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WATER SECURITY ISSUES IN SOUTH AFRICA AND CHILE

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INTRODUCTION

1. Water security is increasingly recognised as a major policy issue by international institutions and governments around the globe. It is a major agenda item for the OECD, the UN, the World Water Forum and the World Economic Forum. The new Green Growth Strategy (2011) of the OECD in particular, aims to help countries foster economic growth and development while ensuring that natural assets (water) continue to provide the resources and environmental services on which our well-being relies (OECD, 2011). In that context, water security should be seen as a contributor to economic growth, provided the right policies, strategies and measures are developed and implemented.

2. South Africa and Chile have both taken leading although somewhat different initiatives towards ensuring water security, and also to promote the allocation of water in order that the greatest overall benefits can be achieved. This paper gives a concise exposition of the water situation, water policies and experiences in South Africa and Chile, for the potential wider benefit.

1. THE SOUTH AFRICAN CASE

1.1 General background on South African water situation

3. South Africa is located in a predominantly semi-arid part of the world. The climate varies from desert and semi-desert in the West to sub-humid along the eastern coastal area, with an average rainfall for the country of about 450 mm per year (mm/a), well below the world average of about 860 mm/a, while evaporation is comparatively high. As a result South Africa's water resources are, in global terms, scarce and extremely limited. The country has no truly large or navigable rivers, and the combined flow of all the rivers in the country amounts to approximately 49 000 million cubic metres per year, less than half of that of the Zambezi River, the closest large river to South Africa.

4. South Africa is also poorly endowed with groundwater as it is mainly underlain by hard rock formations which, although rich in minerals, do not contain any major groundwater aquifers which could be utilised on a national scale. Never the less, groundwater played a pivotal role in the settlement and initial development of the country, and continues to do so especially in the rural parts of the country.

5. Due to the poor spatial distribution of rainfall, the natural availability of water across the country is also highly uneven with more than 60 % of the river flow arising from only 20 % of the land. This situation is compounded by the strong seasonality of rainfall, as well as high within season variability, over virtually the entire country.

6. To aggravate the situation, most urban and industrial development as well as some dense rural settlements, have been established in locations remote from large watercourses, dictated either by the occurrence of mineral riches or influenced by the political dispensation of the past. For example, Johannesburg, South Africa's largest city is one of only two cities in the world that is not located near a major river or at the coast (the other being Mexico City that was on the shore of a lake when founded). Some of the irrigation developments in the country are also located in sub-optimal regions with respect to water use efficiency, having been established during times that water was still relatively abundant and little incentive existed for seeking the most beneficial application thereof. As a result, in several river basins the requirements for water already far exceeds its natural availability, and widely-spread and often large-scale transfers of water across catchments have therefore, been implemented.

7. Four of South Africa's main rivers are shared with other countries, which together drain about 60 % of the country's land area and contribute about 40 % of its total surface runoff (river flow). Approximately 70 % of its gross domestic product (GDP) and a similar percentage of the population are supported by water supplied from these rivers, making their judicious joint management of paramount importance to South Africa. South Africa accepts the principles of the 1997 Convention on the Law of the Non-navigational Uses of International Watercourses and is a signatory to the Revised Protocol on Shared Watercourses in the Southern African Development Community. A number of bilateral and multi-lateral commissions and committees have been in existence between South Africa and its neighbours which facilitate implementing these principles and protocol.

8. South Africa depends mainly on surface water resources for most of its urban, industrial and irrigation requirements. In general, surface water resources are highly developed over most of the country. About 320 major dams, each with a full supply capacity exceeding 1 million cubic metres, have a total

capacity equivalent to 66 % of the total mean annual runoff. There are a number of existing large dams and major inter-basin transfers (Figure 1).

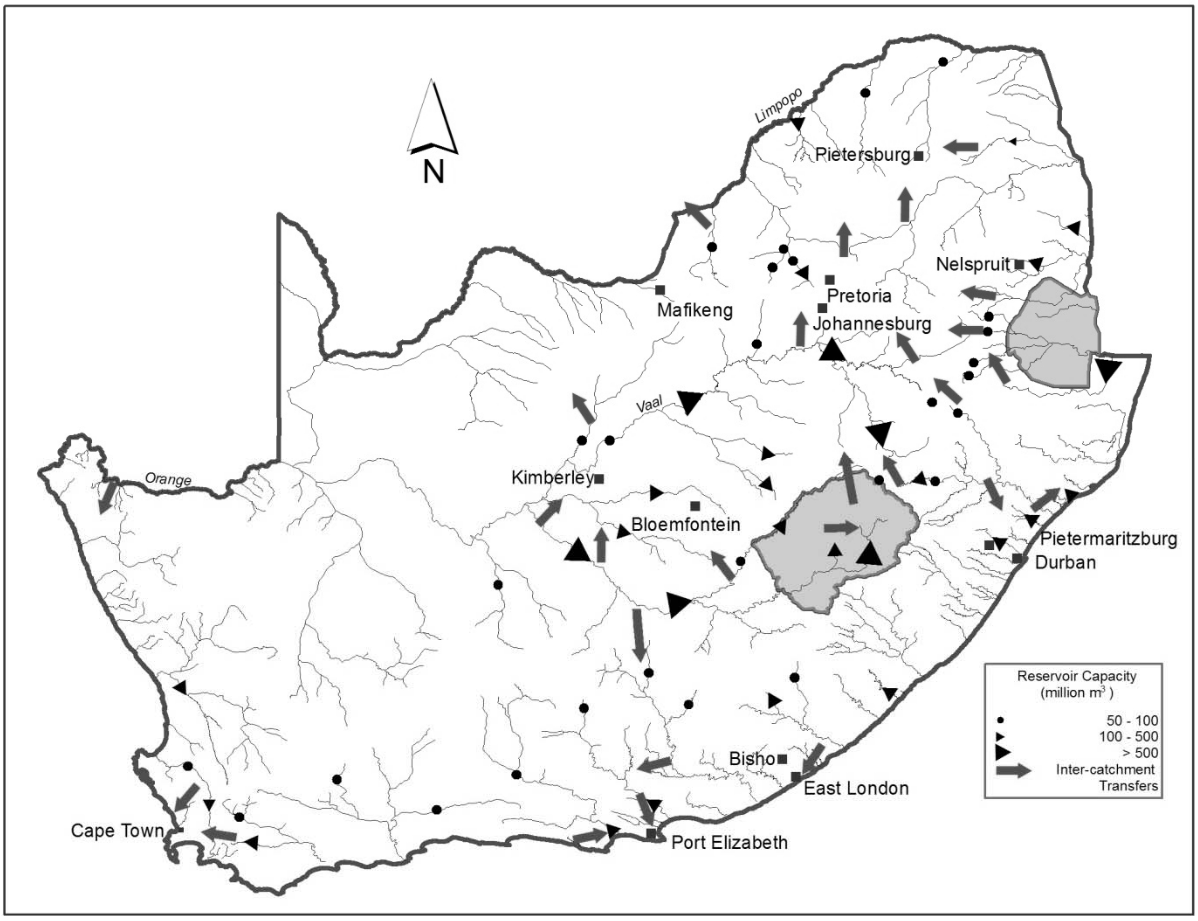
9. Water quality also is a fundamental element of water resource management. In addition to making sufficient quantities of water available for use at specific locations and times as required, it is essential that the water be of appropriate quality for the intended use, whether it be for abstraction or to remain in the river for ecological purposes.

