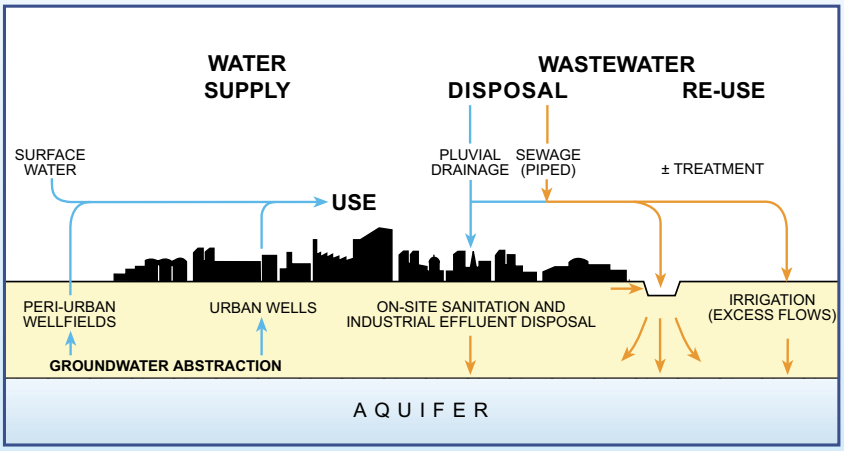
PLANNING REVIEW FOR GROUNDWATER PROTECTION POLICIES



Wider Considerations

Introduction

The purpose of this section is to carry out a review of groundwater issues from a planning perspective in order to integrate land use planning with ground water protection and sustainable use. This review is based upon an analysis of existing literature on planning in developing countries, the sustainable management of groundwater resources and upon case-study material supplied by the British Geological Survey. The Planning Checklist and Assessment Matrix tools described elsewhere are derived from this report. The project brief for this review is as follows:

To undertake a planning review focused on groundwater-dependent developing-world cities. The review would use the experience of the two project case-study cities of Bishkek and Narayanganj to illustrate how aquifer protection policies can be meshed into pragmatic planning tools suitable for use in other developing world cities similarly dependent on groundwater for public and private domestic, industrial and commercial water supply.

The guiding principles for the development of the land use planning policy approach for groundwater protection are those of:

- sustainable development;
- the precautionary principle; and
- the need for policies to be pragmatic, realistic and capable of being implemented without major resource requirements or significant retraining of planning and other relevant staff in government and other agencies.

In groundwater dependent cities in developing countries, the sustainable use of groundwater is crucial to the sustainability of the cities as a whole. Unsustainable practices are performed most often by those who suffer the worst consequences of water shortages and pollution. Before better and more sustainable practices and policies can be fully realised there is a need for awareness building. A further principle, on which a land use planning approach to groundwater management is based, is the need for an integrated environmental policy to be developed in order to facilitate awareness building, participation and consultation.

The report commences with a brief review of existing planning regimes in developing countries, to ensure that any new groundwater policy is compatible with existing knowledge practices and systems. It then examines the relationship between land use planning and groundwater protection issues, with particular reference to the two case study cities. The report then makes the case for two linked principles for the sustainable use of groundwater in developing cities. The first of these principles is the development of an integrated environmental policy approach and the second is the adoption of the concept of environmental capacity as a starting point for the development of an integrated environmental policy for groundwater. In the fifth section of the report the key principles for planning policy that arise out of the earlier review are set out and the suggested main approach to land use policy for groundwater protection is explained.

Existing Planning Frameworks

Planning in developing countries can be characterised as being divided into two broad groups. The first group is economic development planning, which has taken the form of both strategic and regional planning to aid the economic development of countries. The second is spatial or land use planning, which has largely been based upon the planning systems originally created and operated in the developed world. This report will concentrate on the second group – land use planning – and consider some common approaches to land use planning in developing countries.

Land use planning in the former colonial states of the developing world was, in the decades following independence, based largely upon the systems first developed by the colonial powers (Brown, 1997, Conyers and Hills,1984, Chatterjee and Nijkamp, 1983, Doan, 1995, Miles et al 1992, Safier, 1992, Walton, 1992). These planning delivery systems were largely top-down in nature and were based upon a 'Master Plan' that was translated on the ground through zoning approaches to spatial planning whereby land use types would be directed to specific areas of land.

The command economies of the former Soviet block also relied a great deal on 'Master Planning and Zoning' (Nientied, 1998). The Master Plan would set the strategic land use objectives and at local level these would result in areas of cities and regions being zoned or allocated for specific land uses. This zoning approach would be implemented through some form of development control or development authorisation system.

