, wetlands, lakeshores, and beaches) have disappeared under concrete, and elsewhere are channelled, diverted and/or degraded. Experience has shown that all of these cases are candidates for remediation, rehabilitation and restoration. They can then form parts of networks and corridors that extend into the areas that are given the highest levels of environmental protection through reservation or environmental zoning, and thus should be mapped as part of the wider land analysis.

The objectives of Module 7B are as follows.

- To document and map lost and degraded waterways that have potential for remediation, rehabilitation and restoration in the UREMP Area and beyond.
- To provide comprehensive and credible input to planning decisions about the directions and nature of urban development and the distribution of ecosystems restoration in the UREMP Area, so that high-value waterways are restored and fully protected from urban development, urban sprawl and overdevelopment.

Riparian and coastal locations for restoration should be assessed according to the 'National Ecological Protection Red Line - Ecological Function Red Line Delineation Technical Guide (Trial)' (Huan Fa [2014] No. 10). Coastal zone locations, including tidal flats, mangroves, coral reefs and other locations important for terrestrial and marine life, should apply the method and index of the Marine Functional Zoning of China report of the state oceanic administration.

The **outputs** of Module 7B are maps and databases in the GIS defining each location where the restoration of rivers and water bodies are a priority, describing its specific characteristics as listed above at the beginning of this Step, stating the goals of biodiversity restoration at that location, and explaining the reasons for the chosen boundaries.

Module 7C: Identify and map the potential for urban greening and open space

Many of the fundamental aims of UREMP – protecting and restoring ecosystems and biodiversity, valuing ecosystem services, protecting agricultural land and landscapes, and providing access to nature and recreation – can be achieved in small but significant ways within urban areas as well as in the hinterland. Unused land can be planted until it is needed; streets, parks and urban landscaping can be planted with endangered species and food bearing plants; roofs and walls of buildings can be made green; and natural and productive areas can be included in city plans.

The findings of Steps 1, 2, 4, 5 and 6 may include the identification of opportunities for urban greening and for the use of green spaces to achieve outcomes beyond enhanced recreational opportunities and urban amenity. In any event, the findings of Steps 1, 2, 4, 5 and 6 should be scrutinised to identify such opportunities. Existing, planned and potential parks can become part of green networks and corridors, they can be used to restore biodiversity or to produce food and fibre, and in this way they may strengthen the case for nearby land to be given high levels of environmental protection.

The **outputs** of Module 7C are maps and databases in the GIS defining each location where there is an opportunity for urban greening and open space to contribute to the protection of the environment.

Module 7D: Identify and map the potential for brownfield remediation

The remediation of brownfield sites is a contribution to environmental protection in its own right, in that contaminants are reduced, and land is made available for development as an alternative to converting non-urban land to urban. It may be even more beneficial, in that brownfield sites can become part of green networks and corridors, they can be used to restore biodiversity or to produce food and fibre, and in this way they may strengthen the case for the land including the old brownfield site to be given high levels of environmental protection.

The findings of Steps 1, 2, 4, 5 and 6 may include the identification of opportunities for brownfield remediation, and the findings of those Steps should be scrutinised to identify such opportunities. Thus, the **outputs** of Module 7D are maps and databases in the GIS defining each location where there is an opportunity for the remediation of brownfield sites that can contribute to the protection of the environment.

Module 7E: Indicative environmental restoration zoning and mapping

All data and maps produced in Modules 7A, 7B, 7C and 7D are combined to delineate land in the UREMP Area that has potential for restoration, making the land appropriate for environmental protection. Thus, Module 7E continues the series of *indicative zoning maps* showing red, yellow and green lines that began with the output of Module 3E.

The map produced in Module 7E, like the others from Steps 3, 4, 5 and 6, is called 'indicative' because it shows protection zones in relation to a single set of parameters, in this case relating to air quality. The air quality priority areas show a ranking, and a set of policy measures, that need to be reconciled and negotiated before they can be integrated into the final UREMP protection zoning map that is the output from Step 8.

Within Module 7E, the same reconciliation and negotiation needs to take place to integrate the outputs of Modules 7A, 7B, 7C and 7D. This is a task that needs to involve the whole UREMP team, since decisions are being made about values, ranking, priorities and regulations. It also should involve representatives of neighbouring UREMP teams (if neighbouring teams exist) or alternatively representatives of neighbouring provinces and local governments, since natural systems exist (and need protection) on both sides of all UREMP boundaries.

When the four collections of spatial data from Modules 7A, 7B, 7C and 7D are overlaid and combined, to produce a new set of defined areas zoned red, yellow and green, the data underlying the ranking of each area needs to remain associated with that area. In other words, red, yellow and green protection zones are not uniform. They comprise many sub-areas based on competing values and competing policy responses, which must be capable of being explained and justified. Likewise, being zoned red, yellow or green does not carry with it a single set of opportunities and constraints. Any sub-area of these zones may be subject to a set of regulations that are specific to that sub-area, and that must be capable of being explained and justified.

The **outputs** of Module 7E are an indicative zoning map and databases relating to specific locations in the UREMP Area with significant potential for restoration that can contribute to the protection of the environment. This becomes critical input to the preparation of the UREMP integrated environmental protection zoning map in Step 8.

2.8.1. Example: Planned protection and restoration of grasslands and forests in Baotou City

In Baotou City, population growth and overgrazing has resulted in severe environmental degradation, particularly in arid and semi-arid zones, at high altitudes and in areas with steep terrain. The plan includes measures to protect forests, restore vegetation, conserve water and arrest soil erosion, principally through three long-term projects: Natural Forest Protection, Returning Grazing Land to Grassland, and Returning Farmland to Grassland and Forest. A target of 25,000 has been set for moving "ecological migrants" from villages with poor conditions, scarce water and severe desertification to regions with greater opportunities. Grazing land with an area of 10,000 km^2 will be restored to grassland, by prohibiting grazing either permanently or for a period. In desert grasslands, sand is stabilised by building fences and reseeding appropriate plants, growing these plants into pioneering species, fixing the desert grassland, and developing a stable vegetation community. For wandering dunes, sand is stabilised through the construction of physical barriers and grass square barriers, by planting shrubs in the sand barrier, and by reseeding local pastures. Appropriate measures are being implemented in areas of severe water loss and soil erosion. Since 2000, the area of forest protection and extension has increased to 1700 km^2, with a target of 3000 km^2.

A description of the Baotou projects is given in Report Two: Technical Guidelines of UREMP.

2.8.2. Example: Developing Xiamen's coastal assets, with restoration of ecosystems

The environmental planners in Xiamen have developed clear policies for the coastal environment. They found that Xiamen's marine resources were significant economic assets that needed to be protected and developed in ways that strengthen environmental protection and restoration. The Xiamen port should continue as a major node serving Fujian province, south Jiangxi, and east Guangdong, and be the centre of a coastal industrial base including maritime high-tech industries. Coastal and cultural tourism, including ecological tourism and recreational fishing, could provide incentives and resources for the protection and restoration of the coastal and marine environments. Major measures (in different locations on land) are needed to control the sources of marine pollution, depending on the type of emissions, including agricultural runoff, urban runoff, rural domestic refuse, and sewage treatment discharge. In restoring Xiamen's marine biodiversity, it was essential to overcome scepticism about the possibility of success, through public participation, publicity, education, better management, and legislation. New coastal engineering projects must be strictly limited, and the structure and intensity of the fishing industry must be controlled. Restoration of the structure and function of the Maluan Bay ecosystem involves many measures and projects: establishing a coastal wetland reserve, prohibiting illegal reclamation, conserving the region's biodiversity, reducing the release of highly concentrated pollutants, decontaminating sediments, forbidding fishing, regulating the introduction of exotic species, and constructing a large scale mangrove plantation.

A description of the Xiamen projects is given in Report Two: Technical Guidelines of UREMP.

2.9. Step 8: Environmental Protection Zoning

Module 8A: Comprehensive environmental protection zoning and mapping, combining, evaluating and weighting sector results

The objective of this module is to produce a summary environmental protection zoning map delineating environmental protection zones (red line), restricted development zones (yellow line) and development zones (green line) based on the maps and data produced in Steps 3 to 7. The method includes an overlay and evaluation of all data and maps produced in the concluding zoning maps that have so far built up the UREMP Atlas.

The UREMP environmental protection zones, red line, yellow line and green line are compiled on layers of comprehensive analyses, each leading to many more than just three sets of controls.

Any one Step – for instance, Step 4: Prepare an Indicative Zoning Map for Green Land – generates many layers of analysis – in this case, forests, agriculture, mineral resources, etc – which might distinguish between different kinds of forest lands, or different environmental impacts of agriculture, or different environmental sensitivities. The resulting indicative zones for Green Land will show a range of assessments concerning the environmental value of distinct areas of land, and a range of potential policy responses (no development of any kind, certain kinds of positive development, encouragement of rehabilitation, long term protection for future purposes, etc).

Each of Steps 3, 4, 5, 6, and 7 will generate an indicative zoning map of this kind, with a range of assessments and policy responses depending on a number of spatial and non-spatial factors.

To give another example, Step 5: Prepare an Indicative Zoning Map for Water Quality Protection. There will be layers of analysis – rivers, lakes, wetlands, coasts, water source protection, flood mitigation, etc – identifying the attributes and values of specific land or water environments according to their condition and their potential roles as protected areas. These will be merged into indicative zones for water quality protection, managing locations in a variety of ways according to their value for particular purposes.

This is a complex but essential process. It results in five indicative zoning maps generated by Steps 3, 4, 5, 6, and 7. By overlaying the five maps, areas with exceptional value, and areas with high values for a number of sectors, and areas with potential to provide essential ecosystem services, become candidates for the *red line environmental protection zone*. The reasons for including each specific spatial unit, water location, and air quality cell in the red line zone might be quite different. In short, land, water and air locations in the red line zone are not all the same. They are all to be given the highest level of protection from development, but for possibly diverse reasons.

Protecting these red line locations will generally require that environmental controls are reflected in land use master plans and urban master plans, and that development control policies are reflected in the various policies and practices of the agencies responsible for water resource management, forestry management and agricultural land management. In negotiating such coordinated planning, the UREMP planners will need more than the colour on the map. They will need to document, explain and provide evidence for the decision to place any specific spatial unit in the red line zone.

While areas of land and water in the *yellow line zone* do not justify the blanket ban on development provided by the red line environmental protection zone, they are protected in specific ways depending on their attributes and the impact that various kinds of development would have on their environmental values and functions.

Accordingly, the yellow line zone is differentiated, with different policy implications in different areas. In some parts of the yellow line zone, low-impact urban development is compatible with environmental protection; in other parts, forms of green development such as farming or recreation are compatible, and may be beneficial; in yet other parts, the construction of certain kinds of infrastructure may have little impact, or may be beneficial. Implementing these polices will require negotiations with those responsible for land use master planning, General Urban Planning, water resource management, forestry management and agricultural land management.

The problem of boundaries: defining a single layer of spatial units

The summary environmental protection zoning map produced in Module 8 is divided into a patchwork of separate land and water parcels according to the value of each location and the management responses

required to protect and enhance that value. Through the investigations and decisions made in Modules 3, 4, 5, 6 and 7, the whole of the UREMP Area is divided and subdivided into distinct locations, or *spatial units*.

The boundaries of the spatial units for ecosystems and landscapes will be determined largely by the extent of natural systems: ecosystems may be fragmented, and may be in patches; landscape units may be determined by land cover and land use, some with natural boundaries, some with boundaries made, for instance, by following the edges of fields or roads or power lines. The boundaries of the spatial units for Green Land will often differ from these. The boundaries of the spatial units for water will reflect the water environment. Spatial units for air may be cells in a broad grid.

In Module 8, all of these spatial units must be overlaid, compared and merged into a single set of boundaries for the final redline map. In some places, subsets and subareas will be required, creating new, smaller spatial units, to reflect the different kinds of controls and polices (responses) that are needed to protect the environmental values of those places. In other places, the nature of the controls and policies may allow the planners to define larger spatial units that incorporate the spatial units relating to two or more factors, since the same management response applies across the group of spatial units.

This task will be iterative, since refining the data and refining the management responses for various factors will lead to revisions and amendments. In the end, however, a single layer of spatial units is likely to be needed. This is a task that needs to involve the whole UREMP team, since decisions are being made about values, ranking, priorities and regulations. It also should involve representatives of any neighbouring UREMP teams or alternatively representatives of neighbouring provinces and local governments, since natural systems exist (and need protection) on both sides of all UREMP boundaries.

The problem of zoning: reducing multiple assessment to a single zone

Any particular place in the UREMP Area may be in the red line zone for ecosystems, the yellow line for land, the green line for water, and in one or other of those zones for air and for restoration. There may be individual places with many combinations of those zones for the different factors. The challenge for the UREMP planners is to integrate those differing zones for the final, comprehensive environmental protection zoning map.

Using the new, integrated spatial units prepared as just described, the multiple zones derived for each factor must be transformed into a single red, yellow or red line zone.

A common ranking used in environmental assessments is a rank based on a scale of 1 (poor) to 5 (good), as in Table 2.4 and Table 2.6. In the process of transforming multiple zoning outcomes into a single zone this practice has serious dangers.