10. The natural quality of water over most of South Africa is generally good. Water quality has, however deteriorated in the rivers or river reaches receiving large quantities of effluent. Some rivers with relatively high salinity (brackish) water occur in the dryer parts of the country.

11. Major sources of pollution of surface waters are agricultural drainage and runoff; urban runoff and effluent return flows, industries, mining and rural settlements with insufficient sanitation services. The most important of these currently are insufficiently treated urban effluent and acid mine drainage. Pollution of groundwater mainly results from mining activities and human settlements.

12. Water is also extensively re-used in South Africa, adding nearly 20 % to the yield available from the surface water resources. Currently, this mainly occurs at inland centres where treated effluent is discharged back to rivers for cascading downstream use, constituting the indirect re-use of water. The direct re-use of water (where water from an effluent stream is returned to a water supply system for re-use directly after treatment) is extensively practised by the mining and industrial sectors within the battery limits of their operations, but is still only applied on a small scale at isolated locations for general municipal and domestic purposes.

Figure 1. Major existing dams and inter-catchment transfers in South Africa



Source: Basson (1997)

13. The use of water is dominated by irrigation, amounting to over 60 % of the total water use in the country, the bulk of which is used consumptively. Water requirements for urban and domestic use account for nearly 30 %, with the remainder being used for mining, bulk industries and as cooling water for power generation. Afforestation, which intercepts large quantities of water before it reaches the streams or rivers, is more dominant in the wetter parts of the country.

1.2 National Water Policy

14. The National Water Policy (NWP) was preceded by the development of 28 Fundamental Principles and Objectives for a New South African Water Law (enacted in 1998). Principle 7 is particularly relevant to water security: "The objective of managing the quantity, quality and reliability of the Nation's water resources is to achieve optimum, long-term, environmentally sustainable social and economic benefit for society from their use".

15. Three fundamental objectives for managing South Africa's water resources arise from the Principles.

- To achieve equitable access to water, that is, equity of access to water services, to the use of water resources, and to the benefits from the use of water resources;

- To achieve sustainable use of water by making progressive adjustments to water use with the objective of striking a balance between water availability and legitimate water requirements, and by implementing measures to protect water resources; and,

- To achieve efficient and effective water use for optimum social and economic benefit.

16. Important proposals to facilitate achievement of the NWP's objectives include the following:

- Water will be regarded as an indivisible national asset. National government will act as the custodian of the nation's water resources and its powers in this regard will be exercised as a public trust; and,

- Water required to meet basic human needs and to maintain environmental sustainability will be guaranteed as a right, whilst water use for all other purposes will be subject to a system of administrative authorisations.

17. The above principles from the NWP and as legalised through the National Water Act are further expanded upon by the National Water Resource Strategy (DWAF, 2004). The Strategy again emphasises one of the primary principles that the nation's water resources are to be managed in such a manner to achieve optimum long-term social and economic benefits for all people. It is recognised that water is also a finite resource and that water allocations may have to change over time to meet this objective on an ongoing basis.

1.3 Priorities for allocating water

18. The National Water Act gives highest priority to water for the 'Reserve', which includes water for basic human needs and for the natural environment. Thereafter international obligations as agreed with neighbouring countries must be respected and honoured.

19. Beyond this, water should be allocated by public authorities and by river basin to ensure that the greatest overall social and economic benefits are achieved. Consideration must not only be given to this primary aim, but also to potential disbenefits to society where water is made available to competing optional uses. This applies both to long-term allocations for water use as well as to short-term curtailments in supply during periods of drought and temporary shortage. Where surplus or unused water exists, prioritisation need to apply, provided that the water is not used wastefully.

20. To facilitate the most beneficial utilisation of water, a general guide on priorities for water use is given below. The priorities are listed in the National Water Resource Strategy (DWAF, 2004) in descending order of importance, although the order may vary under particular circumstances:

1. Provision for the Reserve;

2. International agreements and obligations;

3. Water for social needs, such as poverty alleviation, primary domestic needs and uses that will contribute to maintaining a social stability and achieving greater racial and gender equity;

4. Water for uses that are strategically important to the national economy (such as power generation),

5. Water for general economic use, which includes commercial irrigation and forestry. In this category, allocation is best dictated by the economic efficiency of use. With the introduction of

water trading, demand will automatically adjust over time to reflect the value of water in particular uses; and,

6. Uses of water not measureable in economic terms. This may include convenience uses and some private water uses for recreational purposes, which are likely to be of low priority.

21. Additional factors to be considered in assessing priorities for the allocation of water are the level of assurance of supply required, the extent to which to use is consumptive and the quality of return flows.

22. It is important to realise that all water use by a particular sector or user is unlikely to be of the same priority. Water to maintain primary production functions, for example, would be of higher value and priority than the additional water required for other uses in the same enterprise. This also relates to the efficiency of water use, with greater efficiency leading to a higher value of water. The same principle applies to a greater or lesser extent to all uses of water.

23. There is thus no pure economic basis or incentive for the allocation of water, but rather it is strived to achieve the overall best balance and sustainability by taking into consideration a wider spectrum of influencing factors and resulting outcomes.

1.4 Water use licences

24. The use of relatively small quantities of water, mainly for domestic purposes (including non-commercial gardening and stock watering) and for certain recreational purposes is provided for under Schedule 1 of the Water Act. Users must have lawful access to the resource (such as on farm land). No numerical limits are specified. However, the extent of such uses must be reasonable with regard to users' needs and not be excessive in relation to the resource and the needs of other users. All other uses are subject to the issue of water use licences as follows (DWAF, 2004):

- May only be issued by a responsible authority, to which a prospective user must apply;
- Replaces all previous entitlements, if any, to use water for the purpose specified in the licence;
- Is specific to the user to whom it is issued and to a particular property or area;
- Is specific to the use or uses for which it is issued;
- Is valid for a specified time period, which may not exceed 40 years;
- May have a range of conditions attached to it; and,
- Must be reviewed by the responsible authority at least every five years.