As a result most developing countries, and the former command economies, still employ some form of development control and/or building construction regulations system (Archer, 1992). There were a variety of reasons for adopting the land use zoning approach to development. Land use zoning can provide economies of scale, in terms of infrastructure provision and servicing. Zoning can also attempt to ensure that incompatible uses – housing and heavily polluting industries – are not located together. It can also be used as a tool to direct types of development to places where planners feel they are needed or would be most appropriately located and, indirectly, protect other areas from unwanted or undesirable development.

The Master Plan approach has, over the last few decades, become widely seen as no longer either feasible or desirable (Miles et al 1992, Safier, 1992). Master Plans are far too inflexible to meet the medium or long term needs of developing countries and their record, in terms of implementation, has been woefully poor. According to Morah (1996) there are a number of reasons why the Master Plan approach has largely failed in developing countries:

- lack of sufficient resources;
- external global influences on the development of countries;
- lack of co-ordination between agencies;
- rapidly changing developmental priorities; and
- government instability.

A further problem faced by the Master Planner has been the trend towards mass urbanisation of the developing world. The massive growth of urban areas has often been at odds with the objectives of the plans in force and, despite this, unstoppable (Doan, 1995). The mass urbanisation that has taken place in the former colonial states of the developing world has recently been experienced in the former soviet command economies where the Master Plan approach has also largely failed (Nientied, 1998).

Over the past two decades or so the approach to land use planning in many developing countries has become far more pragmatic and incremental, with a drive towards what can be termed 'project based planning' or 'local discretion planning', whereby the focus of attention is on attempts to ensure that any development that does take place is of a sufficient standard to meet its objectives and needs (Gallant and Kim, 2001, Miles et al, 1992). This approach provides a greater degree of flexibility and recognises the limited influence individual governments have on the nature of much physical development that is taking place in developing countries. These limitations are imposed by virtue of the:

- influence of globalisation;
- lack of resources;

- lack of awareness on the part of the poor and others of the importance of long term planning in deliverance of essential infrastructure and environmental services; and
- impact of unplanned mass urbanisation, originally as a consequence of rural emigration.

The Master Plan approach to planning was very much government led and based upon large centrally funded development projects such as infrastructure provision. More recently the role of central government in many development countries has become more 'enabling' or 'facilitating' than providing and the private sector's influence on development and planning has become much stronger (Miles et al, 1992). This has led to a far more market based and pragmatic approach to land use development. However, pragmatism and flexibility may provide an escape from the rigid and largely unenforceable Master Plan approach but it does tend to only provide for short-term answers. With the widespread acceptance of the principles of sustainable development, more long term solutions to land use problems need to be developed. These sustainable solutions will need not only to retain a degree of pragmatism and flexibility in order to remain practicable and realistic, but also will need to be developed within a framework which recognises the demands of a sustainable future.

Issues in Groundwater Protection

The experience of mass and rapid urbanisation in developing countries has resulted in less sustainable use of urban groundwater systems and practises than existed in the past (Carmon et al 1997, Swyngedouw, 1995). The original water infrastructure in cities in the developing world was often put in place by the former colonial powers and served the size and scale of the cities at that time (Swyngedouw, 1995). In some cases there has been some expansion of piped water systems as part of 'Master Plan' objectives since independence. However, according to Sharma (2000) the speed, scale and unplanned nature of urbanisation has consistently outstripped the ability of governments to provide the necessary water infrastructure to both serve the expanding population and protect groundwater.

This has resulted in many cities of the developing world having two distinct water resource characteristics, what Sharma (2000) describes as **'cities on network'** and **'cities beyond network'**. The 'network' is the water services – piped water and sewage collection systems - that have been planned and constructed as an integrated part of the land use planning of a city. While in many cities of the developing world the maintenance and expansion of the 'on network city' has failed to adequately protect groundwater, it is the 'cities beyond network' which arguably pose the greatest threat to groundwater resources as abstraction and waste disposal are largely unregulated and unmanaged.

Hence we see the potentially unsustainable practice of using the same water source for both drinking water and sewage disposal. This is often compounded by the establishment of small businesses and other informal commercial activities within housing areas and these informal businesses use the groundwater system for the disposal of toxic and other wastes (Sharma 2000). Yet, according to Altaf (1994) there is evidence to suggest that there is not only a demand for better water services in rapidly growing cities, but also a willingness of households to pay for those services.