- It gives the process an erroneous appearance of precision or objectivity, when the rankings are actually relative values based on expert judgements.
- It often leads to a mechanical process of summing the numbers to produce a combined score. This is a bad error, for the numbers indicate rank (they are ordinal numbers) and are not a measure of value (they are not cardinal numbers). The best way to avoid this error is to use a scale such as E (poor) to A (good); or any ranking that does not encourage rankings to be added together, such as --, -, ±, +, ++; or ⇊, ↓, ↓↑, ↑, ⇈.
- The rankings for each factor are not comparable. A rank of ‘B’ for the ecosystem is not same as a rank of ‘B’ for land, or water, or air, or restoration. These ranks are already based on multiple considerations and express – for each factor – a relative value for significance or sensitivity or vulnerability or rarity or combinations of these, and require different responses.

For all of these reasons, the value of any particular spatial unit cannot be measured by a simple addition or combination or ranks.

The value of any particular spatial unit must be based on a considered assessment of its overall significance and value in the widest context. The reason and significance of the rank for *each* factor has to be considered, and then the relative value of the specific spatial unit has to assessed in the context of its total significance in the UREMP Area and beyond. This task will be iterative, since refining the value or management response for one spatial unit may lead to revisions and amendments of other spatial units. In this way, the entire UREMP team must agree on an overall relative value for each and every spatial unit.

The problem of controls and policies: knowing why each area is significant

The coloured map produced in Module 8 determines if each location is in the environmental protection zone (red line), the restricted development zone (yellow line) or the development zone (green line). This could suggest that the only *response* required to *pressures* and *impacts* is to prevent, restrict or allow development on each spatial unit.

In fact, not all places in the red line zone are the same, and the implications for places in the yellow line zone are even more varied. The appropriate response for some places in the yellow line zone may be no development of any kind. Or it may be that certain kinds of development have the potential to deliver offsets, or protection, or restoration. Or it may be that at this place certain kinds of urban development have less impact than anywhere else.

Therefore, the coloured map must be seen as the top layer of a spatial database with many layers. For each specific spatial unit, the final environmental protection zoning map is the index to the information on that spatial unit: the value of that place for ecosystem services, for land use, for water, for air, and for the potential for restoration.

The final environmental protection zoning map gives access to the reasons for allocating the land to that zone, and it gives access to the specific controls and policies recommended for the place. Thus, the UREMP Atlas contains all maps produced in the preparation of the UREMP Plan, the reasons for assessments, and the responses that are required to protect the values of the place.

The problem of implementation: harmonising land use, urban, resource and environmental planning

Creating the comprehensive environmental protection zoning map and database in Module 8 is the definitive step in the URMP process, but it is only the beginning.

The zoning map and database enables the UREMP partners to document, explain and provide evidence for the decision to place any specific spatial unit in any particular zone. It therefore provides the UREMP partners with the information they need to enter into negotiations with governments, departments and agencies to have the controls and polices incorporated into planning instruments, implemented in development control for all relevant development proposals, and applied in General Land Use Planning, General Urban Planning, water resource management, forestry management and agricultural land management.

3. Policies and institutional arrangements of UREMP

Recommendations for policies and institutional arrangements
to implement and mainstream UREMP in the PRC

3.1. Planning system, laws and regulations for PRC's Green Land

3.1.1. Planning systems in the PRC

In the PRC, governments and departments at all levels prepare plans. The most important plans include the National Economic and Social Development Plan, Major Function-Zone Planning, General Land Use Planning, the General Urban Planning (a twenty-year strategic plan for a city) and the Environmental Protection Planning. The first and last ones do not contain the spatial planning contents; the other three divide the landscape according the land type. Table 1.1 compares the planning targets, contents between these plans.

Table 3.1 Summary of the main macroscopic planning system in China

Plans	Responsible department	Planning period	Main content	Environmental related content
National Economic and Social Development Plan	NDRC (National Development and Reform Commission)	5 years	Economic development, industrial layout, population and employment, and social welfare, etc	Pollutant emission reduction
Major Function-Oriented Zone Planning in China	NDRC (National Development and Reform Commission)	10 years	Space development pattern based on main function-oriented zone	The environmental policy specific to different main functional zones
General Land Use Planning	Ministry of Land and Resources	About 15 years	Structure and layout of various types of urban land	Ecological land
General Urban Planning	The Ministry of Housing and Urban-Rural Development	About 20 years	Urban spatial pattern, development goal and urban scale, etc	Treatment facilities for public pollution
Environmental Protection Planning	Ministry of Environmental Protection	5 years	Objectives, tasks and measures of ecological protection and pollution prevention, etc	Environmental protection

The *National Economic and Social Development Plan* is the overall strategy for economic and social development for the country or a region, with the objectives of economic growth, scientific and technological progress, and social development. The plan addresses environmental protection. As an example, the twelfth five-year plan for national economic and social development had provisions on strengthening discharge of pollutants reduction and governance, preventing environmental risks, and strengthening environmental law-enforcing supervision. These measures depend upon the strict management, so their binding effect tends to be weaker based on the bad regulatory climate. Unlike zoning and land use planning, this kind of environmental planning is not spatial or location-specific – it relies on guidance and objectives.

The *Major Function-Oriented Zone Planning in China* of 2011 sets the future distributions of population, economy, land use and urbanization patterns. The *Major Function-Oriented Zone Planning in China* is usually led and managed by the National Development and Reform Commission. The zoned areas are divided into *optimised*, *prioritised* (key development areas, where the resources and environment carrying capacity are stronger, and economy and population agglomeration conditions are better), *restricted*, and *prohibited* (all kinds of natural protection area). Implementation has not always been effective, since the plan focuses on function rather than location, and ignores the spatial and development characteristics of places.

General Land Use Planning is long-term structure plans made by governments at all levels. They are usually formulated by land and resources departments. The primary purpose is to strengthen the

supervision of land use, to ensure coordination of the related departments, based on the requirement of land use . Municipal and county level land use planning do not include urban areas.

General Land Use Planning seeks to protect the environment, but the scope to do so is limited. The General Land Use Planning from 2006-2020, approved by the State Council in October 2008, established a red line for the protection of 0.18 billion hectares of arable land, including the basic ecological land with the intention of retaining 75% of cultivated land, garden land, forest land, grassland, water areas and unused land that has important ecological functions, and addressed issues of ecological integrity and restoration. However, General Land Use Planning is inflexible and tends to maintain the status quo, relying on satellite monitoring and spot checks for enforcement. When land use plans should be combined with general urban plans, as a result of classifying land according to natural boundaries and ignoring urban expansion and infrastructure, the land use plans have the higher legal status but do not provide adequate mechanisms for resolving conflicts and disputes.

General Urban Planning works within the context provided by the above plans, to achieve the economic and social development goals of a city. It is usually written by the Ministry of Housing and Urban-Rural Development. It covers the entire municipal districts including urban area, urban built-up area expansion, and rural areas including county, townships and villages.

General Urban Planning will provide the development strategies in phases with the purpose of efficient land use and investment, and will include a chapter on Environmental Protection. *General Urban Planning* provides a kind of balance between commitment and flexibility, and between continuity and change; adaptive management; and effective enforcement, particularly at the planning approval stage for urban projects. On the other hand, *General Urban Planning* focuses on development opportunities with inadequate consideration of the protection of farmland, including land requisition and resettlement compensation; and it integrates the contents in *General Land Use Planning* for resolving land use conflicts and disputes.

Environmental Protection Planning sets environmental targets for a given period. The National Environmental Protection Planning divides into the Environmental Protection Planning, the National Environmental Functional Zoning and several specific plans for environmental protection. The State Council has recently issued the Action Plan on Air Pollution Prevention and Control and the Action Plan on Water Pollution Prevention and Control and will also promulgate the Action Plan on Soil Pollution Prevention and Control soon. Local governments have issued relevant environmental protection plans and specific plans.

Other works on Environmental Protection implemented by other agencies are listed as follows:

- National, provincial, municipal and county level Water Resources Protection and Management, and Flood Risk Management Planning are under the responsibility of the National Ministry of Water Resources, the provincial departments of water resources, and municipal and county level Water Affairs Bureaus respectively.
- National, provincial, municipal and county level Forest Protection, Reforestation and Forestry Management are under the responsibility of the State Forestry Administration, and provincial, municipal and county agencies respectively.
- National, provincial, municipal and county level Agricultural Land Management are under the responsibility of the National Ministry of Agriculture, the Provincial Department of Agriculture, and the municipal and county level Agriculture Bureaus respectively.
- Municipal and county level Landscape Architecture Design are under the responsibility of the National Ministry of Housing, Urban and Rural Development, the Provincial Level Department of Housing and Urban Rural Development, and under the responsibility of the municipal and county level Planning Bureaus respectively.

Most of the other forms of plans mentioned above include the contents on environmental protection. For example, the National Economic and Social Development Plan requires a reduction in the total pollution discharges; General Land Use Planning contains requirements regarding the use of land with high ecological values; and *General Urban Planning* pays attention to public sewage and solid waste treatment plants. Generally, in these plans, environmental protection will take a back seat when facing the requirement of economic and urban development.

UREMP is intended to fill the described gaps in the existing planning system and play an integrative role bringing together the various institutions and their planning processes. Urban-rural *Environmental Protection Planning* will take a leading position to Economic and Social Development Planning, Land Use Planning and General Urban Planning. Crucial aspects of UREMP's contribution to spatial planning include the following roles:

- on all political levels where environmentally relevant decisions are taken;
- integrating all the different environmental production authorities;
- filling the gaps concerning spatially relevant environmental concerns such as climate protection and adaptation, conservation of areas important for recreation, drinking water replenishment and protection, storm water retention, biodiversity protection etc;
- finding institutionalized ways for integration with Economic and Social Overall (Spatial) Planning;
- coordinate interrelated regions and action departments.

With the revision of the Environmental Protection Law of 2014 and the development of UREMP Plans, Environmental Protection Planning becomes one of the main national forms of planning. Article 13 of the Environmental Protection Law provides as follows.

> *Article 13. The people's governments at or above the county level shall include environmental protection work into their respective economic and social development planning.*
>
> *The competent environmental protection administration under the State Council shall develop a National Environmental Protection Planning in accordance with the National Economic and Social Development Plan, and submit to State Council for approval and implementation.*
>
> *The competent environmental protection administrations of local people's governments at or above the county level shall, in conjunction with other relevant departments, develop the environmental protection plans applicable for their respective jurisdictions in accordance with the national environmental protection plan, and submit to people's governments at the same level for approval, and thereafter the promulgation for implementation.*
>
> *The environmental protection plans shall include objectives, tasks and safeguarding measures, etc. for ecological environmental protection and environmental pollution prevention and control, and shall align with the planning of main functional zones, overall land use, and urban and rural development.*

To achieve the aims of this law much remains to be done, particularly through the UREMP process. Environmental protection planning needs to develop the characteristics that will make the plans more effective: (1) consolidate the legal status of environmental production; (2) establish evaluate system and planning hierarchy; (3) set up the environment standard; (4) uniform mandatory contents in different plans, and (5) uniform approval and enforcement provisions. UREMP Plans must therefore use the language and processes of spatial planning, including land parcel boundaries for red lines and yellow lines, and explicit rules to be applied at the planning approval stage for urban projects. In these ways, UREMP Plans will be able to achieve the intentions of Article 13 of the law: alignment with the planning of main functional zones, overall land use, and urban and rural development (Figure 3.1).