25. Water use licences or authorisations may be transferred on a temporary basis for one year in the case of water for irrigation, and permission may be granted for an extension of a further year.

26. Permanent transfers may be affected by one user offering to surrender all or part of an allocation to facilitate a licence application by another prospective user (DWAF, 2004). Transfers of this nature constitute trade in water use authorisations, and require new licence applications, which will be subject to all relevant requirements of the Act relating to applications for licences, including the need for a Reserve determination if one has not already been carried out. Permanent transfers become effective only when the new licence is granted. They may be authorised only by a responsible authority, which may attach

different conditions to the new licence than were attached to the surrendered licence. One such condition may be that the new user must pay compensation to the original licence holder, which could be viewed as a form of market related trading.

27. Both the temporary or permanent transfer of water use licences are only permissible when the original and transferred water use are from the same resource.

1.5 Economic value of water

28. Various project related studies have been conducted in South Africa towards assessing the economic value of water. The main approach used was to determine sectoral water utilisation efficiencies by means of a "water multiplier' analysis, to obtain an indication of the relative importance of water in production by some of the water use sectors and sub-sectors of the economy (Basson *et al*, 2010).

29. As a broad comparison, national multipliers were determined per million m^3 unit of water used, expressed as employment opportunities and Gross Domestic Product (GDP) supported. Distinction was made between high, mid and low level jobs, based on the skills levels required to produce the output (Table 1).

Table 1. Economic returns from water use, South Africa

(per million m3 water used)

Sector	High-level jobs	Mid-level jobs	Low-level jobs	GDP (ZAR million)[a]
Agriculture (general)[b]	10	30	210	13
Gold Mining	650	2 880	11 900	1 600
General manufacturing	6 800	27 000	28 000	6 700
Pulp and paper	25 000	79 000	81 000	23 000
Beverages	38 000	131 000	158 000	37 000
Glass products[c]	233 000	716 000	836 000	250 000

a) Expressed in 2009 values
b) Least efficient (includes irrigation, rain-fed and livestock farming)
c) Most efficient
Source: Basson *et al*, 2010

30. The results show agriculture as the most inefficient user of water. Gold mining and general manufacturing could serve as being representative of water use efficiencies in the mining and manufacturing sectors. It is important to note that the results are based on national statistics, and therefore reflect the average performance of the different sectors.

31. Wide variations around these averages are bound to occur, but they are unlikely to change the essence of the results, considering the very large difference between agriculture and the following sector in the ranking.

32. Similar outcomes were obtained with respect to a new water resource development in the Olifants River catchment (Table 2).

Table 2. Economic returns from water use, Olifants River catchment

(per million m3 water used)

Sector	Gross Value Added (GVA) (ZAR million)	Employment
Agriculture (irrigation)	20	200
Mining	370	3 300

Source: Basson et al (2010)

33. Commensurable results were obtained by comparing the utilisation efficiencies of water in different geographic areas. In this case the economic benefits of allocating the water to the Orange and Fish/Sundays River region, where the economic activity is dominated by irrigated agriculture, were compared with the benefits achievable by applying the same volumes of water to the diversified and industrialised economy of Gauteng, the central industrialised province. The results of the analysis indicated that allocating water for use in the industrialised areas rather than for irrigated agriculture, will, from the economic point of view, render the highest returns (Table 3).

Table 3. Economic returns from water use, Orange River and Gauteng areas

(per million m3 water used)

Factor	Irrigated Agriculture[a]	Diversified Industry[b]	Ratio[c]
Production (ZAR million)	2.1	510	1:240
Employment	24	1 940	1:80

a) Orange River area
b) Gauteng area
c) The ratio refers to diversified industry having 240 (or 80) times greater returns than irrigated agriculture.
Source: Basson *et al* (2010)

34. The results obtained from the economic analyses indicate that agriculture as a general economic sector and irrigation as a specific sub sector, are relatively inefficient users of water. The agricultural sector utilises significantly more water to produce output and creates less employment per unit of water than any other sector in the economy.

35. It is important though, that the above examples not be viewed as absolute indicators, and that the strong linkages and interdepencies that exist among economic sectors also be appropriately accounted for. The agricultural sector, in particular, supplies raw materials as inputs to other primary and secondary sectors, though in some cases those raw inputs could be imported at lower cost to the economy. Agriculture also creates a strong demand for goods and services, such as fertiliser, machinery and financial services. Similar considerations also apply to other primary sectors such as mining.

1.6 Environmental water requirements

36. The allocation or 'reserving' of water to ensure sustainability of the natural environment is given the highest priority in the National Water Act, together with water for basic human needs.

37. Provisional assessments indicate that, as a national average for South Africa, about 20 % of the total river flow is required as ecological Reserve, which needs to remain in the rivers to mainain a healthy biophysical environment (DWAF, 2004). This proportion, however, varies greatly across the country from about 12 % in the drier parts to around 30 % in the wetter areas. These figures being subject to improvement as better understanding of the functioning of ecosystems is gained over time.

38. In terms of the National Water Resource Strategy, the impacts on both the social and natural environment need to be taken into account, and assessed together with the technical, economic and other factors. The scientific assessment of water requirements for the natural environment therefore, only addresses part of the equation and is subject to a more holistic evaluation of influencing factors.

39. The reservation of water for environmental purposes obviously reduces the potential availability of water for economic uses, with resultant socio-economic implications. Quantifying the environmental water requirements should therefore not be based on scientific assessment only, but needs to be augmented by assessments of the potential economic and social implications, and subjected to due public involvement.

40. A complicating factor in South Africa is that sufficient provision was not made in the past for environmental water requirements and that in many cases water resources have been over allocated. Although the legal and institutional framework for addressing the situation are in place, it will remain a complex and extended process.

1.7 Inter-catchment transfers and multi-purpose developments

41. South Africa is well known for its extensive network of large scale schemes for the transfer of water from areas of surplus to areas of deficit; and to where the greatest benefits are to be achieved. Water resources over much of the country have been linked through inter-catchment transfers and are managed as large integrated systems, thereby reducing the potential risks of failure through the combined utilisation of resources and the balancing of climatic variability over large geographic areas (Basson and van Rooyen, 2001). Based on the probalistic assessment of the likelihood and severity of drought in specific areas for example, water is transferred to areas that may be suffering from severe drought conditions, from areas where the prevailing conditions are less critical. A high level of sophistication has been reached in this regard, and substantial greater utility is thus obtained from South Africa's water resources than the sum of the component parts (Box 1).