The results of mass rapid urbanisation on groundwater quality and quantity are now fairly well documented and include complex relationships between land cover, run-off and aquifer recharge, contaminant type and load and unsustainable over-abstraction (Burke and Moench, 2000, Carmon et al, 1997, Foster et al 1998). Foster et al (1998) also show that rapid urban expansion can result in the loss of water resources as the shallow upper aquifer suffers from over-abstraction, becomes too polluted for use and is therefore lost as a resource. Greater pressure is then placed upon lower aquifers. Changes in water table level, as a result of urbanisation, can also affect the existing

building stock in terms of subsidence and waterlogging of foundations – this problem may become more acute with climate change.

The consequences of these problems largely rebound upon the people that cause them, in terms of health problems related to inadequate water supply, poor sanitation and waste management and polluted drinking water (Ferguson and Maurer, 1996, Hope and Lekorwe, 1999). Yet, Burke and Moench (2000) argue that because groundwater is often seen as a 'common property' – that is free – by those who make up the 'city beyond network' population, its use by them is largely undervalued and the complexity and fragility of groundwater systems largely unknown, and therefore there is little understanding of the contradictions, in terms of water resource management, that their lifestyles create.

Issues Raised by the Case Studies

The British Geological Survey carried out two case studies on groundwater vulnerability; one in Bishkek in Kyrghyzstan and the other in Narayanganj in Bangladesh. These case studies are reported in full elsewhere[1] and it is not the intention here to repeat that work. In this report the main issues raised by the case studies will be examined in terms of their relationship to land use planning. The relationship between physical development in rapidly growing cities and the quality and quantity of groundwater resources is a clear one and the problems associated with them are well documented (see Burke and Moench 2000). The role of this review is to identify from those issues, and the experience of the case studies, a land use planning policy approach for moving towards more sustainable development in groundwater dependent cities of the developing world.

The case study cities were examined on the basis of a risk assessment process that related land use types and the hazard they posed to groundwater. The land use types were identified and ranked in terms of the degree of risk they posed to groundwater. This risk assessment process is a well-developed area in land use planning and is used extensively throughout the world in decision making tools such as Environmental Impact Assessment (EIA). Simple risk assessment techniques therefore form a firm base from which land use planning policy approaches can be developed. The case studies also made use of Geographical Information Systems (GIS) techniques to map both groundwater vulnerability and existing land uses. GIS is being increasingly used in land use planning and has been developed specifically for the identification of vulnerable environmental features such as groundwater (Canter et al 1994). GIS has been used for planning in a variety of ways around the world, including plan making and in EIA, and it would seem to be an appropriate tool for aiding decision making in the application of land use policy approaches for groundwater protection.

From a planner's perspective the main issues flowing from the case studies are:

- it is possible to make use of existing information to develop GIS based groundwater and aquifer mapping for developing cities, although additional work may be required where such data are not available;
- it is also possible to generate GIS based maps of existing land use for developing cities;
- the relationship between existing development and the problems associated with the impact of rapid urbanisation on groundwater resources is best characterised in terms of risk assessment;
- the stakeholder analysis carried out as part of the case studies suggest that there are conflicting interests in the management of groundwater resources; and
- groundwater characteristics are always complex and always individual to a city and often change with the development of a city so that any land use policy approach to groundwater

[1] See Morris et al (in press)

protection must be sufficiently flexible to ensure it is applicable in a wide range of circumstances.

Environmental Management and Land Use Planning

The Need for Integrated Environmental Management

There is widening recognition of the importance of land use planning in the delivery of sustainable development (Rydin 1998). Land use planning has long been the means through which public infrastructure and services have been delivered in both the developed and developing world. It has also been the most widely used mechanism for the protection of valued environmental or culturally valued features and resources. However, attempts to integrate traditional land use concerns, such as the provision of physical and economic development, to the growing concern over the pressures imposed by such development on the wider environment, have not been so widespread (Hope and Lekorwe, 1999). One of the reasons for this has been the lack of co-ordination between agencies responsible for planning and those with a responsibility for environmental matters (Brown and Wolfe 1997, Morah, 1996). Other problems include the:

- often 'illegal' and unplanned nature of both new housing and commercial development;
- unregulated use of natural resources; and
- lack of awareness of the importance of environmental considerations in the long term and of the need for the sustainable development of cities.