Figure 3.1 Relationship of UREMP Plans to other forms of planning in China

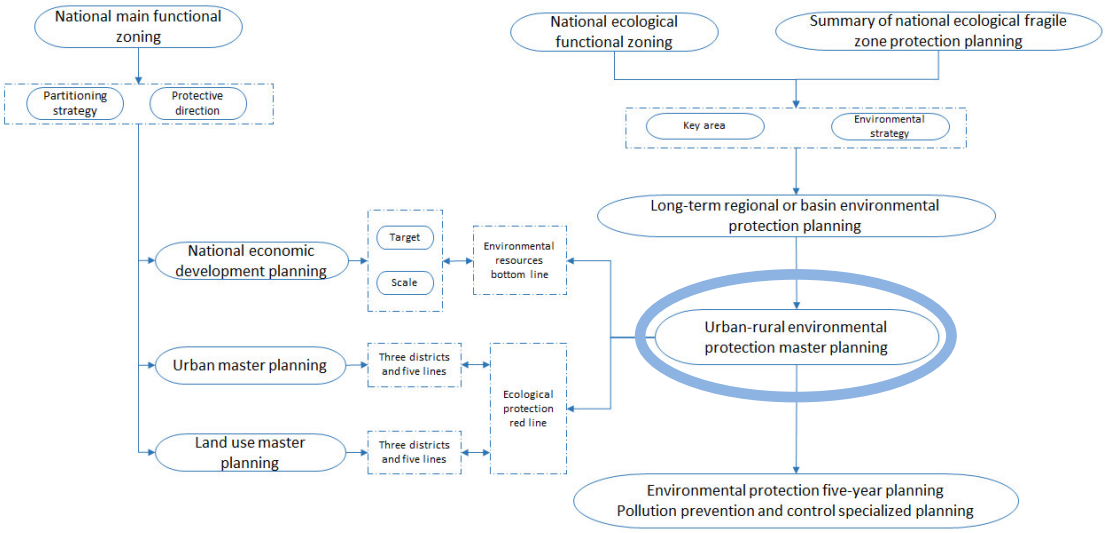


Table 3.2 Comparison of main characteristics between Environmental Protection and other plans

Name	Type	Planning System	Mandatory content	Approval System	Implementation Review
National Economic and Social Development Plan	5-year period Non-spatial planning	Three categories and three types: According to the administrative hierarchy, it is divided into categories national, provincial (Autonomous region, Municipalities), and city; According to the objects and functions, it is divided into categories of overall planning, special planning, regional planning	Implementation of key development goals and projects	National special planning is approved by the State Council, or the authority's relative. The planning involving multi-provinces (autonomous regions and municipalities) is approved by the State Council. Overall the draft planning is prepared by the same level of development and reform department, and it is approved by People's Congress for consideration at the same level.	Attention to the development objectives and strategies, emphasis on macroscopic, and neglect the construction, resulting in difficult implementation of project, lack of policy space.
Major Function-Oriented Zone Planning in China	20 years Spatial Planning	National and local level	Based on the main functional areas, locating the space development pattern	State Council is responsible for approval of the national main functional areas planning. For the provinces and cities, the main functional area planning is prepared according to the main functional areas of the country.	Too much considerations about the policy attribute of functional areas, ignoring its spatial properties and development properties, resulting in failure to effectively implement
General Land Use Planning	20-30 years Spatial Planning Bottom-up "Land decided by population", "Supply decided by needs"	No national level, only the city, county and township (town) levels	Urban Development range, control development area, development intensity, urban construction land, and so on	Grading approval. State Council is responsible for approval of provinces, autonomous regions and municipalities with the city government, cities with populations over1 million. In addition to the cities above, the government of provinces, autonomous regions and municipalities, is responsible for approving the overall planning of other cities and towns; the government of the town level is responsible for approving for the other township overall planning. The government of the city is responsible for the approving the city zoning planning.	Focus on land-use, development intensity and development opportunity, but the lack of balance of arable land into consideration. Emphasizing compliance with land legislation, but the way of convergence and dispute resolution procedures are not clear
General Urban Planning	15-20 years Spatial Planning Top to bottom "Preserve the red line	According to China's administrative divisions, planning is divided into five levels, including national, provincial (autonomous regions and municipalities), city (prefecture) and	Emphasis on long-term control of basic farmland red line of arable land of 18million mu.	Grading approval. Only the State Council and provincial governments are responsible for the approval of the overall land use planning. The land use overall planning of township is approved by the city o autonomous region government authorized by the	Focus on natural boundaries of land, lack of consideration of urbanization, resulting in incomplete urban layout structure, it is difficult to build infrastructure. With higher legal status,

	of farmland"	county (city) and township (town)		province government.	emphasizing compliance with city legislation, but the way of convergence and dispute resolution procedures are not clear
Environmental Protection Planning	5-year period Non-spatial planning	According to China's administrative divisions, including national, provincial (autonomous regions and municipalities), city (prefecture) and county (city)	Main objective indexes, such as pollutant emission reduction, water quality, air quality	Assign tasks → formulate a general plan→ declaration of the planning (towards same-level government and upper-level environmental protection departments) → approval (the upper-level environment protection departments will organize the experts to review, and provide the suggestions) → the implementation of the planning (after same-level government receives and approves the planning)	It is subject to contents and tasks of the pollution prevention planning, so it is difficult to integrate into the economic and social development process. It is also limited by the environmental management mode, as sub-elements the planning contents are seriously scattered in various sectors

3.1.2. Laws and regulations related to plans

Of the above mentioned plans, only General Urban Planning is backed up by a related law, titled the Urban and Rural Planning Law of the People's Republic of China. Land Use Planning is provided for by the Land Administration Law of the People's Republic of China and environmental planning by the Environmental Protection Law of the People's Republic of China. National Economic and Social Development Planning and the Major Function Oriented Zoning Planning have no applicable laws, but are supported by policy documents such as *Several Opinions on Strengthening Formulation of the Planning on National Economic and Social Development*, *the 11th Five Year Plan Outline on National Economic and Social Development*, and *the Opinions of the State Council on Formulating the Planning of the National Master Functional Areas*.

The practice of environmental management was started from 1973 in China after the State Council held the first national conference on environmental protection. China's environmental management system, as listed in Table 1.3, has played an important role in solving structural, localised and widespread environmental problems along with the deepening of China's reform and opening up.

Table 3.3 China's principal environmental management system

The Old Three	The New Five	Subsequent measures
Environmental impact assessment	City system for urban environment	Environmental protection planning
"Three at the same time"*	Environmental protection responsibility	Environmental quality standard
Pollution levy	Pollutant discharge permit	Total emission control
	Time-limited abatement and management	Environmental monitoring
	Centralised pollution control	

*"Three at the same time" means that measures to prevent and control environmental damage are *planned, constructed and implemented* at the same time as the main project is carried out.

As noted in the previous section, the revision of the Environmental Protection Law is a major landmark in environmental protection. It supports UREMP-related systems in the thirteen ways shown in Table 1.4.

Table 3.4 Environmental Protection Planning under the Environmental Protection Law

No	Environmental Management System	Classification	Corresponding content of UREMP
1	The standards of environmental quality	Supervision and management	Environmental function zoning system, "the baseline of quality" and "upper limit of emission"
2	Environmental monitoring system		The basic public service systems of urban-rural environment
3	EIA		During EIA, check UREMP red line and environmental function zoning
4	Environmental protection responsibility and assessment system		The outcomes of UREMP can be incorporated into the evaluation indicators
5	Eco-compensation	Protection and improvement of	"The format of the red line" and "ecological red line"

6	Environmental and health monitoring, investigation and risk assessment system	environment	"Environmental function zoning system" and "quality baseline"
7	"Three at the same time"	Pollution prevention and control	Environmental risk prevention facilities can be incorporate into the "Three at the same time" system
8	Pollutant-emission charge		Upper limit of emission
9	Total emission control		Upper limit of emission
10	The management of discharge permit		Upper limit of emission
11	Elimination of the high-polluted technology, facility and products		Projects for UREMP implementation
12	Unexpected environmental risk control and emergency-response mechanism		"Risk red line" and "the basic public service system of urban and rural environment"
13	Environmental information disclosure	Information disclosure and public participation	The basic public service system of urban and rural environment

The above environmental protection systems and measures, as strengthened by the revised Environmental Protection Law, are described in detail in *Report Three: Recommendations for Policies and Institutional Arrangements of UREMP*.

The report comes to the following conclusion: "The overall planning of the urban and rural *environmental protection* must be set as the highest priority. There are some uncoordinated contents in China's existing planning. The reformed planning process should be focused on building mechanisms for coordination, convergence and integration. A high quality ecological environment is the basis for social harmony and economic development. Therefore, the natural ecosystems should be identified and planned first. Then other plans, including the Economic and Social Development Plan, the Land Use Plan and the General Urban Plan, should be formulated in this context, to reflect the concept of eco-development priorities."

3.2. Revision and extension of environmental protection mechanisms

Urban-rural environmental protection is presently based on national, regional and basin-wide environmental protection provisions issued by the State Council and instruments issued by ministries and commissions; on specific measures of the Ministry for Environmental Protection; on the planning instruments of the cities of the PRC's 18 city-clusters as defined in the New Type Urbanization plan for the PRC (2014-2020) (see the Appendix); on the policies and decisions of the PRC's 655 cities (direct-controlled municipalities, sub-provincial cities, prefecture-level cities and county-level cities) and national development zones; and on other local regulations.

As discussed in Part 1 of this report (see section 1.2 above), urban-rural environmental protection needs a sound legal basis, clear administrative regulations and a societal consensus of the need to protect essential (and even just desirable) green space. Amendments to the current national Environmental Protection Law and the current administrative regulations may be needed, which requires urban and rural administrations to prepare a common UREMP and include the environmental protection zones in all urban and rural master plans. For urban-rural environmental protection to be effective, significant institutional change is needed towards cross-jurisdictional coordination and interdepartmental cooperation.

Report Three: Recommendations for Policies and Institutional Arrangements of UREMP describes best practice examples, from the PRC's pilot cities and from international experience, that illustrate the following principles.

- **A comprehensive system** for the environmental planning system should be laid out from the very start.
- **Process rules** are an important component to ensure that environmental concerns are prioritized. An example for an almost absolute dominance of biodiversity objectives is the EU Habitat Directive, in which every development application impacting on species and habitats of European relevance is audited according to precise criteria.

- **Disclosure of information and public participation** (which are already parts of the PRC's planning system) can be strengthened, for instance to reference some measures in the Netherlands' Aarhus Convention
- **Mechanisms for integrating environmental planning with both sector and spatial planning** can improve the efficient integration of plans at an early stage, and coordination degree between the departments that administer and control land and the environmental protection.
- **Private interests should not be intermingled** into public planning, the inclusion of synergistic private interests into an implementation concept will usually support implementation of environmental objectives (such as in the marketing of environmentally sound agricultural products). The economic valuation of ecosystem services supports this.
- The Chinese pilot cities have demonstrated that an **ecosystem services functions evaluation** is possible and that this can result into a prioritization of areas as to their importance for safeguarding the functioning of the green space.
- One of the Chinese pilots, in Yichang Municipality, has demonstrated that a formal **approval procedure**, in that case by the Municipal People's Congress, is a good precondition for implementation.
- **The concepts of Green space** can help strengthen and defend green space protection under a compelling conceptually coherent concept, which can be integrated in spatial plans and green area protection. Examples include London Green Belt, UK; Regional Park Emscher, Germany; Green Heart in the Randstad, the Netherlands; and Central Park, Hyde Park, Berlin Tiergarten and Englischer Garten Munich. Recently the European Union has agreed on implementing the concept of Green Infrastructures.

These and other principles and best practice examples are discussed in details in *Report Three*.

Where UREMP Areas cover large natural systems, **joint planning partnerships** within and among jurisdictions must be formed. The institutional partnerships will integrate UREMP as an urban-rural environmental protection and planning instrument, develop joint monitoring and enforcement regimes, and promote public environmental awareness engaging stakeholders and communities. The roles of the many administrative units involved in UREMP are listed and described in Table 5 in *Report Three: Policy Recommendations for promoting the Institutionalization of UREMP*.

The necessary steps and procedures to enable UREMP to become an effective and operational instrument include (i) establishing the *legal basis* for environmental protection planning, (ii) setting up *coordination* mechanisms, (iii) developing appropriate *institutions* and (iv) *procedures*, and (v) building *capacity*. These steps are summarised in this Chapter of the report, and are described in details in *Report Three: Policy Recommendations for promoting the Institutionalization of UREMP*.

3.3. Legislative foundations

Chapter 1 of this report, UREMP Objectives and Challenges, describes how the laws of the PRC control construction land and the extent and intensity of urban development (for instance the laws of urban and rural planning), and protection and compensation for farmland (for instance the laws of land administration), but did not institutionalise spatial environmental protection planning. However, the newly revised Environmental Protection Law strengthens many provisions concerning environmental standards, pollution controls, compensation, monitoring and enforcement, and it also contains fundamental provisions for environmental protection planning. The following extracts from specific Articles provide a legal basis for UREMP (emphasis added).

Article 5. Activities concerning environmental protection shall adhere to the following principles: according priority to protection, emphasis on prevention, *integrated governance*, public participation and liability assumption of damages.

Article 13. The people's governments at or above the county level shall include environmental protection work in their respective economic and social development planning […and] shall, in conjunction with other relevant departments, develop the *environmental protection plans* applicable for their respective jurisdictions in accordance with the national environmental protection plan... The environmental protection plans shall include objectives, tasks and safeguarding measures, etc. for ecological environmental protection and environmental pollution prevention and control, and shall *align with planning for main functional zones, overall land use, and urban and rural development*.

Article 18. The people's governments at or above the provincial level shall organize relevant departments or entrust professional institutions to make an investigation and an assessment of the environmental situation, and establish a monitoring and warning system for environmental resources carrying capacity.

Article 20. The State shall establish inter-jurisdiction joint prevention and control coordination mechanisms for environmental pollution and ecological damage of key regions and river basins to implement *unified planning*, standards, monitoring and prevention and control measures. Inter-jurisdiction environmental pollution and ecological damage other than defined in the preceding paragraph of the provisions shall be resolved by *coordination at higher level people's government* or *consultation* from relevant departments of local people's governments.

Article 28. Local people's governments at various levels shall take effective measures to improve environmental quality according to environmental protection goals and governance tasks.

Article 29. The State defines the ecological red line for strict protection of key ecological functional zones, and areas of sensitive and fragile ecological environment. The people's governments at various levels shall take measures to protect regions representing various types of natural ecological systems, regions with a natural distribution of rare and endangered wild animals and plants, regions where major sources of water are conserved, geological structures of major scientific and cultural value, famous regions where karst caves and fossil deposits are distributed, traces of glaciers, volcanoes and hot springs, traces of human history, and ancient and precious trees. Damage to the above shall be strictly forbidden.