Box 1. Gains from inter-catchment transfer

A prime example of the benefits of the systems approach for the management of inter-catchment transfers is offered by the Thukela-Vaal Transfer Scheme. In this case an average volume of 530 million m^3/a is transferred from the Thukela River Basin to the Vaal River Basin, at a transfer rate that may vary from zero to a maximum of 630 million m^3/a. By properly managing the storages and times of transfer, a resultant increase in yield in the Vaal River System of 736 million m^3/a is achieved, whilst the residual yield in the Thukela system is reduced by only 377 million m^3/a.

The total quantity of water physically transferred in South Africa from one catchment to another currently amounts to 3 500 million m^3/a. In comparison, the total surface water yield is approximately 110 000 million m^3/a[1].

42. Water curtailments during times of severe drought are also incrementally introduced based on probabilistic grounds, and selectively applied to different user groups and economic sectors, in order to minimize the economic and social impacts of such measures.

43. The same technical, environmental, social and economic considerations as are applicable to any other water resource development and use of water are applicable to inter-catchment transfers of water. Some specific considerations are:

- The allocation of water away from a catchment can only be justified if it results in an overall benefit from a national perspective;

- The inter-catchment transfer of water may have unique impacts on natural ecosystems that extend beyond those associated with in-catchment developments. Specific consideration needs to be given to the possible transfer of organisms/species and changes in habitat conditions. The potential risks and impacts with respect to the transfer of species being more pronounced with the transfer of water between river basins, than between catchments within the same river basin; and,

- The transfer of water for the express purpose of meeting environmental water requirements in the receiving catchment is not supported.

44. Given the relative scarcity of water in South Africa, most large scale water resource developments are inherently multipurpose schemes, which also facilitates the better utilisation of the benefits of scale. A recent example being the Olifants River Water Resource Development Project in the north-eastern part of the country.

45. The project is located in a valley adjacent to a very dry plateau where about 250 000 people live in scattered communities, with totally insufficient availability of water. To construct a single-purpose dam and water supply network for domestic purposes only, would have been exorbitantly expensive and unaffordable to the predominantly poor households on the plateau. By linking the domestic water supplies to some large scale water resource development for mining purposes, almost halved the unit cost of water from the scheme.

[1] The total surface water yield is the quantity of water that can be abstracted from a water source for use, at a specified reliability, given the level of infrastructure development.

46. A further opportunity was then identified, with the visionary linking of a proposed 1 500 MW pumped storage hydro-electric scheme to the water resource development project, and using the pumped storage scheme to also lift water up the escarpment for domestic use.

47. The scheme, now under construction, will also serve to stabilise flow downstream for environmental purposes. Specific consideration was given to the potential impacts on the Kruger National Park, (South Africa's premier conservation area which is located further downstream) and also to how the yield from the Massinger Dam in Mozambique would be affected.

1.8 Future development options

48. The National Water Resource Strategy requires that a range of possible solutions be investigated whenever there is a shortage of water or a need for additional water, taking account of the availability of surface and groundwater and the interactions between them, and the integration of water quantity and water quality issues. The main policy options to be considered include:

- Demand side measures to increase water availability and improve the efficiency of water use;
- Re-allocation of water, including the possibility of moving water from lower to higher benefit uses by trading water use authorisations; and,
- Supply side measures through the construction of new dams and related infrastructure, including inter-catchment transfers.

49. The significant impacts of all development options and other interventions need to be assessed. Social and environmental considerations need to be accorded the same attention as those of a technical, financial and economic nature. The aim being to ensure that the overall benefits arising from such actions will exceed the cost and that the benefits and costs will be distributed equitably.

50. Given the blend of tangible and intangible factors to be considered, public participation forms an important corner stone of the process to be followed.

51. Assessments were made of the remaining potential for water resource development in South Africa as well as of means to extend the utility of the resources, together with associated costs (Basson *et al*, 2010). It is intended to serve as background to spatial and sectoral development planning on a national scale to, amongst others, determine the most appropriate parameters and locations for large future developments. It should also serve as background towards achieving the most beneficial allocation and sectoral use of water.

52. It is important to note that in an integrated and industrialised economy such as in South Africa, the availability of water as a singular factor, only in exceptional cases would be an engine for investment and economic growth. Water typically only represents a relatively small proportion of the costs of production whilst various other factors would determine the viability of a development. However, water remains a critical element to almost any kind of development and the non-availability of water generally manifests as a serious impediment to growth.

53. There are two representative cases of how the growth in water requirements can be met in future. One is for an inland area around Johannesburg and the Gauteng Province, which is supplied with water from the Vaal River System, and represents more than half of the economic output of South Africa. The other being the Cape Town area on the coast together with some surrounding developments.