Ferguson and Maurer (1996) argue that poor urban environmental management imposes long term economic costs on a city in terms of the social welfare costs associated with poor health and the decline in productivity of the workforce and productivity costs resulting from the misuse and wastage of natural resources. Other longer term costs include the decline in the quality of the building stock as a result of the subsidence caused by over abstraction of groundwater (Setchell, 1995). Environmental management is essential for the sustainability of a city and the case for integrated environmental management in developing countries is never clearer than in the case of groundwater management and protection. Relating the physical development that causes groundwater degradation and the need to provide sustainable water resources for the people who live and work in that development, is where integrated environmental management is required. In this context integrated environmental management of groundwater would require the integration of:

- groundwater protection policies;
- waste management policies;
- pollution prevention policies; and
- land use planning.

That level of integration would also require the co-ordination and co-operation of all relevant agencies, the private sector and NGOs (Burke and Moench 2000). It will also require a co-ordinated awareness raising campaign to ensure that the links between public health, groundwater management policy and land use planning are understood by the people those issues, and their policy responses, affect the most.

Groundwater as Environmental Capacity

As part of any overall strategy, or integrated environmental policy, approach to groundwater protection, consideration should be given to the use of 'environmental capacity', whereby the groundwater of a city are seen as one of the city's essential environmental resources on which all of the city's essential long term needs depend. The concept of environmental capacity originates in work carried out in Germany on the development of a participatory approach to environmental

policy making and decision-making (Mason 1999, p.92, Wilson, 1999, see also OECD 1994). Environmental capacity forms the baseline set of environmental conditions or standards on which a community relies for its resources, health and quality of life. It is the capacity of the environment to absorb and accommodate change without succumbing to irreversible damage (Rydin, 1998). The concept is based upon the recognition of key principles including:

- some environmental factors (e.g. groundwater) are essential and have a finite capacity to sustain life;
- the value placed upon these environmental factors is largely subjective and will change over space and time (e.g. the more directly reliant a group are on a specific environmental factor the more value they will place upon it);
- the process of environmental capacity building requires awareness building to aid participatory approaches to decision making and policy implementation (Rydin 2000).

Identifying environmental capacity is a participatory process through which policy makers decide what environmental factors are most valued by a community and how much those factors are valued against other factors. These factors can be both protectionist – the desire to preserve some valued environmental feature – or normative – the desire to achieve some form of environmental improvement - and they can be 'green' issues – ecology, landscape etc – or 'brown' issues – pollution etc. The process of identifying the environmental capacity of an area also acts as an awareness and environmental educational delivery system, as before a community can determine what their most valued environmental attributes are, they must first be fully informed on their choices.

The purpose of identifying and developing environmental capacity is to establish standards and objectives for policy on the basis of social, economic and cultural realities. The process should also establish links between different environmental factors so that policy responses may be developed on an integrated basis. In this way, for example, minimum standards of groundwater quality (the environmental capacity) can be established and a time period set for their achievement using policies developed to meet those targets. Success of the policies can then be tested against the standards and time periods previously established. For example, through a participatory process a community may decide that they would most like to see an improvement in public health; the environmental factors that control this would include air and water quality. In this case minimum standards for air and water quality would be established and a time period set for their achievement. These objectives would establish the pressure needed to ensure policy makers develop appropriate mechanisms for the delivery of the standards. The fact that all the relevant stakeholders have been included in the identification of, and establishment of, the environmental capacity and the mechanisms needed for their achievement should aid the policy implementation process.

As the concept of environmental capacity as a policy making process relies upon consultation and participation, it provides the mechanisms for stakeholder involvement in decision making. This could have direct links with the Local Agenda 21 project (where present) the whole concept of sustainable development. The process also requires a more integrated and holistic approach to policy making and implementation and provides the means through which the links between public health, groundwater protection and land use planning can be made. For groundwater dependent cities in developing countries, groundwater's environmental capacity is one of the, if not the, most important factors in providing for a sustainable future (Carmon, et al 1997). By basing land use policies, and integrated environmental polices as a whole, on the principles of groundwater's environmental capacity – the quantitative and qualitative standards below which it must not fall – groundwater becomes the central focus of all policy and land use planning becomes one of the tools used for implementation.

Options for Developing Land Use Planning Policies for Groundwater Protection

Framework for Policy Development

The above sections have set out the context within which land use planning policies need to be developed for the protection of groundwater in the rapidly urbanising areas of the developing world. The development of land use policy responses to groundwater problems in such cities must have regard to the following:

- where groundwater is the main (or a significant) source of water it provides one of the basic needs for survival and should be seen as a priority for ensuring its protection and sustainable use – the key environmental capacity of a city;
- different land uses pose different levels of risk to groundwater and any policy approach needs to reflect this in order to deal with all, or as many as possible, different situations and conditions;
- to be of practicable use under different planning regimes, in the short, medium and long term, land use policies for the protection of groundwater need to be robust, pragmatic, flexible and sustainable;
- top-down' approaches to environmental policy making and decision making have only limited success as the 'value' of a policy is not always understood or accepted by those who are most affected by it – awareness building and consultation are the key to successful policy implementation;
- land use policies will need to be seen as part of a more holistic integrated environmental management programme; and
- the implementation of the policy approach would need to draw on existing skills and knowledge and not require either significant re-training of existing professional and administrative staff or large resource inputs.