Article 30. Exploitation and utilization of natural resources shall be developed in a rational way that conserves biological diversity and safeguards ecological security. *Ecological protection and restoration programs* shall be developed in accordance with laws and be implemented.

Article 5 not only authorises *collaboration* and *partnerships* between people's governments at all levels, it *mandates integrated governance* as one of the five fundamental principles on which the Environmental Protection Law is based.

The Articles listed above, and others, provide a legal basis for the preparation of spatial plans for environmental protection, for planning for environmental carrying capacity (understood as the absorptive capacity or bearing capacity within the environment's maximum load), for including red lines in plans, for enforcing controls to protect ecological functions and ecosystem services, and for *aligning* these spatial plans with urban master plans, zoning plans and urban and rural development plans.

Specific rules are needed beyond these enabling provisions. There are at least three ways in which the adoption of new rules and regulations might be achieved.

- As national and provincial laws and regulations are revised and expanded, provisions to guide environmental protection planning, and to ensure that other forms of planning align with UREMP Plans, can be introduced progressively.
- As planning is undertaken within the Thirteenth Five-year Plan, people's governments at all levels can develop ways to prepare and implement UREMP Plans, and as the National Ecological Red Line Protection Plan is formulated it can include technical regulations and controls to be included in UREMP and other plans.

- UREMP can be given legal status by issuing departmental rules, including new National Environmental Protection Program Regulations, and national Instructions based on the experiences of the pilot cities.

Local laws and regulations are needed as well. If the Ministry of Environmental Protection prepares and issues guidance documents, People's Congresses at all levels may adopt legislation, to be implemented by the people's governments at the same level. UREMP Plans can be authorised by the relevant People's Congresses to give them greater force. For instance, in Yichang, one of the first twelve pilot cities, the Standing Committee of the National People's Congress of Yichang approved and issued the environmental protection plan in January 2015. For more details of the Yichang pilot program, see Chapter 4 of this report.

However these reforms are achieved, the specific position of UREMP is that of a proactive, conceptual precautionary spatial planning, which covers and integrates all environmental compartments such as land, air, water, soil, flora, fauna etc. and all ecosystem services. Therefore UREMP needs to be independently legally anchored in the Environmental Protection Law of the PRC, which should be amended to include UREMP as a legally binding planning instrument. The legal basis of UREMP will require the following principles to be adopted.

- Carrying out UREMP is mandatory in all municipalities and existing and planned city-clusters everywhere in the PRC, and within a certain period (i.e. within the 13th Five-Year Plan).
- For this reason, the spatial scales of other plans (which have to implement UREMP) have to be met, to integrate UREMP into the other spatial planning types (land-use, urban, etc).
- It is mandatory to apply the environmental protection areas and zones, and the recommended environmental management measures, of a UREMP Plan when planning for economic, social, land use, transportation and other development.
- Technical guidelines for UREMP have to be followed in order to ensure quality and comparability of assessments and planning results, and compatibility of digital mapping and information platforms and standards.
- UREMP will be approved by standardized procedures, firstly by the government(s) which prepared the UREMP, secondly by higher levels of authority including provincial and national levels as applicable.
- Implementation of UREMP has to be systematically monitored and evaluated, and UREMP Plans should be updated every ten years, synchronized with but ahead of and subsequently integrated with the General Urban Planning by the municipalities.

Report Three examines the options for integrating UREMP into the existing legal system. When linking UREMP in the Environmental Protection Law to existing environmental protection laws and regulations, offset mechanisms, monitoring and spatial control mechanisms will be particularly relevant. The most important environmental protection laws and regulations are the following.

- Regulations for pollution control including environmental quality standards, the total emission control system and discharge permits management. Not all ecosystem services are currently covered by standards. It is recommended that UREMP establishes local and regional quality standards and threshold values for all environmental media.
- Total-amount control policies can use UREMP to scale down national targets to lower political levels (provinces, districts, local industries).
- The environmental monitoring system including health monitoring can be combined well with UREMP by using UREMP as an environmental information system.
- Environmental assessments are reactive instruments, which respond to a planned project; they can rely on UREMP as an information basis and source of evaluation standards. An eco-compensation

should be installed as a new instrument for offsetting environmental impacts caused by new development.

- Environmental protection should be initiated by UREMP on the basis of a sound evaluation and prioritization of land functions leading to an appropriate implementation of UREMP objectives. On the other hand, UREMP has to incorporate existing protected areas.
- Existing economic policy instruments which can be used by UREMP are pollution charges and eco-compensation.
- Environmental disclosure and public participation legislation should be connected to UREMP legislation. UREMP should have the duty to perform public participation as well as to provide information which is suitable for public participation.

3.4. Scope of UREMP Plans

UREMP will consist of, first, a data analysis and, second, an evaluation of the state of all ecosystem services as well as pressures and impacts. This will include natural productivity for crops and fiber (especially natural soil fertility), renewable energy potential (solar, wind), water provision, storm water retention, GHG-storage, biodiversity and cultural ecosystem services, and bioclimatic services.

The evaluation results reflect to which degree the state of the environment can fulfil objectives and targets laid down in legislation and how many emissions and other pressures impair the functioning of the ecosystems. From the evaluation results spatially explicit objectives and targets are deduced. The content of UREMP should relate as much as possible to environmental policy mechanisms such as total amount control or eco-compensation which are influential and established in order to support UREMP's status and implementation.

The most prominent results will be a zoning concept including red, yellow and green line zones, representing different valuable and endangered or impaired areas. Priorities for the responses usually are deduced from the value and endangerment of the ecosystem services. Areas with predominantly highly valuable assets such as very important water resources or endangered species and habitats have to be protected in nature reserves in the context of legally binding red line zones. The red line zones will be differentiated into areas with different necessary land use restrictions.

Yellow line zones are applied to areas of predominantly medium valuable ecosystem services, where selected impairing land uses should be restricted beyond minimum legal land use restrictions or emission standards in order to safeguard the functioning of ecosystem services. These areas can maintain multiple ecological services and provide concepts for multifunctional measures. Small areas of high value can be strictly protected inside yellow line zones. Urban development of relevant scale should be excluded in such zones because sealing the soil destroys the ecosystem functions.

Green line zones represent areas with dominant lower value of ecosystem services. Minimum protection standards are provided by legal emission thresholds, minimum requirement on good land use practices and environmental quality baselines. Generally urban development is possible but also here on specific sites a stronger protection level and exclusion of development or certain industries is possible. The recommendations are discussed in early planning stages in a multi-agent process, including public participation.

Restoration of impaired sites may be an important task for the future.

3.5. Coordination

Since it is essential that a UREMP Plan covers large natural systems, the plan is bound to involve a number of cities and the agencies and sectors of two or more provinces. This regional coordination must

first be based on good internal coordination within each city. This will require a steering committee, led by the appropriate deputy mayor, that includes heads of departments (environment, land and resources, urban and rural planning, water conservancy, forestry, transportation, construction, development and reform, agriculture, and others) and the leadership of the counties and districts within the jurisdiction of the city. The steering committee will report to a coordination and advisory committee led by the mayor – an essential structure in each jurisdiction to facilitate communication, coordination and negotiation with the provincial departments and the surrounding cities and counties, in the development of the joint UREMP Plan, and to ensure consistent implementation of the plan through local planning instruments.

More specifically, planning tasks and responsibilities may be shared and distributed across the appropriate government and planning levels, as shown in the following examples.

- Rivers crossing administrative borders should be handled by the administrative level which covers the entire river-ecosystem.
- Further ecosystems that should be managed on the national level are national parks, and nationally endangered and rare species.
- Examples for local level environmental management responsibilities are creeks, rivers with only local extension, locally rare species or habitats (which may be abundant at provincial level).
- Cooperation of different spatial and political units which cross political boundaries is necessary if implementation tasks have to be solved which concern all involved parties. Such tasks may be common agreements on where to allocate industry or housing development across municipal borders, if misallocations are provoked by incentives for example by the tax system. Best practice examples include the regional association in Germany, and the UREMP pilot studies in the PRC.
- Environmental planning becomes more effective if binding environmental standards with blanket coverage (for example, for pollution control) ensure a certain minimum level of pollution control. Such regulations are then combined and supplemented by area specific regulations in spatial planning. The objectives and regulations laid down in spatial planning can be more specific and be put forward with more emphasis.
- Horizontal coordination mechanisms are needed to overcome the demarcations between sector administrative divisions; UREMP itself may support in the future a better coordination, because sectoral administration will have to work together on compiling the necessary information and agree on multifunctional environmental zoning. A common environmental information system is a very good but hard to achieve means to this end. Steering teams led by the competent deputy mayor and consisting of competent departmental representatives can support cooperation on municipal level; multilateral planning integration is already jointly operated by the National Development and Reform Commission and different ministries.
- The mutual implementation of traffic, industrial and housing development by neighboring cities or between a city and the surrounding rural area needs coordination in order to avoid destructive competition or one-sided exploitation; cross regional planning bodies, who are given executive power for selected issues, may support such integrated development concepts. At the same time, UREMP will already be a means for automatically achieving better cooperation in this case: many cross border conflicts will already be decided on higher planning tiers; the exchange of information and data will be a common interest; performing executive tasks together will safe capacities; and bilateral planning of specific infrastructure and industries will be of mutual benefit if there are no contrary incentives.
- The vertical coordination of planning objectives across planning tiers needs a good flow of information in both directions as well as regular meetings of representatives of all planning levels.

Report Three also examines an alternative model in which the separation of functions is taken further, with separate discrete UREMP Plans at the national level, the provincial level, and the municipal level, referred to as a "multi-tiered planning system".

Examples of multilevel planning systems are the federal systems of Switzerland with its 22 Cantons, and Germany with its 16 Provinces, and lower administrative regions, cities, and counties, where the competencies and responsibilities of the different political levels for protection and restoration of ecosystem services are defined mainly in hierarchical order for the different political levels according to the spatial extent of the ecosystems and the value of their ecosystem services.

Report Three discusses the application of this to the PRC, with an examination of the advantages and implications of the model. Table 4 in *Report Three* sets out in more detail the share of labour (division of responsibilities) between different UREMP planning tiers in this model.

3.6. Institutions

The development and implementation of UREMP Plans will require major changes in institutional cultures and professional practices, as well as laws and regulations. Once achieved, however, the resources available for environmental protection will be larger and stronger, natural systems will be planned for and managed holistically, and development will be controlled with greater authority and effectiveness.

To achieve these ends, two forms of coordination and institution building will be required.

Firstly, within the UREMP partnership of jurisdictions, different levels of government, with different traditions and different resources (structures, procedures, IT platforms, etc) will need to collaborate and negotiate on the *preparation* of a shared set of maps, databases, assessments and rules. Even if smaller neighbouring UREMP Plans were prepared to separately manage parts of larger natural systems, the same communications and negotiations would be unavoidable. The creation of the partnership, with the guidance, authority and technical and fiscal resources of one or more higher level governments, is likely to achieve coordination and integration faster and more effectively.

Secondly, the *implementation* of the shared UREMP Plan will also require new relationships between professions and disciplines, merged procedures and negotiated outcomes, if environmental values are to be fully incorporated into land use plans, master plans and urban and rural development plans. The result, however, will be an integrated planning system for the region, improving environmental protection, urban qualities, sustainability, quality of life, and public engagement.

These considerations lead to the following proposals.

- **Level** There are about 300 municipal people's governments in the PRC. Sitting between the provincial people's governments and the counties and districts, and with the guidance of the environmental protection departments of superior people's governments, these are the key bodies for driving UREMP, with the capacity to integrate the work of their own technical departments, to collaborate with the other municipalities in the partnership, and to fund the essential work.
- **Expertise** Supervised by the relevant municipal environmental protection bureaus, the research and planning work can be carried out by consultants, with the outputs always reviewed by independent experts.
- **Planning process** The preparation of a brief and then an outline of the planning task must be completed first. Then drafts of the UREMP Plan are formulated for consultation with experts, departments, stakeholders and the public. At public hearings, opinions should be invited and listened to, relating to the whole planning process.
- **Adoption** The final policies are passed by the various standing committees of the People's Congresses of the various jurisdictions in the UREMP partnership.

- **Implementation** Development control is carried out by the actions of the municipalities, including through decision-making, urban construction, resource exploitation, economic development and other activities, with the environmental protection departments responsible for assessing performance and outcomes.
- **Evaluation** A formal mechanism is established to evaluate the effects of the planning instruments on sustainability (economic, social, environmental), and in particular the effects on protecting significant environmental values, functions and places.
- **Guidance** National and provincial environmental protection departments should evaluate the UREMP outcomes, issue complete regulations, technical rules and methods, propose legislation, participate in planning discussions, and receive the reports and data from the governments at all levels.

3.7. Procedures

Comprehensive, location-specific environmental protection planning, and integration with existing forms of spatial planning, will require new management policies and procedures. The following initiatives are proposed.