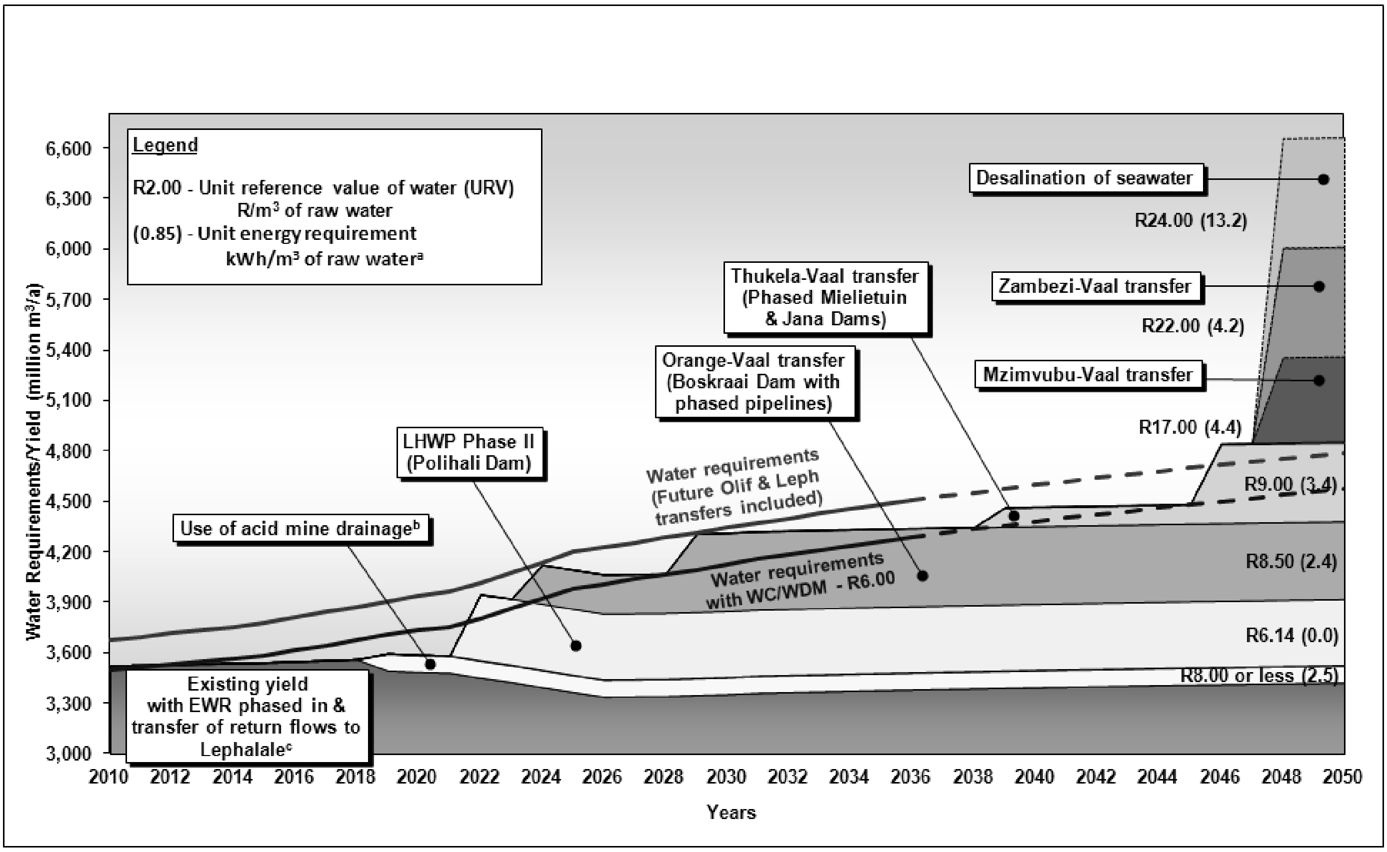
54. For the Vaal River System, the target is to bring new interventions on line to meet the growth in water requirements after having first implemented water conservation and Water Demand Management (WC/WDM) measures. Evidence shows that further inter-catchment transfers still offer the lowest cost options for the augmentation of water resources serving the inland parts of South Africa (Figure 2). This does not imply however, that these would necessarily be the overall best options to be implemented. In particular, due consideration needs to be given to the possible re-allocation of water.

55. As would be expected, the desalination of seawater and pumping it to an elevated inland location would be prohibitively expensive. It nevertheless remains the ultimate fall-back option, and serves as a valuable benchmark and often sobering reference. Also important to note is the reduction of the water available for use, as a result of greater allowances for environmental flows which are planned to be introduced. The subsequent slow rise in the basic water available is due to increasing volumes of return flows to the Vaal River.

56. A totally different situation applies to the coastal Western Cape area (Figure 3). This area, being more remote from large rivers and not having the same benefits of scale of the Johannesburg/Gauteng area, is totally dependent on the development of modest inland resources (surface and ground water), the re-use of water and desalination of seawater. The rather pronounced drop in the availably of the water resources already developed is due to provisions for environmental water requirements (EWR), together with a provision for the possible impacts of climate change.[2]

[2] Indications are that the Western Cape is likely to be the area in South Africa that may soonest and most severely be affected by climate change.

Figure 2. Vaal River augmentation options



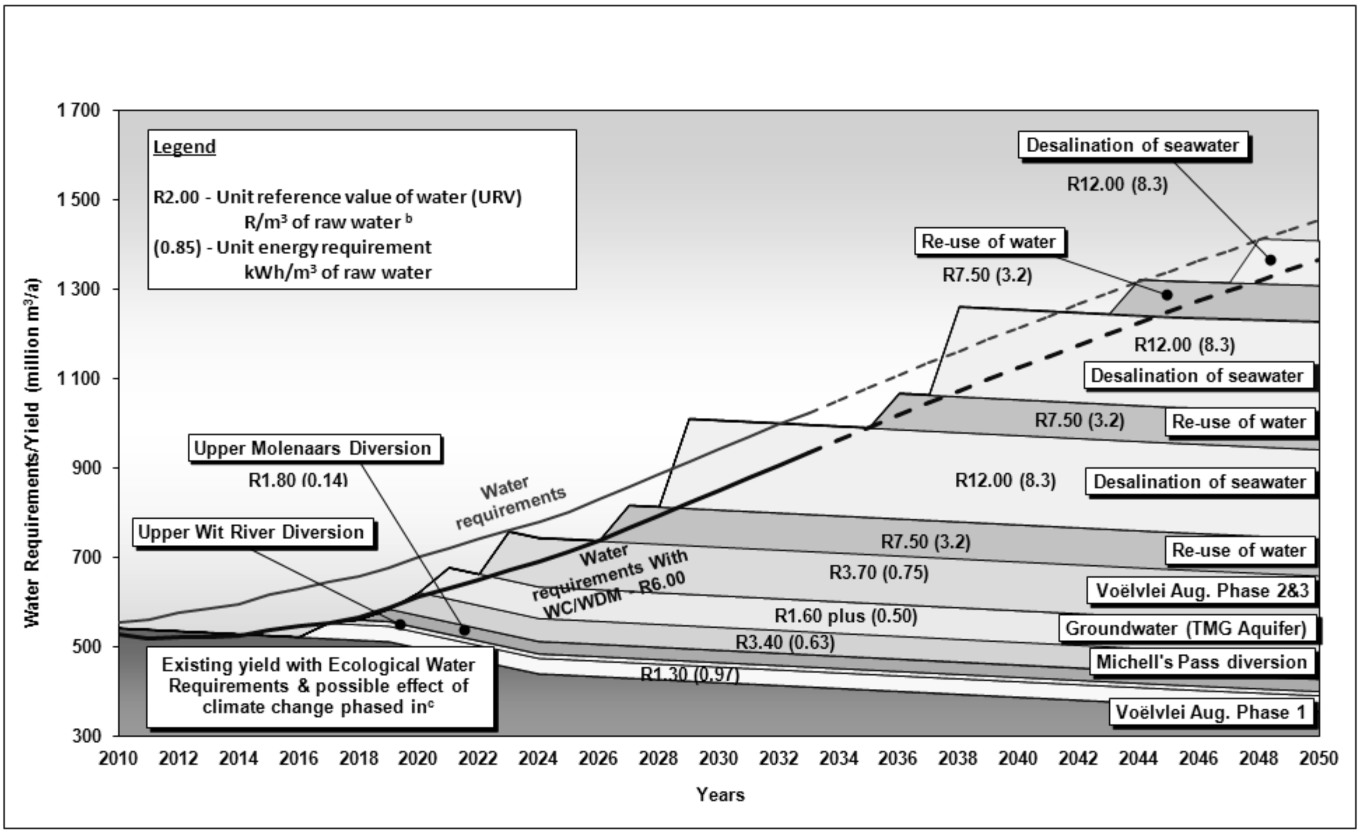
a) In ascending order of unit cost of water.