The Risk Assessment and the 'Suitable for Use' approach

Risk Assessment

Hecht (1999) argues that sound environmental policies for the achievement of sustainable development should be risk based. Risk assessment should therefor be the starting point for the development of land use policies for groundwater protection and sustainable groundwater use. The work carried out by the British Geological Survey in Narayanganj and Bishkek were based upon a risk assessment process and highlighted the different risks to groundwater quality posed by different types of land uses. In Narayanganj, for example, 208 sites were identified where land uses had the potential to contaminate the groundwater system. These land uses included metal processing works, chemical installations and fuel filling stations. These different land uses were set against the vulnerability of aquifers so that a simple risk assessment could be carried out to identify, through the use of GIS, the degree of risk to an aquifer posed by different types of activity. Under this basic risk assessment process, risk is characterised in terms of the relationship between different land uses in a given location and the vulnerability of the aquifer in that location. The results of this risk assessment were then characterised as high, medium or low.

This assessment model follows the simple risk assessment process used in many countries for identifying the risks associated with land contamination. Land is considered to pose a risk due to its contamination where there is a 'source' (contaminant), 'pathway' (means of transmission of the contaminant) and a 'receptor' (an organism or entity capable of being harmed by the contaminant). Where one or more element ('source', 'pathway' or 'receptor') is absent a site is not considered to

be a hazard (Rostron 2001 p.210). In the case of groundwater vulnerability, the risk is highest where aquifer vulnerability is highest and the land use is in the highest hazard category in terms of pollution. This risk assessment is therefore also based upon a source (land use type) and pathway (geological mobility of pollutant) and receptor (the aquifer). The assessment process relies upon the availability and accuracy of information on the different land uses and industrial processes, the waste management practices of individual companies and the geology over the aquifer. The two case studies have demonstrated that this information can be gathered in sufficient detail for GIS generated maps of land-uses and areas of highest to lowest aquifer vulnerability to be produced. The risk assessment model for groundwater protection is set out in Table 1, together with examples of how it can be applied to a specific land use.

'Suitable for Use'

These risk assessment techniques can be easily translated into a land use policy approach that draws on the traditions of zonal planning, can be used in development control, is pragmatic and flexible while providing for long term improvements for groundwater quality. This is the **'suitable for use'** approach. In many respects the suitable for use approach to land use planning has its origins in Environmental Impact Assessment whereby the impacts of a development project are assessed against existing and potential environmental conditions of a site. The principles underlying this

approach have also developed out of policies for the development of contaminated land and make use of the risk assessment process discussed above as well as the precautionary principle.

Based upon the 'source' → 'pathway' → 'receptor' risk assessment principles, the 'suitable for use' approach poses the question 'is the proposed 'use' of the land 'suitable' given the nature of the use and the condition of the land? From the Narayangani and Bishkek case studies this would be translated to 'is the proposed 'use' of the land 'suitable' given the nature of the use and the vulnerability of the aquifer in that location?'

The decision would then be based upon the risk assessment information provided by the 'source' →'pathway' → 'receptor' data. The diagram at Fig. 1 below illustrates the 'suitable for use' approach when applied to groundwater vulnerability modelling. The diagram at Fig. 1 is illustrative of the general approach, however in applying the 'suitable for use' approach in practice it will be necessary to take into account matters such as the magnitude of the likely consequences of locating specific uses in specific locations. Applying the 'suitable for use' approach for groundwater protection policies recognises groundwater as a key element of a city's environmental capacity and places groundwater protection as the starting point for land use planning decisions.