- **Integrated spatial planning** The three primary red lines for land, water and air will reinforce, and must be integrated with, the system for setting environmental quality thresholds, limits and standards. Gradually prohibit the industries that discharge pollutants to the atmosphere and water system that are marked within the areas enclosed by red lines.
- **Location-specific standards** Locally, the national and provincial limits on pollutants should be applied to districts, counties, catchments and industries, adjusted to local conditions and based on environmental quality.
- **Location-specific limits and caps** In all critical locations, the maximum loads for land, water and air and maximum absorptive capacities should be assessed, changes in conditions should be projected into the future, and emission reduction should be prioritised in land use planning and development control.
- **Location-specific interventions** Specific interventions relating to environmental impact assessments, controls on existing industries, environmental risk assessment, and pollution reduction requirements should reflect the location of the subject area within the land, water and air red and yellow lines.
- **Eco-compensation** The eco-compensation policy should aim to equalise ecosystem services; areas which cannot reach the standards of basic services should be compensated – in some cases the government may need to purchase those services.
- **Risk management** Based on red lines and yellow lines, policies, controls and penalties (compensation for environmental damage) should ensure that the responsibilities for risk assessment and management are known, and that existing polluters are also responsible for risk assessment and management.
- **Ecological assets accounting** A comprehensive system of ecological assets accounting should be developed, with specifications, techniques, statistics and training supported at the central level.

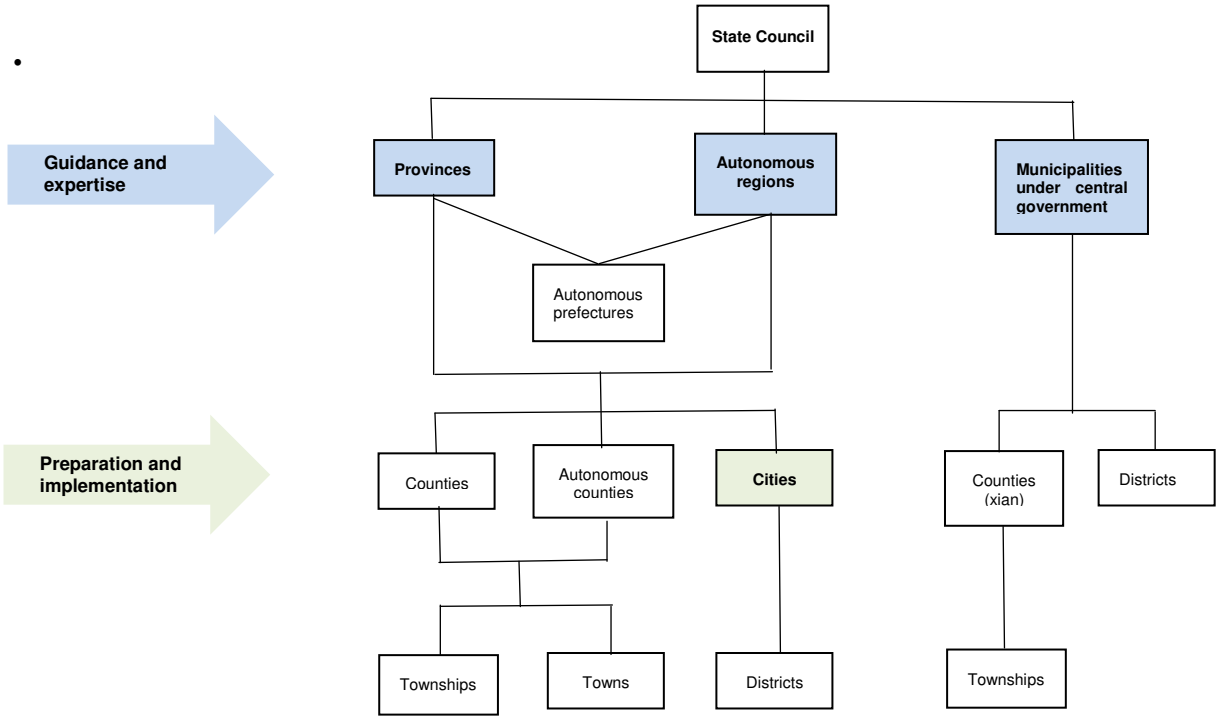
3.8. Capacity Building

The preparation of UREMP Plans will require access to data across many fields, the integration of data with GIS systems, standardisation of planning techniques and close collaboration with colleagues involved in urban planning, transport planning, economic management, construction, infrastructure provision and resource use. The preparation of UREMP Plans, by collaborating cities, should be overseen and guided by units staffed with qualified and experienced staff members in environmental planning agencies of provinces, autonomous regions and municipalities directly under the central government (Figure 3.2). These units should form an environmental planning team with complete business areas,

professional skills and reasonable personnel structure and provide the necessary instruments and equipment, service systems and modelling tools. The professional teams should receive specialised UREMP training.

Figure 3.2 Key government levels in the development of UREMP processes

Figure adapted from Saich, T. *Governance and Politics of China*, Palgrave, New York, 2001, reproduced in Chen, Xiaoyan. Monitoring and Evaluation in China's Urban Planning System: A Case Study of Xuzhou, prepared for *Planning Sustainable Cities: Global Report on Human Settlements 2009*, UN Habitat, 2009, page 4. Note that the two Special Administrative Regions of Hong Kong and Macao have variant structures.



3.9. UREMP and the 13th Five Year Plan

One of the outcomes of this TA project is the inclusion of urban-rural environmental red lines as described in this UREMP document in the national, several provincial and a number of municipal 13th Five Year plans.

Overall environmental planning is a key task of the 13th Five Year Plan. It is suggested that the first UREMP Plans be prepared by a group of typical cities selected from national environmental protection model cities, key national environmental protection cities, key cities involved in air and water pollution planning and cities in newly established areas and districts. Specifically, the 20 city clusters proposed for the New Urbanization should be among the first to prepare UREMP Plans.

Cities and counties should participate in "multilateral integration" jointly operated by the National Development and Reform Commission, Ministry of Land and Resources, Ministry of Environmental Protection and Ministry of Housing and Urban-Rural Development, particularly in relation to spatial planning for environmental protection.

It is suggested that UREMP planning should be discussed, approved and implemented by People's Congresses at the relevant levels, and that UREMP Plans should be reported to the Ministry of Environmental Protection for the record.

The experiences and advice of the pilot cities, research institutions, relevant experts and representatives of local residents should be actively requested, to ensure that UREMP Plans use innovative techniques and are locally relevant. Existing international and domestic channels should be used to share knowledge and

practices. Similarly, funding for UREMP work should be actively requested from central government, local governments and international agencies.

A table listing the internal units and responsibilities at the national, provincial and municipal levels in relation to preparing UREMP Plans is given in Table 5 in *Report Three: Policy Recommendations for promoting the Institutionalization of UREMP*.

3.10. Next Steps in the Institutionalization of UREMP

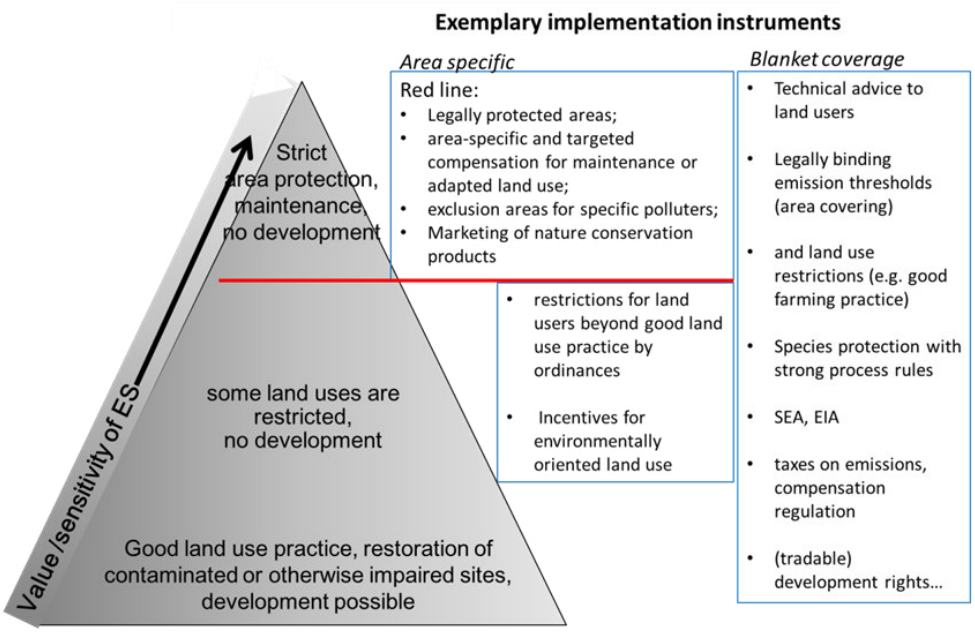
The implementation of UREMP can be executed (i) by the mandatory status of the environmental zoning; (ii) by integration of the objectives and restrictions into economic and social planning instruments and (iii) by using existing instruments of implementation and developing new mechanisms. Figure 3.2 gives examples for implementation instruments to be used in the different environmental zones.

It is crucial that the legislative establishment of UREMP will include links to environmental implementation instruments and vice versa. For example, the existing Eco-compensation should be bound to UREMP planning designations. Thus, the need of a region for support is proven and can be compared to other regions. Accounting systems can support such prioritization for implementation. Area protection in nature reserves should also be based on such UREMP evaluations of protection needs.

The introduction of UREMP is a strategic task which has to account for the flow of decisions in the PRC's planning system. The steps may be to first summarize good arguments for UREMP using the experiences from the Chinese pilots and demonstrating that UREMP is technically manageable. The establishment of UREMP as a key task in the 13th Five Year Plan and in the environmental protection legislation will also be crucial steps. Further stages may be to start UREMP in the 18 city clusters, to build the environmental information as well as the knowledge and innovation platforms including standardized mapping and assessment methods, to provide the financing and to initiate training schemes.

Report Three has detailed findings on capacity building and training based on the experiences of the pilot cities.

Figure 3.3 Instrumental Options for UREMP implementation in Red Line Zones and beyond



4. Pilots and International Best practices of UREMP

Progress reports and lessons learned from best practices in environmental protection in the PRC pilot cities and internationally

4.1. Learning from environmental protection in the PRC and internationally

As noted earlier in this report (Chapter 2, Section 2.1) red line zones for environmental protection were first used in the Pearl River Delta Environmental Protection Plan (2004-2020), initiated by the State Environmental Protection Administration (SEPA) in 2003. Arising out of that experience, and after considerable development of the concept, in 2012 the Ministry of Environmental Protection of the People's Republic of China (MEP) (which replaced SEPA in 2008) initiated pilot programs in twelve cities, and later in a further twelve cities. In 2013 Vice Minister Jian Zhou of MEP chaired a forum attended by 31 provincial Environmental Protection Departments, twelve pilot city governments, and ten representatives from the departments of MEP. In 2013 ADB joined with its preparation of a TA concept paper and the name UREMP was created and in 2014 the ADB financed consultants started to prepare this report. Since then many pilot cities have prepared overall urban environment plans. As a result, the content, technical framework and management systems for UREMP were basically established and were constantly improving. The cities of Fuzhou, Yichang, Guangzhou and Weihai also explored a series of practical trials, including in environmental system analysis, environmental spatial regulation, evaluation and management of resource capacity and improving environmental functions (Table 4.1).

Table 4.1 Characteristics of four pilot cities, Fuzhou, Yichang, Guangzhou and Weihai

Source: *Report Four: Domestic Pilots and International Best Practice Cases of UREMP*

	Regional distribution	**Area** (km^2)	**GDP** (million Yuan)	**Population** (million)	**City type**
Fuzhou	Eastern coast	7434	1292	15420	Livable city; regional central city of west bank of Taiwan Strait
Yichang	Upper Yangtze River	21227	408	2818	World famous hydroelectric energy base; regional central city, middle/upper Yangtze River
Guangzhou	Pearl River Delta	11968	710	4678	International Central City
Weihai	Eastern coast	5797	280	2550	Coastal open city; port and tourist city

In comparing the PRC UREMP as developed by this TA, to systems elsewhere, no precise equivalents were found. Nevertheless, comparisons can be made, regarding the legal basis, coordination mechanisms, management mechanisms, and supervision of notable examples of planning systems that protect Green Land from urban development, urban sprawl and overdevelopment. The key points of comparison are listed in Table 4.2.