b) The reason for the use of processed acid mine drainage to be scheduled before the inter-catchment transfer from Lesotho, LHWP Phase II which has a lower unit cost, is because the latter cannot be implemented in time to meet the growth in requirements.

c) The existing yield refers to water already developed and available for use.

Source: Basson *et al* (2010).

Figure 3. Western Cape augmentation optionsa



a) Includes provision for the negative effects of climate change in the Western Cape.
b) In ascending order of unit cost of water.
c) The existing yield refers to water already developed and available for use.

Source: Basson *et al* (2010).

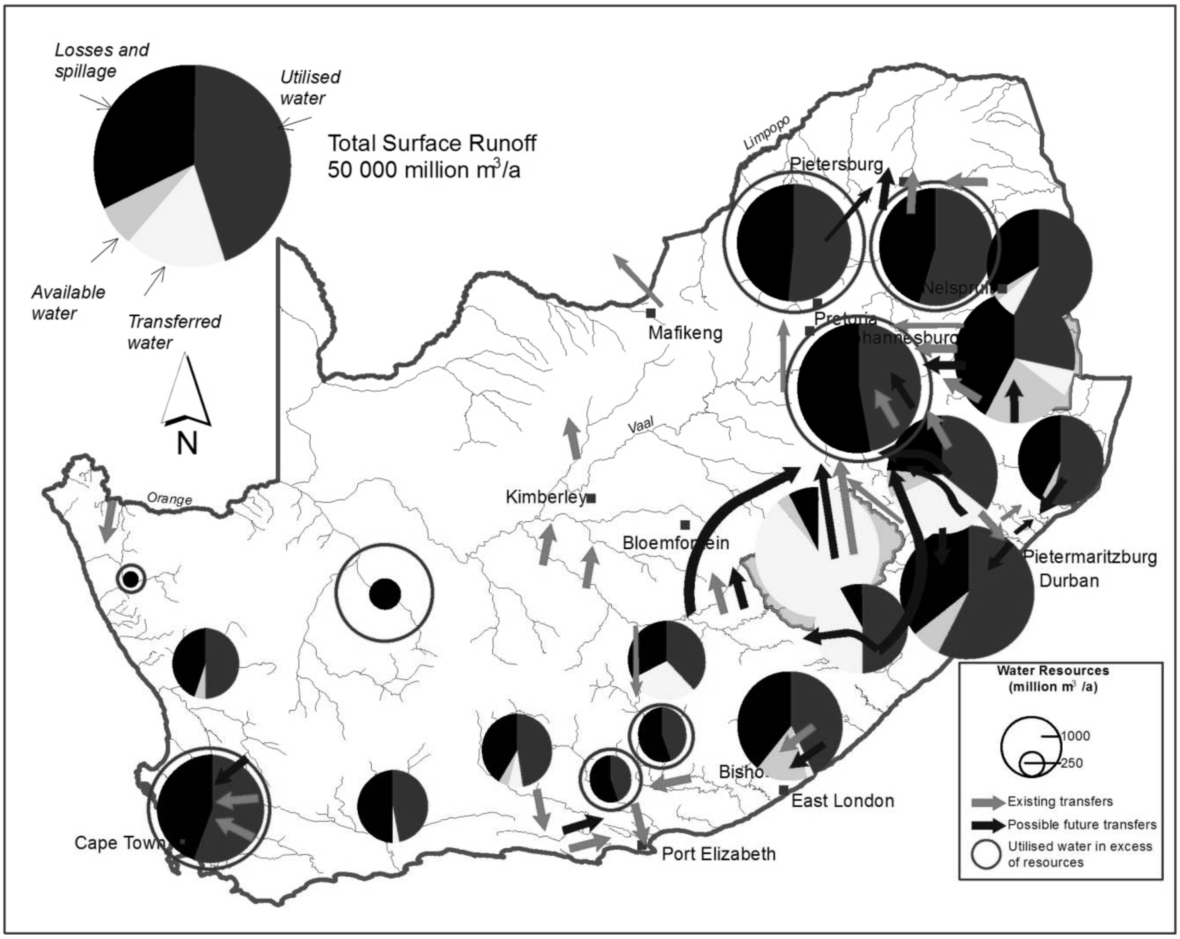
57. Conclusions from both cases, together with similar findings for other parts of South Africa, are that water can be made available to meet the future needs in all the major urban and industrial centres in South Africa, although at steeply increasing costs in most cases. Comparisons of the unit reference values (URVs)[3] to the economic value of water[4] indicate that the unit cost of water from some new water resource developments will substantially exceed the economic value of some existing water uses; most notably irrigated agriculture.[5] The re-allocation of water could therefore offer a feasible alternative to some new resource developments and augmentation schemes. It is projected that water resources across the country will become even more inter-connected and inter-dependent in future (Figure 4).

[3] Given in Figures 2 and 3.

[4] As in Tables 1, 2 and 3.

[5] Although the URVs and economic values are based on different financial and economic approaches and are not intended to be directly comparable, they at least provide a broad indication of the relative costs and economic values/benefits.

Figure 4. Projected use of surface water resources in South Africa by 2030



Source: Basson (1997)

1.9 Risks to water security in South Africa

58. The water sector (and implicitly also water security) comprises a wide diversity of interests, physical components, authorities, role players, inter-dependencies, externalities and other factors. These are compounded by the great differences in levels of development that are still evident in South Africa. Water security also applies in different ways to different water use sectors, whilst the failure of water security has different impacts and degrees of severity on different use sectors.

59. For ease of reference, the main components of the water security chain can be identified as:

- Water resources, as the primary element;
- Water services, comprising the treatment and public supply of water; and,
- Governance frameworks for managing the above.