Table 1 Risk Assessment Model

Source	Pathway	Receptor	Risk
Land use type	**Properties of Surface and sub-surface layers**	**Aquifer Type**	**Probability of contamination occurring**
			
Fuel Filling Station	**Thick low permeability surface layer**	**Fine grained alluvium porous tuffs, semi-confined porous aquifers**	**Low**
Fuel Filling Station	**High water table**	**Fractured aquifers**	**Very high**

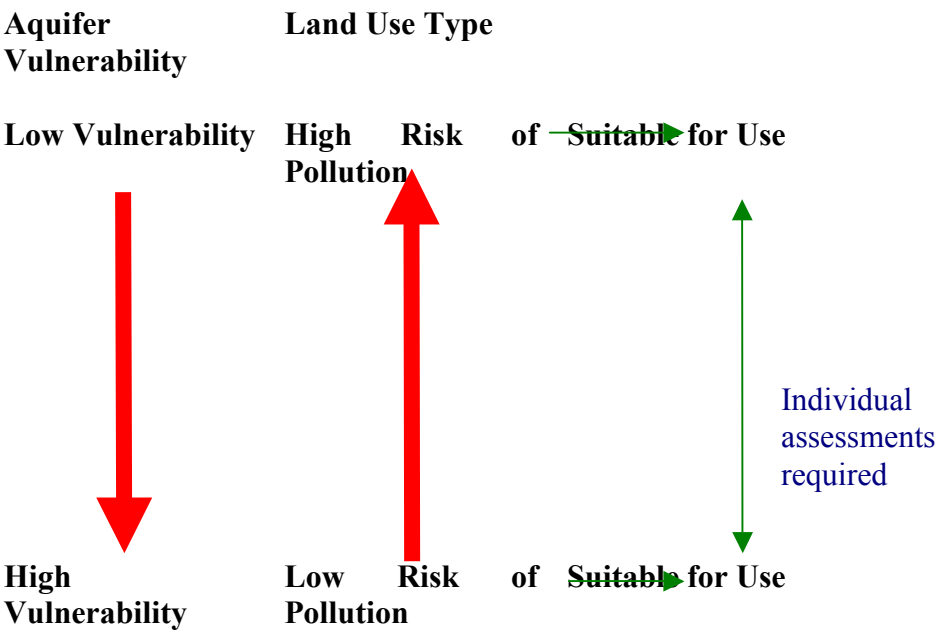


Figure 1 Suitable for Use Approach

In order to develop a consistent and transparent approach to the suitable for use assessment it will be necessary to develop checklists and/or matrices as rational planning tools to aid decision-making. These checklists and matrices could be used to ensure that all of the relevant information is gathered, assessed, documented and maintained on planning files. It is suggested that an information availability checklist is created to ensure that the relevant necessary information is gathered and assessed. This checklist should record information about the site, including aquifer vulnerability data, and information on the project/development that is proposed for a site. This will be information that is used in the risk assessment process as well as in the 'suitable for use' assessment. An example of such a checklist is provided at Appendix One of the report. A 'suitable for use assessment matrix' should also be developed and this should record the following information:

- details about the project/development;
- details on the site and its locality;
- the relevant agencies to be consulted;
- the sources of all information gathered on the groundwater conditions and on the project/development and its location;
- the risk assessment results (e.g. high , medium or low risk);and
- the outcome of the suitable for use assessment.

An example of what a suitable for use assessment matrix may cover is also at Appendix One. The checklist and matrix provided are illustrative only as checklists and matrices will have to be developed to suit the relevant circumstances of individual cities. From this 'suitable for use' assessment more traditional zoning policies can be developed so that new development is directed to those areas that are suitable for the uses proposed. For example, if the GIS generated map of Narayanganj that is reproduced at Appendix Two of this report is referred to, it can be seen that the vulnerability mapping of the aquifer can be used as the basis for a sustainable groundwater land use zoning policy. This policy can be used to map areas for specific land uses as part of standard zonal planning procedures. The areas where vulnerability is high could be zoned for land uses that have low risk of pollution and the areas where vulnerability is low, or negligible, could be zoned for land uses that have characteristically high risks of causing pollution.

The suitable for use approach can also be used in development control assessments of applications for planning authorisation. It provides a test against which applications for planning consent can be assessed. To be applicable to complex conditions in as many situations as possible, the suitable for use approach can be applied pragmatically and be used as a standard to which developers and others should demonstrate they can comply. For example, if a potentially non-conforming use is applied for in an area where aquifer vulnerability is considered medium or high, and yet there are other sound planning, economic or environmental reasons why the project should be located on the site, a suitable for use assessment should be required. That assessment should require the developer to demonstrate the proposed land use can be made suitable through the application of mitigation measures – drainage, impermeable barriers, waste management practices etc - to ensure that their use will not constitute an unacceptable risk to the groundwater. These measures would then need to be secured through long term legal agreements that would be binding on future as well as existing owners of the site.