Table 4.2 Comparison of environmental protection initiatives in the PRC and internationally

Source: *Report Four: Domestic Pilots and International Best Practice Cases of UREMP*

	Legislation	**Coordination**	**Management**	**Supervision**
UREMP in China	There are provisional technical requirements but no legislation yet	A pilot exploration of "integration of several plans" is under progress, but there is still no mechanism for connection.	The basic mechanisms for compilation, implementation and management of plans has been established	There is still no mechanism for supervision
Green belt in London, UK	National planning policy framework, law of	The coordination between planning department and environment department is required by regulation. The UK has no UREMP, but should include the	The green belt is implemented by the local planning authority with adequate means for planning.	A dedicated Planning Inspectorate is established in England and Wales to oversee local planning and hear appeals

	planning	strategy of solving environmental issues through the urban planning system		
Urban Growth Boundary (UGB) of Oregon State, USA	Decree concerning the Land Use Planning of Oregon State	UGB is the growth areas around the cities. The land might belong to the jurisdiction of adjacent town, which needs to be coordinated by the land protection and development committee of the state.	Metro is a regional institution that formulates and manages UGB, namely, the regional government and metropolitan planning organization.	The land use supervision system of the state. The local government will submit the UGB proposal, while the land protection and development committee will approve it.
Spatial planning of Netherlands	Law concerning spatial planning	The spatial planning and the environment are the responsibility of one department (Ministry of Infrastructure and the Environment)	The municipal administration is responsible for implementation. The urban land use and construction scale will be subject to the control of an annual plan while urban planning will be reviewed and approved based on an environmental assessment.	Joint monitoring by the Environmental Assessment Agency and the Mobility Expertise Center
Spatial planning of Denmark	The Planning Act Finger Plan 2007, the national planning directive for Greater Copenhagen	The Ministry of the Environment's water resource plans and Natura 2000 plans comprise a binding framework for municipal planning. The spatial planning of Greater Copenhagen is the responsibility of 34 municipalities. Regional urban development must coordinate with the master infrastructure of Copenhagen, especially the public transport service.	Three of the seven environment centers under the Ministry of the Environment will coordinate with each city on spatial planning, so as to integrate the interests of the whole country. The implementation of Copenhagen spatial planning is based on the assessment of development of the whole region, which must be consistent with the principle of the whole urban structure.	The planning system of Denmark is decentralized. The municipal council is responsible for city level and local comprehensive land use requirements, while the regional council formulates the spatial development strategic plan for each region, and the Ministry of the Environment ensures the national interests by establishing the national plan and ensures that municipal planning meets national requirements.

4.2. Fuzhou UREMP

Fuzhou city is located in the frontier area of the southeast mountain ecological barrier and downstream of the Minjiang River. The area of Fuzhou is 12,000 km^2 with a population of 7.1 million, including five districts, five counties and two cities. Fuzhou city is an important city in the southeast coastal economic zone and it has important ecological functions, with international migratory nodes for birds. Fuzhou is the central city of the West Strait Economic Zone, the southeast coastal advanced manufacturing base, and one of China's important natural and cultural tourist centers.

The bioregions of Fujian Province are the medium and low height mountain area, the low height hills and valley basin, the coastal tableland and hills, and the offshore area. Environmental functions in Fuzhou city include the protection of fisheries and wetlands, the maintenance of water environment and reservoirs and the landscape around them, and the protection of the sources of drinking water. Research in relation to these issues needs to cover the areas of Fuzhou and the adjacent cities of Putian and Quanzhou.

Taking into account the pattern of urban areas of Fuzhou, the location of the subregions of the four bioregions shared by Fuzhou and neighbouring cities, the pollution spread offshore by the main river through Fuzhou, and the distribution of atmospheric pollutants coming from the northeast beyond the city and spreading southwest from the city, the UREMP team defined the areas for comprehensive research as being the whole of Fuzhou and its offshore areas, together with Ningde to the north and Putian and Quanzhou to the south, all in the Province of Fujian.

Fuzhou mapped 16 water environment control units (combining water-collecting area and functional area of water environment). The measurement of environmental capacity was based on both a one-dimensional model and a two-dimensional model, and an uneven coefficient was introduced for correction. The measurement of the pollution load was (for non-point sources) by the experience coefficient method; and (for point sources) by investigation and statistical methods.

The Fuzhou UREMP planners determined that measuring water runoff volumes requires relatively small amounts of data compared with calculations based on cross sections, and can directly give an efficient estimate of the total capacity of the entire water system. All sub-watersheds were classified as saturated (pollution discharge is 1.5 times the absorptive capacity), balanced (discharge is between 0.8 and 1.5 times the capacity) and surplus (up to 0.8 times the capacity). Management measures included changing the guidelines for regulating industrial establishments, with new policies in overloaded areas for (i) replacing small units with large ones, (ii) substituting materials with less polluting materials, and (iii) reducing pollution by "replacing project with half pollution". Management measures also included setting new targets: in overloaded areas, the discharge of pollutants is to be halved by 2020; in these areas and in balanced areas, the discharge of pollutants should be limited to 90% of the absorptive capacity; and in other areas, in principle, the discharge of pollutants should not increase above present levels. In these ways, targets were set for all watersheds for 2020 and 2030.

Fuzhou has established a multi-objective indicator system for absorptive capacity of water resources, which combines the indicator evaluation and analytic hierarchy process to calculate the index of absorptive capacity of water resources over future years for all districts and counties in Fuzhou, on which advice concerning water resource allocation will be based.

Fuzhou adopted CALPUFF as the primary model for simulating air flows, to evaluate concentration vulnerability, layout sensitivity and receptor importance. The grid for both concentration vulnerability and layout sensitivity was 3 km by 3 km. The object of evaluation was sulphur dioxide. Fuzhou adopted the Weather Research and Forecasting (WRF) model as the meteorological model, and used the WRF-modified A-value method to calculate the environmental capacity and bearing rate of sulphur dioxide, nitrogen oxides and particulate matter (SO_2, NO_X and PM_{10}).

The findings were translated into targets and controls for SO_2 and NO_X based on three basic principles: the atmospheric environmental quality of all districts and counties should not be degraded, emissions in months with bad weather conditions should not be overloaded, and air quality must continuously improve. This allowed the whole administrative area of Fuzhou to be divided into red line, yellow line and green line zones of atmospheric environment quality.

In preparing a UREMP plan, practical experience shows that the first step is to establish the database of geographic information, including topography, vegetation, and land use including urban land use. The second step is to analyze air, water and ecosystems on land and in the marine environment, to identify the sensitive areas and vulnerable areas of all environmental systems.

Remote sensing and GIS technologies are used to map terrain, topography, climate, soil, vegetation coverage and land use; to assess the sensitivity, vulnerability and importance of urban and rural ecosystem, and to define core areas, buffer areas, ecological corridors, radiating strips and strategic ecological nodes. From this, red, yellow and green line zones were determined.

4.3. Yichang UREMP

Yichang city is located in the west of Hubei Province, at the junction of the middle-upper reaches of the Yangtze River. The area of Yichang is 18000 km^2 with a population of 4.05 million, and includes five districts, five counties and three cities.

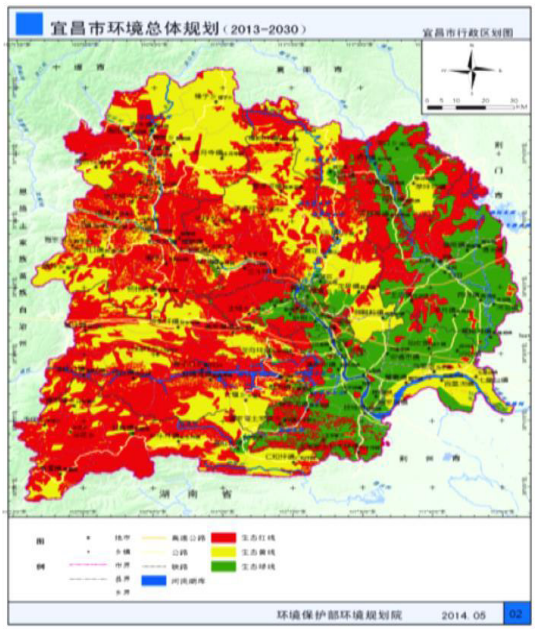
At a high level and large scale, the Yichang administrative area performs the following nationally-significant functions: as an important nodal region, Yichang functions to maintain the ecological conditions of the Yangtze River basin; as a transitional zone from the Qinling and Dabashan Mountains to the Jianghan Plain, Yichang is a typical example of a complex ecological environment with strong environmental sensitivity; Yichang plays an important role in guaranteeing ecological environmental security of the Three Gorges Reservoir Region and western areas of Hubei Province; Yichang functions as a gene bank to preserve certain endangered species of China; and Yichang is a crucial area to protect species abundance, safeguarding national species security.

The importance, vulnerability and sensitivity of the water environment was analyzed. There are 2545 watersheds, 286 surface water environment functional areas, and 135 drinking water protection areas. Drawing on comprehensive analysis, red, yellow and green lines were mapped. In the red line area: (i) there should be no sewage discharge; (ii) polluting facilities should be removed, and new construction, renovation and expansion of such facilities should be prohibited; (iii) all construction approvals should be suspended; (iv) pollution prevention and control should be strengthened; and (v) industrial point-source pollution with larger impact on the water environment should be gradually reduced. Strict approval standards should be implemented in the water environment yellow line area. Water quality compliance should be promoted in the water environment green line area in accordance with the requirements of relevant economic and social development plans as well as environment protection planning.

In formulating air quality protection policies for Yichang, the environmental planners first simulated the wind field for the whole administrative area of Yichang at a resolution of three kilometres, then used terrain data to simulate atmospheric flows at a resolution of one kilometre, emphasising wind directions and speed. The sensitivity of the spatial distribution of pollution sources was quantified using the CALPUFF model, to identify locations with higher affected scope and degree under equal pollution emission. The transmission and concentration of air pollution were quantified using the CALPUFF model, to identify locations where pollution was likely to be concentrated. Finally, the receptors were mapped in relation to land use and built-up areas, to estimate the affects on people's health. This spatial analysis enabled the planners to divide the whole administrative area of Yichang into red line, yellow line and green line zones (Figure 4.1).

Map 4.1 Ecosystem protection red line zoning of Yichang

Source: *Report Four: Domestic Pilots and International Best Practice Cases of UREMP*



4.4. Guangzhou UREMP

Guangzhou is the provincial capital of Guangdong Province and also the political, economic, scientific, educational and cultural center of the province. Guangzhou city has a population of more than 10 million, and the region's GDP was more than one trillion RMB. It covers an area larger than Shanghai and is a typical large city in China. At present, Guangzhou city has completed the initial outline text of the environmental master plan for the city.

In analyzing the water environment, Guangzhou identified 120 control units (combining water-collecting areas and functional areas of the water environment). Both one dimensional and two dimensional models were used. For pollutions sources, the experience coefficient method was used; for point sources, each pollution outlet was investigated and statistics were collected. Management strategies were based on about 90 water environment control units.

In analyzing the atmospheric quality, Guangzhou used the CMAQ model to estimate concentration vulnerability, layout sensitivity and receptor importance. For concentration vulnerability, a 1 km by 1 km was used; for layout sensitivity a 3 km by 3 km grid was used. The system tested for sulphur dioxide, nitrogen oxides, ozone and fine particles (SO_2, NO_x, O_3 and $PM_{2.5}$). Goals were set to meet the principles that atmospheric environmental quality of all districts and counties should not be degraded, that emissions in months with bad weather conditions should not be overloaded, and that air quality needs to continuously improve. These objectives were translated into red line, yellow line and green line zones of atmospheric environment quality.

Remote sensing and GIS technologies were used to map terrain, topography, climate, soil, vegetation coverage and land use; to assess the sensitivity, vulnerability and importance of urban and rural ecosystems; and to define core areas, buffer areas, ecological corridors, radiating strips and strategic ecological nodes. The assessment of ecosystem importance took into account many factors including water source conservation, water and soil conservation, biodiversity protection, nutrient maintenance, eutrophication, coastal belt protection, storm tide resistance, marine breeding areas, flood regulation, wind prevention and sand-fixing. The report 'National Ecological Protection Red Line-Ecological Function Red Line Delineation Technical Guide (Trial)' (Huan Fa [2014] No. 10) was followed in the development of comprehensive red, yellow and green line zones for Guangzhou, incorporating the controls listed in Table 4.3.

Table 4.3 Controls applied to the environmental protection zones in Guangzhou

Source: *Report Four: Domestic Pilots and International Best Practice Cases of UREMP*

	Control Requirements
Ecological function red line zone	Visit and tourism projects inconsistent with natural reserves, forest park and scenic area protection directions should not be constructed. Necessary construction projects in scenic spot should follow requirements in related laws and regulations. Construction land area and construction contents should not exceed related requirements. The built-up unrelated construction projects should be demolished or closed. Population is guided for relocation in order, thereby realizing 'zero emission' of pollutants and improving environmental quality.
Ecological function yellow line zone	Various development activities should be strictly controlled, construction projects damaging ecological environment should not be newly constructed or expanded. Pollution-type industrial projects should not be constructed. Biological environment should be comprehensively remedied in key areas with biological damage and water-soil erosion. Development content, mode and open strength control should be strengthened, various industrial enterprises should not be newly constructed, and area of existing industrial development should not be expanded in principle. More strict industry access environment standard should be implemented, project access should be strictly controlled, and biological restoration should be energetically implemented.
Ecological function green line zone	Biological protection should be focused in regional development and construction activities, development scope, mode and development degree should be strictly made clear. Biological restoration should be strengthened in biological environment vulnerable areas with serious water and soil erosion, etc. in the region, and the above activities should be orderly developed under the precondition of guaranteeing biological environmental health.