60. The situation with respect to water security in South Africa is quite diverse, ranging from high levels of services and security in most of the large metropolitan areas, to severe and immediate risks in less

developed and rural areas. The more important aspects with relation to economic growth and environmental sustainability are:

- The larger surface water systems that supply water to the main urban, industrial and mining centres are well managed at a high level of sophistication.[6] However, delays have been experienced with respect to the implementation of some large new water resource developments, which are partly attributable to a lack of sufficient institutional capacity.[7] These delays, if not contained, could have some negative impacts on the potential for economic growth;

- Water quality in many of the country's surface streams has been severely compromised by the inadequate treatment and control of effluent discharges and urban/agricultural runoff. This poses serious environmental, health and economic risks in many places. The situation is largely attributable to a lack of institutional capacity for the monitoring and enforcement of standards, as well an insufficient technical capacity for the operation and maintenance of treatment facilities;

- The general efficiency of water use still leaves much scope for improvements, especially with respect to irrigated agriculture and losses from municipal distribution systems. This results in more water being used than actually needed, with resulting increases in the risk of failure to supply; and,

- The abstraction of water for irrigation is poorly managed and controlled, largely as a result of insufficient institutional capacity. This has serious impacts on the ability to manage environmental flows and also negatively impacts on the overall efficiency of water resources management.

61. Although pricing is seen as an instrument to encourage the more efficient use of water, water conservation and a shift from lower to higher value uses, it has not been strongly applied to date. In most cases the price of water is based on some form of cost recovery, given a blend of old and more recent infrastructure, which then does not reflect the marginal cost of water from new resource developments, nor the economic value of water. Exceptions being new stand alone water resource developments for economic use, such as mining, where the full cost of water from such development is to be carried by the users. Given that water is not freely tradeable in South Africa, the price of water in South Africa largely remains an administered item.

62. An external risk to water security that needs to be recognised and accounted for, could result from global climate change. South Africa, because of its general aridity and high variability of rainfall in space and time, is especially vulnerable to changes in water availability.

63. Indications from global circulation models (GCMs) are that greater variability in rainfall and climatic conditions may be expected. This includes the likelihood of an increase in the duration of dry spells in the interior and north eastern areas of the country, also more intense rainfall and the possibility of more frequent and severe flood events. The probable net effect would be greater variability in runoff and therefore of the usable portion of runoff, together with reduced recharge of groundwater.

[6] Many of the smaller surface water schemes and groundwater developments are poorly managed with resultant high risks of failure.

[7] The government tends to under spend available funds due to lack of institutional capacity.

64. Specifically, there is growing consensus amongst the scientific community that rainfall over the south western part of the country can be expected to significantly decline and become highly variable over the coming decades.[8]

65. South Africa has strong and enabling water legislation, well developed infrastructure, leading water resources technologies and management capability, and a sound track record. Given the political commitment together with some strengthening of institutional and technical resources, it undoubtedly has the ability to ensure that sufficient water of appropriate quality will be available in future to sustain a strong and growing economy, high social standards and healthy ecosystems.

1.10 Regional economic integration

66. The principle of striving to achieve the overall best utilisation of water which forms one of the corner stones of the National Water Resource Strategy for South Africa, should not be restricted to the geographic confines of the country, but should also be viewed in a regional and more broadly in a global context.

67. From a regional perspective, South Africa uses 60 % of its scarce water resources on irrigation, a substantial portion of which is used to sub-optimally irrigate crops which are regarded as rain-fed crops in other countries, notably some southern African countries. A concept which could have far reaching mutual benefit for the southern African region, would be to move some of this production to countries with more favourable climate and soils. An order of 25 million hectares of high potential rain-fed cropping land could be available for this purpose (DWAF, 2010). In comparison, irrigated agriculture in South Africa covers the order of 1 million hectares.

68. Such an initiative should fit well into the agenda of the Southern African Development Community (SADC) towards promoting greater trade and co-operation amongst these countries. It should also lead to the establishment/expansion of local agro-industries as well as other economic linkages, together with related infrastructure and other investments.

69. A number of major socio-economic constraints to the exploitation of this potential have been indentified, that would need to be addressed (DWAF, 2010). These include land tenure issues,[9] the high rural population spread presents a challenge to commercialisation of agriculture, poor or lacking infrastructure and general services (e.g. training and research). As experience shows in other countries, measures would have to be taken to accompany structural adjustment of the South African agricultural sector. A proactive role of the respective governments is needed to bring such regional co-operation to fruition. It would inherently be a long-term initiative to allow time for the gradual introduction of the necessary social and economic adjustments to be made.

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8 An assessment of how the yield may be impacted upon is shown in Figure 3.

9 The majority of the high potential land in neighbouring countries is occupied by subsistence farmers on commonly owned land.

2. THE CHILEAN CASE

2.1 General overview

70. Chile has a unique geography. Being squeezed between the Andes Mountains in the east and the Pacific Ocean in the west, the country is only about 177km wide on average, whilst extending over 4 270km from north to south. As a result, it is one of the most diverse countries on earth from a water resource perspective. The climate ranges from one of the wettest parts on earth in the cool and damp south, to one of the driest deserts on earth in the temperate north. The central area around Santiago and Valparaiso and where the majority of the population reside, enjoys a temperate Mediterranean type climate with annual rainfall in the range of 400mm to 800mm.

71. Southern Chile holds one of the largest stores of freshwater on earth, most of it in the form of ice fields and glaciers, with meltwater from these feeding the rivers and numerous lakes. One of the wettest places being Valdivia, with an annual rainfall of over 2 500mm. The economy of the region is based on livestock production, lumber, salmon and trout farming, with oil and natural gas abstraction in the far south. Given the abundance of water and steeply flowing rivers, large potential for hydropower generation exists, although at locations relatively remote from the main demand centres. The area is sparsely populated and also receives some tourism during summer.

72. The central part of Chile is characterised by numerous short, steep and highly seasonal rivers. The rivers rise in the Andes Mountains where they are fed by spring snowmelt, and with flows swelling from winter rains over the lower lying areas, with considerably contracted flows during summer. Substantial artificial storage was therefore provided amounting to about 15.8km^3 behind 78 large dams throughout the country (IJHD, 2010). Substantial hydropower is also generated, which amounted to 42 % of the national power production during 2009 (IJHD, 2010).

73. Central Chile forms the urban and industrial core of the country. It includes the three largest metropolitan areas in the country – Santiago, Valparaiso and Concepción, and is home to the majority of the population. Extensive agricultural production takes place in the many fertile valleys of central Chile. High value crops (fruits and grapes) is grown under irrigation, much of it for the export market, taking

advantage of Chile's southern hemisphere location for exports to the north. Pulp, paper and lumber are produced mainly in the southern areas, whilst cattle raising is common in many of the wider valleys.