The suitable for use approach can be quite easily applied to proposed new development, where a developer requires a licence or other form of authorisation to proceed. It is more difficult to deal with existing land uses that do not comply with the zoning scheme. However there are a number of policy tools that can be used to encourage the relocation of non-complying uses. As part of an overall integrated environmental policy where groundwater is seen as crucial for the long-term sustainability of a city, fiscal measures can be applied to encourage relocation. These measures can include:

- higher land or property taxes for non-conforming uses than for conforming uses and the use of the additional revenue from the higher taxes for infrastructure support for conforming uses. Property or land tax is already used extensively in the developing world to recover a share of the increased value of land that development brings (Archer 1992). It should also be used as a tool to steer development in the direction of greater groundwater protection;
- where land is in public ownership much greater control is possible and where governments are considering the release of land for development they should do so only on suitable for use principles. Indeed publicly owned land assessed to be of low aquifer vulnerability could be specifically released and set aside for the relocation of existing non-conforming uses. Many developing countries have been using land readjustment agreements to transfer land ownership, particularly in rural areas (Larsson 1997). These land readjustment agreements could also be used to transfer the ownership of the existing non-conforming site to the government and ownership of a new site from the government to the non-conforming user. Profits made by the government in the sale of the old site to a conforming user could be used to provide infrastructure and services for the new site as well as finance for the clean up of the old site.;
- development rights for high value commercial uses that pose a relatively low risk on sites of high vulnerability can be partially exchanged for the clean up of such sites;
- in most Asian countries, and many other developing countries, there exists some form of building construction regulations (Archer 1992) and these could be widened to include groundwater protection measures that are far more stringent for non-conforming uses than for conforming uses; and
- where groundwater has been deemed to be a major component of the essential environmental capacity of a city, external funding agencies should be targeted for funding the relocation of those existing land uses that present the highest risk to long term sustainability of the ground water system.

The above are only a few examples of how the suitable for use approach can be used to steer development in a more groundwater sustainable way. There is scope for more mechanisms to be used and these will largely depend upon local circumstances. The key to the operation of the

suitable for use approach is its acceptance as the starting principle for land use planning decisions and that in turn depends upon the wider acceptance by the community of groundwater as a significant component of the essential environmental capacity on which the sustainable development of a groundwater dependent city relies.

Suitable for Use as an Integrated Environmental Policy Tool

The suitable for use approach to land use planning provides a flexible and pragmatic starting point. It can of course be developed as a wider environmental standard as part of an integrated environmental policy. One clear groundwater example of this is where, through over abstraction and extensive pollution, an aquifer is no longer used for high value uses such as potable supply. A suitable for use assessment can be carried out to determine if the water can be utilised for less sensitive uses such as amenity area irrigation or for cooling in industrial processes etc. The suitable for use approach can also be used to investigate different water pollution remediation systems so that water is treated to a standard compatible with an intended use rather than to a standard where it can be used for all general purposes. In this way even heavily polluted water can be brought back into some form of beneficial use to ensure the overall sustainability of the resource.

General Conclusions

This report has reviewed existing practice in developing countries and related well established planning procedures such as zonal planning and development control decision making to the need to consider groundwater as a pivotal element of a city's **environmental capacity**. From that starting point, and the need for an **integrated approach to environmental policy**, it has been argued that planning decision making, for both forward policy making and development control, can be based upon a risk assessment process that makes use of the **suitable for use approach** to planning. The suitable for use approach is considered to be pragmatic, flexible and in placing groundwater protection as the starting point for land use considerations, provides an appropriate tool for more sustainable management of groundwater resources.

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Appendix 1 Land-Use Planning Checklist & Matrix Tool