4.5. Weihai UREMP

Weihai city, located on the eastern tip of Shandong Peninsula, has an area of 5797 km2. It is an eastern coastal city, a node of the Bohai economic circle, and within the Shandong Peninsula Blue Economic Zone. Weihai is a famous coastal tourist city in China with a good environment and beautiful scenery. It is a model city for the atmospheric environment and ecological environmental quality in Shandong province, and also an ecological culture city with history, religion, humanity and nature. On 8 August 2014, the Weihai environmental master planning outline received expert endorsement.

The control units chosen for assessing the water environment were 43 reaches, combining water environment functional area of the main rivers and actually monitored sections. The runoff volume method was used to measure environmental capacity. Pollution loads were estimated by the experience coefficient method for non-point source pollution and by the investigation and statistical method for point sources.

The importance, vulnerability and sensitivity of the water environmental system were analyzed. The important areas, sensitive areas and vulnerable areas in the administrative districts of the city were recognized, and zoning requirements were formulated. The red line zone should have no sewage outfalls. New construction, renovation and expansion of emission pollutant construction projects should be prohibited (completed projects should be removed or disabled). Construction project approval should be suspended, water environment pollution prevention and control should be strengthened, and industrial point-source pollution with larger impacts on the water environment should be gradually reduced.

In the yellow line zone, strict approval standards should be implemented. A comprehensive and systematic water environment monitoring network needs to be established, and total control and total replacement measures implemented. Emission of water environment pollutants should be gradually reduced. In the green line zone, water quality compliance should be actively promoted in accordance with the requirements of the relevant economic and social development plans as well as environment protection planning.

In assessing the atmospheric environment, both the CALPUFF and CMAQ models were used to assess sulphur dioxide and nitrogen oxides (SO_2 and NO_x) and primary particulate matter concentration vulnerability (on a 1 km grid), layout sensitivity (on a 3 km grid) and receptor importance. Taking the annual average concentrations of the three pollutants reaching Class I and Class II standards as constraint conditions, the 1 km ventilation coefficient was calculated using the WRF-CALMET model. The A-value method was adopted for calculating the maximum allowable emissions of SO_2, NO_x and particulates in the four typical months of January, April, July, October and the whole year. The spatial patterns of environmental capacity of the three air pollutants was mapped for each district and county, and the whole administrative area of Weihai was divided into red line, yellow line and green line zones of atmospheric environment quality.

The methods for assessing and protecting ecosystems in Weihai were similar to those used in Guangzhou, based on 'National Ecological Protection Red Line-Ecological Function Red Line Delineation Technical Guide (Trial)' (Huan Fa [2014] No. 10). Similar controls were applied to the red line, yellow line and green line zones (Table 4.5).

Table 4.4 Proportion of red line, yellow line and green line zones in Weihai

Source: *Report Four: Domestic Pilots and International Best Practice Cases of UREMP*

	Area	Proportion
Red line area	1761 km^2	31%
Yellow line area	1139 km^2	20%
Green line area	2744 km^2	49%

4.6. International best practice cases: European Union “Green Structure”

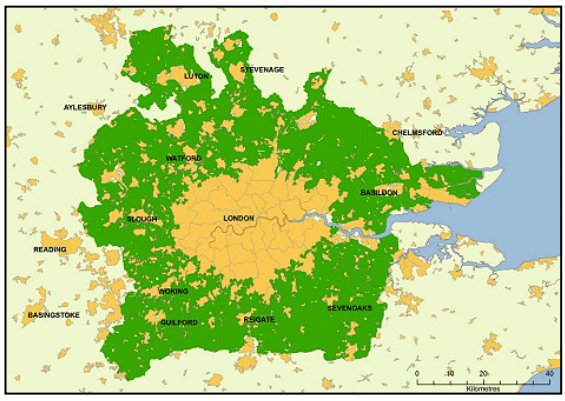
The European Union initiative ‘COST Action C11’ 2005 promotes the concept of ‘Green Structure’ as an umbrella term to include green belts, open space, buffer zones and all the other labels which planning and environmental professionals apply to land adjoining urban development and transitioning to and integrated with agricultural land and rural landscapes. (COST – Cooperation in Science and Technology - is the longest-running European framework supporting trans-national cooperation among researchers, engineers and scholars across Europe.)

The COST project conceded that, within Europe, the traditional pattern of ‘compact urban islands within a sea of green’ has been reversed. These trends continue apace despite negative urban growth rates. The majority of the population now lives in landscapes where this pattern is turned upside down. Structural green space has always been a key element in the western tradition of development planning and the design of urban form; but, in reality, it is seldom considered in a ‘holistic’ or ‘systemic’ way which encompasses intra-urban space, extra-urban space and inter-urban space as integrated ecological, social and economic assets.

The main lesson from this experience is that while something approaching a professional consensus on the need for sustainable urban growth patterns may exist world-wide among urban and regional planners, this consensus does not generally extend across political and business interests. In this situation, every green space becomes a battle-ground and the establishment and defence of green structure at the urban and metro-city scales involves extensive and continuous justification. Observing European experience relating to green structure, there will be methodological lessons and operational lessons. China can cherry-pick the best ideas but it demands its own solutions.

4.7. International best practice: UK Green Belts

The greenbelt is both a policy and land-use designation. It is designed to retain areas of undeveloped land and protect the farmland which surrounds urban areas. To quote official guidance on the subject, “The Government attaches great importance to Green Belts. The fundamental aim of Green Belt policy is to prevent urban sprawl by keeping land permanently open; the essential characteristics of Green Belts are their openness and their permanence” (UK Government, *Planning practice guidance*, February 2014; http://planningguidance.planningportal.gov.uk/blog/guidance/).



Green belts are not necessarily encircling 'belts' as the name suggests. Although the seminal London Green Belt takes this form, there are other instances where the legislation has been used to create green ‘wedges’ - axes of protected land which extend into the built-up area of a city, or so-called 'green lungs' – intra-urban zones entirely surrounded by development. Green belts have been criticized for causing sporadic and dissociated development, where new growth takes place in new locations in rural areas, while suburban greenbelt areas remain sacrosanct. Green Belt boundaries are set down in local plans and have precise boundaries at this scale.

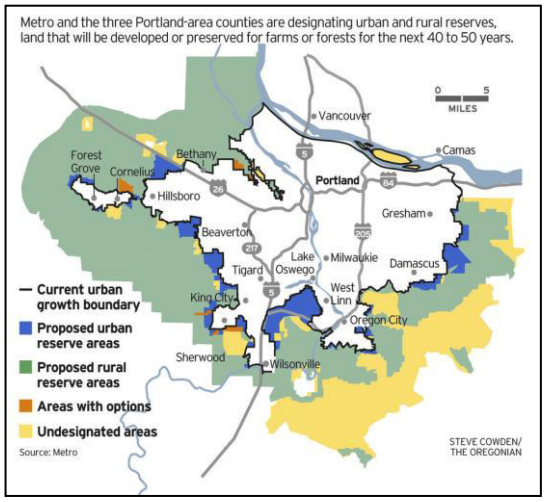
Marco Amati, in his history of green belts in cities as varied as London, Tokyo, Vienna and Melbourne, observes that “a number of well-known alternatives to a green belt exist, allowing planners to opt, for example, for a green wedge, a greenway or a green-web. Despite these forces of change, green belts can be found next to fourteen cities in the UK, where they have remained a central plank of national planning

policy for more than fifty years. Planners have successfully enforced green belts despite sustained periods of high development pressure particularly in the South-East of England. Green belts have garnered broad political support throughout successive changes of government. Yet, the UK's green belts are by no means sacrosanct and a debate currently rages on their future in relation to housing and the urban fringe" (Amati, M, *Green Belts: A Twentieth-century Planning Experiment*, Routledge, 2008).

4.8. International best practice: Portland's urban growth boundary

Despite its name, an urban growth boundary is not a line but a zoning measure. It zones the land outside the boundary in a manner that restricts urban development and seeks to maintain a working rural landscape right up to the edge of the built-up urban area. Inside the boundary, many forms of land use may be permitted and protected, including nature reserves, open space, ecological land, and the like. The primary purposes of an urban growth boundary, therefore, are to retain the urban region's compactness, and to increase the urban density, while preserving good-quality farmland, forests and open space. In turn, these goals are intended to strengthen urbanity and reduce the dominance of private car transport (particularly for the journey to work).

The first example of an urban growth boundary was in the State of Kentucky in 1958. Since the 1970s a number of state-wide programs have been created. Seven states have mandated urban growth boundaries at the local level (Hawaii, Maine, Maryland, Minnesota, New Jersey, Oregon, Tennessee, and Washington). The urban growth boundary for the metropolitan area of the city of Portland in Oregon is the most developed and best known. It dates from 1973.

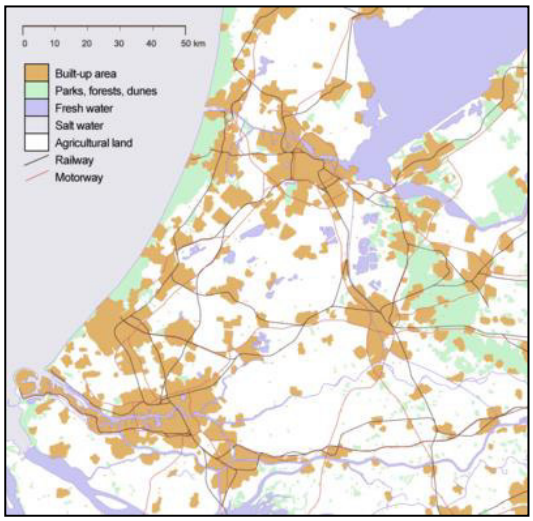


The current urban growth boundary of the Portland Metro area encompasses an urban area of approximately 400 square miles with a population of about 1.5 million people. Every few years since the late 1970s the boundary has been moved as necessary. Mostly the additions to the urban area were small; sometimes hundreds or thousands of acres were added, and in one case 19,000 acres were added, to meet the state's legal requirement that urban authorities must maintain a 20-year supply of residential, commercial, and industrial lands inside their urban growth boundaries. Five-year spatial plan updates include modifications of the boundary to maintain the land supply requirement and safeguard employment creation. The urban growth boundary has expanded much less than the population has grown; in its absence, sprawl would have ensured that the opposite would have been true.

The urban growth boundary has been successful, and popular. Inside the urban growth boundary the average density of housing has increased from five dwellings per acre to eight dwellings per acre and multi-occupancy housing units now make up about half of all new building permits. However, high rates of infill and redevelopment have been associated with low overall levels of housing production. There is a housing deficit in Portland, and in 2004 Portland ranked among the 10% least affordable housing markets in the USA (Myung-Jin Jun. The Effects of Portland's Urban Growth Boundary on Urban Development Patterns and Commuting, *Urban Studies,* Vol. 41, No. 7, 1333–1348, June 2004). Nevertheless, despite controversies, recent votes in Oregon show that, even in the US where individual freedom is defended and property regulation is resisted, the citizens value environmental and amenity benefits over some forms of property rights.

4.9. International best practice: Randstadt and Green Heart

Randstad consists of a ring of cities, including Amsterdam, Rotterdam, The Hague and Utrecht, with a population of about 6 million, and a central core with 670,000 inhabitants. Since the late 1950s, the idea of Randstadt (rim city) has been that of a ring of discrete but interrelated urban regions surrounding a large central open area (the 'Groene Hart' or Green Heart) about 60 kilometers across, with the urban regions clearly separated by green buffer zones.



There are a few long-established small towns and numerous villages within the green heart. Nevertheless, it is largely a rural area, characterized by livestock and arable farming, market gardening and leisure pursuits. The population density in the outer, urbanized 'ring' is approximately 1,680 per km^2, and in the Green Heart 470 per km^2 (slightly higher than for the Netherlands as a whole). The main part of the Green Heart is located in the province of South Holland, with smaller segments in North Holland and Utrecht. The Green Heart contains 43 municipalities in their entirety and parts of 27 others. The Green Heart is thus not entirely rural, nor are the constituent cities entirely urban. Nevertheless, the 'hollow centre' gives Randstad a totally different character from most multi-nuclear metro-cities and city clusters, e.g, London or Paris.

Randstad is the best-known planning doctrine associated with Netherlands and advanced by Dutch planners and policy-makers. Ranstadt received extensive international attention in the mid-1960s. Since then, it has been put forward in many quarters as a sustainable urban development model. However, the 'green heart' is perhaps a less coherent concept than its international reputation may suggest. The major cities are as separate and distinct from each other as most adjacent urban areas. The original Green Heart was a vague planning concept. Randstad remains an area with a de facto structure but no clear boundaries and no clear policies.

The Netherlands experiences the world-wide trend where population and economic activity gravitates towards metropolitan and mega-city regions. Hence debate continues about how Randstad should develop further and about how it should be governed. Much of the debate has been driven by the 'Deltametropolis Association', founded in 1998. The four largest cities combined with another eight municipalities and four regional chambers of commerce in the Randstad to form a pressure group for change. The weight of consensus now is to develop the Randstad region into a metropolitan entity called the 'Deltametropolis'.

Thus national, regional and local stakeholders have formed a broad and growing coalition for change motivated by ambitions to improve the international, inter-regional and inter-urban competitiveness of Randstad as an investment location. Despite protestations and extensive academic papers arguing the merits of this revisionist policy, there are fears that economic growth priorities now effectively threaten the whole 'ring-city - green heart' concept and turn it on its head. The current Dutch government policy allows for the larger cities on the edge of the city region to expand within a program of managed growth which attempts to maintain the essence of a green heart. However, all the evidence suggests that the green heart is shrinking and becoming less green.