74. Santiago is supplied mainly with water from the Mapocho and Maipo Rivers that are also the source of water for some large irrigation developments. The quality of water is generally very good. Some pollution however occurs due to agricultural runoff and untreated effluent discharges.

75. The far northern part of Chile is mainly covered by the Atacama Desert and is extremely dry, with no rainfall having been recorded in certain areas. Rivers or streams are typically highly intermittent, many being endorheic that cease flowing before reaching the ocean. The far north is also where most of the huge mineral wealth of Chile is found, including the largest open-pit copper mine on earth at Chuquicamata and Escondida. The mining industry not only serves as the economic backbone for the north and for harbour towns such as Antofagasta, but also represents a major portion of Chile's export earnings.

76. Given the extreme aridity and scarcity of sustainable water supplies in the area, most new mining developments are dependent on seawater supply for their operations, in cases desalinated (Guerra, Gonzalez and Viveros, 2010). The local water resources at the mining sites typically being brackish groundwater of limited quantity and with extremely low rates of replenishment (if at all).

2.2 Chilean water management/water code

77. Chile has a strong market-oriented economy, which is reflected in water management in the country. The country's constitution of 1980 established the rights for private ownership of water. The 1981 National Water Law laid out a strategic vision of water resources development that focused primarily on improving economic efficiency (GWP, 2006). The aim was to establish strong water use rights, create water markets and reduce the role of the state in water developments.

78. With the introduction of the water code in 1981 Chile soon became known as one of the leading countries in the world for its free-market approach to water law and economics. Water was classified as "national property for public use", but granted permanent transferable water use rights to individuals (Pakhus, 2006). The "water code" recognises all rights to water under previous laws, and once granted, water rights are fully protected as private property rights under the constitution. In terms of the 1981 water code, water rights are granted independently from land ownership and are not treated merely as private property, but also as a fully marketable commodity that can be traded freely without restriction like any other property right.

79. Given the high variability of river flows in most areas, provision is made for the proportionate temporary reduction of water allocations to all water rights holders in a river basin during times of water scarcity (Pakhus, 2006). The code allows for the temporary transfer of water rights during periods of droughts, when the buyers would be those that risk suffering the greatest economic losses. These arrangements are becoming very important as the stress on water resources increases.

80. Water rights were initially allocated on the basis of prior use, mainly to irrigators and to water supply utilities. These rights were allocated free of charge, permanently, and without any limit on the quantity demanded (GWP, 2006). In the event of the applications by more than one candidate exceeding the availability of water, rights were to be allocated through auction. Water rights are not associated with any water uses and there was no obligation that the water rights be utilised. Water rights could then be traded, whilst new water rights could also be obtained from the Director General of Water, provided that technical evidence is provided with respect to the availability of water resources and that granting of the new rights would not harm existing water rights holders.

81. Distinction is drawing between rights for surface water and groundwater as well as between consumptive and non-consumptive uses (Pakhus, 2006). The latter mainly to provide for hydropower developments, and also allows for the diversion of water but with the provision that it be returned to the original river channel.

82. There are conflicting views on the successes achieved with the 1981 water code. In some regions in Chile, water markets have been successful at achieving the original objectives of reallocating water to higher value uses and capturing economic efficiencies through trading. Intersectoral trading also transferred water to growing urban areas in the Elqui Valley and the upper Mapocho waterhed, where water companies and real estate developers bought water rights from irrigation farmers (Pakhus, 2006). Trading was found to be more active in areas of water scarcity and driven by demand from relatively high-valued water uses. In other areas, however, it did not become common practice. Many water rights owners consider legal security to be much more important than market pricing and trading (Bauer, 2008).

83. Several shortcomings and unintended consequences of the 1981 water code became apparent during the years after its inception. In general, the concept of Integrated Water Resources Management (IWRM) was not well established yet at the time and little attention was given to the overall management and sustainability of water resources. In particular, very little attention was given to environmental considerations and water quality issues, as well as to social equity considerations.

84. The shortfalls of the 1981 water code were sought to be corrected by the 'water code reform' that was passed in 2005 after 12 years of debate (GWP, 2006). It upholds the private ownership of water and the trading of water as a means to improved utilisation of the resource whilst seeking to address the social equity and environmental sustainability concerns. It also confirms water as a national resource for public benefit, and strengthens the state's role in managing the resource (Pakhus, 2006).

85. Some provisions of the reform include:

- Giving the President of Chile authority to exclude water resources from economic competition in cases where doing so is necessary to protect the public interest;
- Obliging the General Directorate of Water Resources (DGA) to consider environmental aspects in the process of establishing new water rights, especially in terms of determining ecological water flows and protecting sustainable aquifer management; and,
- Charging a license fee for unused water rights and limiting requests for water use rights to genuine needs, as a deterrent against hoarding and speculation.

86. The general intent of the 2005 water code reform therefore was to establish a more stable balance between the public interest and the rights of private individuals, and among social and productive demands and environmental considerations.

2.3 Environmental aspects

87. The 1981 water code did not provide for environmental water requirements along rivers and water bodies; neither quantitively, qualitively nor temporal. A large proportion of vertebrate freshwater species have in recent years been found encountering conservation problems, although not positively linked to inadequate environmental flows, flow characteristics or water quality. These aspects have subsequently been provided for in the 2005 reform and supporting environmental legislation.

88. A broader environmental issue of concern relates to the possible impacts of climate change. Studies continue to indicate that the world's glaciers are melting faster than expected (Maughan, 2008). This would affect the lives of millions of people around the world that are dependent on glacier melt for their water supply, and in many cases for their livelihood. Large variations in streamflow characteristics can be expected, which would impact on water availability for domestic and industrial uses, irrigation, hydropower generation and for sustaining of ecosystems. Current problems due to the over-extraction of water are also likely to be exacerbated by the impacts of climate change. An example being the Copiapó Valley where water abstraction is far in excess of the sustainable yield.

89. A large proportion of Chile's river flow originates from high altitude glaciers in the Andes Mountain range, and findings by the Intergovernmental Panel on Climate Change (IPCC) are that many of these glaciers are drastically reducing their volume at an increasing rate, putting at risk the continuous water supply they provide (Maughan, 2008). In an assessment by the British Foreign and Commonwealth Office, Chile is viewed as the planet's ninth most vulnerable country to climate change.

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