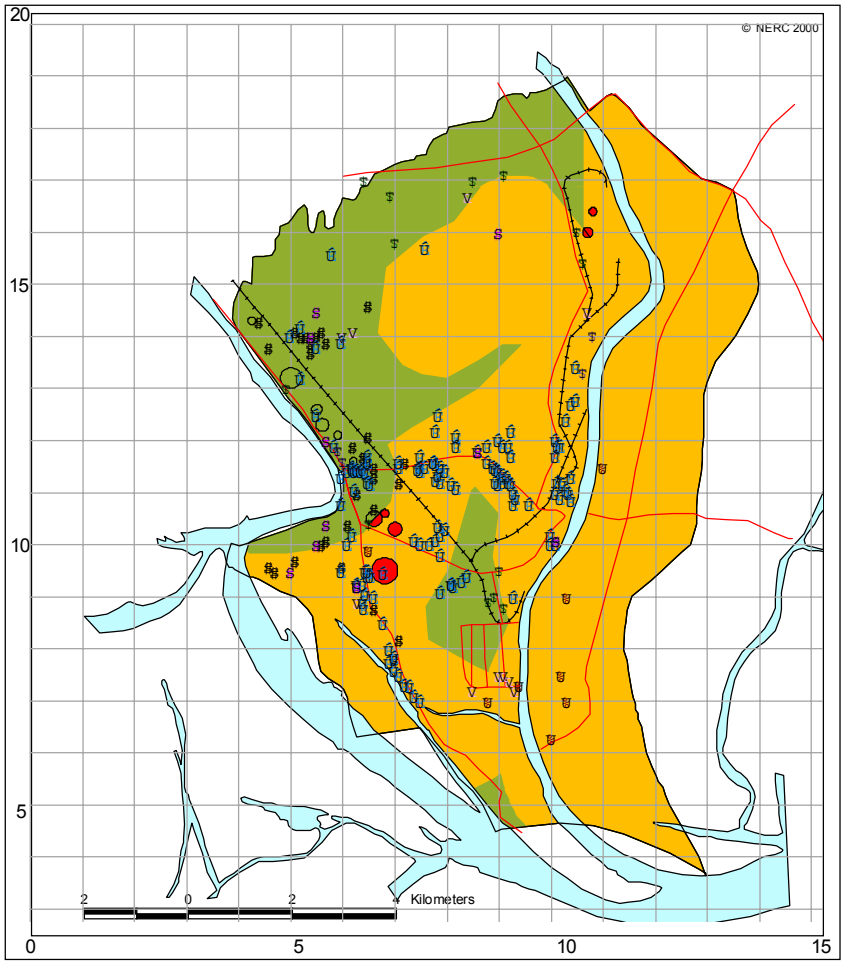
Suitable for Use Information Checklist (fromWeston, 2001)

Is the following information about the site available?	**Yes/No/NA**
Information on the Aquifer	
Aquifer type	
Aquifer vulnerability	
Depth of water table	
Permeability of surface layer	
Information on existing water uses at or near to the site	
Existing end uses of water on-site and by neighbouring uses	
Existing waste disposal upstream and downstream of the site	
Existing water abstraction from the aquifer from the site	
Existing water abstraction from the aquifer from the site	
Existing water abstraction upstream and downstream of the site	
Degree of interaction/connection to shallow aquifer either with nearby water surface (rivers, lakes, springs)	
Degree of interaction/connection to underlying deeper aquifer	
Is the following information about the project/development available?	
Industrial sector (manufacturing/ service/tourism etc)	
Size, scale and other physical details	
Materials to be used in construction and operation	
Materials to be produced during operation	
Materials to be stored on site during operation	
Materials to be disposed of during operation and their means of disposal	
Water abstraction requirements	
Other relevant information on the site and its locality	

Suitable For Use Assessment Matrix

Details Required	Responses	Information sources for responses (including agencies consulted)
Project Details		
Name of Project		
Project Proponent		
New project or extension to an existing project?		
Project type (e.g. waste disposal, manufacturing, retail etc)		
Physical aspects of the project (size, scale etc)		
Materials to be used in construction		
Material to be used in operation		
Waste disposal during operation		
Other relevant details on the project that will assist the assessment		
Site and location		
Existing site conditions and uses		
Characteristics of neighbouring uses (retail, chemical works, manufacturing etc)		
Surface cover		
Aquifer vulnerability (High, medium, Low)		
Site preparation details (including any treatment of existing contaminants)		
Other relevant details on the site and its location that will assist the assessment		
Assessment		
Aquifer Vulnerability Risk Assessment Statement	Can the risks posed by the project be characterised as High, Medium or Low?	
Suitable for use?	Is the site suitable for the use proposed (indicate which option from a, b or c:	a) Yes; or b) Yes but requiring mitigation measures – give details and how they will be enforced; or c) No

Appendix 2 Example of Aquifer Planning Tool



Point Source Codes (from Table 2.1)		Point Source Activity	No. of sites
#	2	Metal Processing (plating, galvanising, battery making)	31
$	6	Petrol & Gas Refineries / Storage Depots	4
S	9/10	Organic/ Inorganic Chemicals	10
V	14	Soap & Detergents	10
Û	15	Textiles (dying, bleaching, processing)	132
$	23	Fuel Filling Station	13
Ø	24	Municipal / Industrial solid waste disposal	8

Major Roads
Railway
Major rivers
Project boundary

Vulnerability
High
Moderate
Low

Narayanganj Groundwater Vulnerability and Potentially Contaminating Activities Map