Nevertheless, the ecological corridors that extend from the Green Heart and run between the cities, known as Rijksbufferzones, have kept the Randstad cities separate, after the fashion of the UK Green

Belts. Although this residual green structure was not established to address specific environmental concerns or to further the concept of a sustainable city region it has become a crucial part of the legacy.

4.10. International best practice: Emscher Park

Emscher Park has become a model for environmental rehabilitation and economic recovery with relevance to many obsolete heavy industrial areas throughout the world. North Rhine-Westphalia administration created the Emscher Park in 1989, with the aim to facilitate outstanding urban, architectural, cultural, ecological and economic initiatives.

An independent corporation owned by the state government, IBA GmbH, was set up to drive the project. No changes were made to the powers of local and regional governments, and no new funds were committed. Success depended on inspiration, the credibility of IBA GmbH, the clarity of the vision, the initiatives of federal, state, regional and local governments and other partners, and the redirection of existing resources.

Emscher Park comprises the inter-riverine region between the Ruhr River in the south and Lippe River in the north and with the Emscher River in the centre covering around 457 km^2 across 20 municipalities. The Landscape Park was established as the central component of an integrated development strategy for the former industrial region. About two million people live in the region. In relation to urban management: at the state level, the State Chancellery is responsible for spatial planning of the North Rhine-Westphalia federal state. It also coordinates the involvement of other relevant ministries.

There was a long-standing tradition of regional planning with provisions for green corridors and public green linked to environmental concerns for air quality and water supply in the Rhur Region. This dated from the 1950s but could not survive industrial decline. These factors make it difficult and often uneconomic to build new infrastructure and reuse contaminated brown-field sites.

The Emscher Masterplan established development strategies and identified growth areas and priorities for urban projects, green structure, parkways, water projects and open space as the platform for the development of the regional park system. The Emscher Landscape Park is now conceived as the ‘green heart’ of a Ruhr Metropolis. It covers about 450 km2 and includes more than 200 individual regeneration projects following the establishment of the IBA in 1989. On-going operation and maintenance is the responsibility of the Ruhr Regional Association (RVR).

The strategy was established on the back of 2.5 billion Euros of investment commitments from national, EU and private sector sources. It involves: setting up a collaborative process based on a strong spatial concept of green space; combining hundreds of individual project proposals under a single unifying planning context; and networking communities, private investors, individual citizens, local companies and special interest groups.

As a first step, the extensive inventory of brown-field sites in public ownership was used to generate project ideas. Strategic ‘flagship’ projects were designed to catalyze environmental transformation. The region’s industrial heritage and culture were reinterpreted as assets to create a cohesive regional identity. The master-plan was structured in terms of sub-units each managed by a different steering group. As an

essential precursor to attracting outside investment in economic regeneration, low-cost dwelling units were developed via rehabilitation and new-build programs.

Emscher Park is innovative in a number of ways. It uses 'ecology' as the central organizing focus for the regeneration of the region's economy as well as its environment; industrial wastelands are transformed into a network of open space, recreation, and cultural resources at a regional scale; and as the largest derelict area regeneration project in Europe, it confronts brown-field restoration on a regional, rather than site-specific, basis.

Emscher Park is widely regarded as a highly successful project, and is thus also a model for new forms of governance, including policy networks, joined up government, collaboration, the sharing of resources between and outside governments, and policy making outside government.

This was a highly complex initiative involving the creation of an entirely new administrative structure after the fashion of the time-limited development corporations and enterprise zone authorities in the UK, but on a much larger scale. In this case the vehicle was the 1989 International Architecture Exhibition (Internationale Bauausstellung or IBA). Innovation was fostered through a free exchange of ideas in conferences and seminars, canvassing external expert opinion. Emscher Park has transformed its image as an investment location and has lifted the aspirations of a dispirited population through the simple concept of green structure as a transformative element in the urban environment. The lessons from these international examples are summarised in Table 4.5.

Table 4.5 Summary of international experience for Green Land

Case Study	Key Characteristics	Current Status	Applicability to China
United Kingdom green belt (London and nation-wide)	National-scale zoning and land-use policy instrument, repurposed to address the contemporary concerns of environmental protection, the drive for sustainable cities and the increasingly important climate-change agenda.	Under some threat concerning its impact on cost of housing land in the capital city and impinging on the laissez-faire principles of the free-market economy during periods of economic recession. However, the green belt commands such wide popular support it is likely to weather most short-term political pressures.	Applicable in the China context, but there is a mismatch between the China situation (zoning on environmental criteria as supported by the environmental law) and the UK situation (an instrument based on spatial organization and planning criteria which can be designated without any specific ecological or landscape criteria being met)
United States urban growth boundary (Portland)	Limited location specific initiative which has been continually modified under development pressure, but remains valuable in relation to reducing urban scatter and sporadic development in those locations where it is applied.	Under threat concerning impact on cost of housing land in Portland and impinging on the laissez-faire principles of the free-market economy	Applicable to China, but essentially adds nothing new in terms of the philosophy and tools available to address environmental issues associated with rapid urbanization
The Netherlands Randstad (Groene Hart/Deltametropolis)	More a description of an evolved urban pattern than a planned or implemented concept. Nevertheless, the urban structure and urban environmental qualities thus created have been influential in the planning profession and have demonstrated the values inherent in specific urban and rural land use mixes.	Has not been sufficiently robust to resist the pressures of suburbanization. However, the new development 'concept' for the area is also a possible model for replication with low density suburbs and integral 'green lungs'. The more explicit integration of water elements in delta planning is timely.	The current system is not especially compatible with the objectives of the environmental master planning law. Thus there may be limited application to China, except to demonstrate the value of identifying 'desirable' evolved patterns and protecting them to the extent possible to develop a robust green structure.
Germany Emscher Regional Park	Location specific initiative to address widespread post industrial dereliction.	Growing in importance as a model for the integrated redevelopment of obsolete urban economies and urban patterns	Applicable to China where comparable initiatives are in progress to support urban regeneration and industrial restructuring in the urbanized 'rust belt' of the north east.

5. Guide to the Resources for UREMP

5.1. The outputs of the UREMP TA project

The TA produced four reports and carried out two main workshops and training events, and trainings in pilot cities. The four reports are: (i) *Executive Report: Summary of UREMP in the PRC – Protecting China's Green Land from Urban Development, Urban Sprawl and Overdevelopment*; (ii) *Report Two: Technical Guidelines of UREMP*; (iii) *Report Three: Recommendations for Policies and Institutional Arrangements of UREMP*; and (iv) *Report Four: Domestic Pilots and International Best Practice Cases of UREMP*.

5.2. About the *Executive Report*

This Executive Report provides a comprehensive summary of UREMP, including a description of the methods and techniques to be used, recommendations for policies and for institutionalising urban-rural environmental master planning at various levels of government in the PRC, and lessons from successful examples of UREMP in the PRC and international best practices of urban-rural environmental protection, planning and management. This report is intended for senior government officials, government administrators on national, provincial and local levels, technical specialists, practitioners, stakeholders and members of the public, the thinking behind UREMP, the practical steps to prepare UREMP Plans, and the reforms needed to integrate spatial environmental protection plans with the other land use and urban development plans.

5.3. About *Report Two: Technical Guidelines of UREMP*

Report Two contains the practical steps and guides for the preparation of UREMP plans. It is summarised in Chapter 2 of this report. The method for preparing a UREMP Plan includes eight major Steps: (1) defining the UREMP Area; (2) setting up the data platform and Atlas; (3) describing the overall environment of the UREMP Area; assessing the specific values of (4) Green Land, (5) water and (6) air in the context of urban and other development; identifying opportunities for (7) environmental restoration, and finally (8) integrating all of these findings into the UREMP Plan.

It will be seen that the first three Steps are essentially concerned with initiating the UREMP planning process: defining the UREMP Area, setting up shared map and data systems, and producing an agreed, holistic description of the environment of the UREMP Area. The next three steps are about the core content of UREMP Plans: the many aspects of Green Land, the water environment and the air environment. There is one Step related to environmental restoration, and finally one Step where all of the findings are integrated. The Steps are set out in Table 2.1 of Chapter 2 of this report.

Each Step contains a number of Modules. A Module is a set of specialised tasks related to a particular issue or objective. Each Module generates a specific set of maps and databases in the Atlas. There are potentially 34 Modules in a comprehensive UREMP process, all of them listed in Table 2.1.

5.4. About *Report Three: Recommendations for Policies and Institutional Arrangements of UREMP*

Report Three describes the present state of environmental protection planning in China and considers the necessary reforms and procedures to enable UREMP plans to become effective and operational instruments of environmental protection. The challenges facing environmental protection and the proposed reforms and recommendations are summarised in Chapter 3 of this report.

The recommendations made in *Report Three* address five core issues. One of the five fundamental principles of the Environmental Protection Law is *integrated governance*. Since a UREMP Plan is likely to extend to large natural systems, and is also likely to involve a number of cities and the agencies of more than one province, *coordination* is essential. The report firstly recommends structures that facilitate

internal coordination within the city government, and then structures to facilitate communication, coordination and negotiation with provincial departments and the surrounding cities and counties.

The development and implementation of UREMP Plans will require major changes in *institutional cultures and professional practices*. If these changes are made and maintained, the resources available for environmental protection will be larger and stronger, natural systems will be managed holistically, and development will be controlled with greater authority and effectiveness. Two forms of institution building will be required: firstly, to enable governments to work together in the preparation of UREMP plans, using joint or compatible structures, procedures, IT platforms, etc; and secondly to facilitate collaboration between the diverse professions and disciplines required to fully incorporate environmental values into land use plans, master plans and urban and rural development plans. The report makes recommendations regarding planning levels, expertise, planning processes, formal adoption of UREMP plans, implementation, evaluation and guidance from higher levels of government.

Comprehensive, location-specific environmental protection planning, and integration with existing forms of spatial planning, will require new *management policies and procedures*. The report makes recommendations regarding integrated spatial planning, location-specific standards, location-specific limits and caps, location-specific interventions, eco-compensation, risk management and ecological assets accounting.

Finally, for UREMP plans to become effective and operational instruments of environmental protection, significant *capacity building* will be required. The report recommends that the preparation of UREMP Plans, by collaborating cities, should be overseen and guided by qualified and experienced staff members in environmental planning agencies of provinces, autonomous regions and municipalities directly under the central government. These units should form an environmental planning team with complete business areas, professional skills and reasonable personnel structure and provide the necessary instruments and equipment, service systems and modelling tools. The professional teams should receive specialised UREMP training.

With the revision of the Environmental Protection Law of the PRC, the establishment of a comprehensive *legal basis* for environmental protection planning is urgent. The report sets out options and recommendations to improve the laws and regulations from the national to the local levels.

Report Three lists in Table 5 the internal units and responsibilities at the national, provincial and municipal levels in relation to preparing UREMP Plans.

5.5. About *Report Four: Domestic Pilots and International Best Practice Cases of UREMP*

Report Four is summarised in Chapter 4 of this report. It has three principal components. The introductory section contains a supplementary and additional analysis and discussion of the challenges facing environmental protection in the PRC, leading to recommendations regarding the principles that should guide the development of UREMP. This section is not summarised in this report, since the issues are covered in the first part of *Report Three: Recommendations for Policies and Institutional Arrangements of UREMP* and are summarised in Chapter 3.

The second section of *Report Four* has descriptions of the main features of the UREMP plans of Fuzhou, Yichang, Guangzhou and Weihai. It is illustrated with many maps drawn from these four pilot cities. The third section of *Report Four* describes and discusses four major urban strategies that seek to protect the environment from urban expansion: London's green belt; the Copenhagen finger plan; the Randstad in the Netherlands; and the urban growth boundary for the metropolitan region around Portland in the State of Oregon, USA. The ways in which this foreign experience may be relevant to the PRC are discussed.

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Appendix

National city clusters Referred to in Section 2.1 and Section 3.2.

The initial ten city clusters were Beijing-Tianjin-Hebei, Yangtze River Delta, Pearl River Delta, Central and South of Liaoning, Shangdong Peninsula, West Coast of Taiwan Straits, Central Plains, Middle Reaches of Yangtze River, Guanzhong and Chengdu-Chongqing. These city clusters have been followed by ten more: Harbin-Daqing-Qiqihar-Changchu-Jilin cluster, a Hohhot-Baotou-Erdos-Yulin cluster, a Taiyuan cluster, a Ningxia cluster along the Yellow River, a Yangtze and Huaihe Rivers cluster, a Beibu Gulf cluster, a Central Guizhou cluster, a Central Yunnan cluster, a Lanzhou-Xining cluster and a Urumqi-Changji-Shihezi cluster.

Map A.1 Map of city clusters

Source: HU Lile. 'New-type Urbanization, Eco-civilization in China and Potential Impacts on Biodiversity.' Paper given at the 8th Sino-German Workshop on Biodiversity Conservation, Berlin, 2015.