FORECASTING BASIC NEEDS AND FUTURE PROSPECTS

CHAPTER 2

1 DEVELOPMENT POLICY IN CHAD

The Geneva IV Round Table of October 1998 marked a turning point in Chadian development policy, enabling the Chadian government to engage its partners in dialogue at the highest level on development policy guidelines and priority sectors.

In accordance with the "Revised Orientation Plan to Prepare Chad for the Challenge of the 21st Century – Geneva IV", the government undertook to meet the strategic objective of fighting poverty and improving the quality of life of the Chadian people. Therefore, the "Poverty Reduction Strategy Paper" (PRSP) was drawn up so that all the sector strategies implemented in the country since 1998 could be brought together in a consistent and comprehensive manner. The PRSP will encourage the development partners to provide Chad with stronger financial support as a complement to national resources, including those resulting from oil exploitation that started in 2004. In addition, the PRSP is accompanied by the "National Good Governance Strategy" and espouses the goals of the Millennium Declaration. These strive to "halve, by the year 2015, the proportion of the world's people whose income is less than one dollar a day and the proportion of people who suffer from hunger; and also, by the same date, to halve the proportion of people who are unable to reach, or to afford, safe drinking water".

The PRSP[1] document has an integrated vision of poverty reduction and preparation for the post-oil boom era, and states:

[1] *Poverty Reduction Strategy Paper. N'Djaména, June 2003.*

"In the social sector, it will be a question of focusing on:

- expediting and implementing social policies (health, education, social protection), with a view to rapidly extending coverage in basic services, raising the quality of those services, and narrowing current gaps;
- implementation of specific actions, especially in the areas of nutrition, food security, hygiene, and social protection, geared to improving the lot of the most vulnerable segments of the population.

At the political and institutional level, the focus will be on:

- consolidating the foundations of democracy by completing the establishment of the institutions contemplated in the Constitution; implementing decentralisation;
- strengthening domestic capabilities in government institutions and among the representatives of civil society.

In the economic and financial sphere, efforts will focus on:

- national skill-building in both the private sector and in government departments dealing directly with economic agents."

The PRSP revolves around five principal strategies aiming to generate an overall momentum for poverty reduction in all spheres of the public administration and civil society, while highlighting a nucleus of priority sectors based on the poverty profile and its determinants, namely the health sector, rural development (including water resources and the environment), infrastructure, and the education and training sector. These strategies are:

- strategy 1: promoting good governance;
- strategy 2: ensuring strong and sustained economic growth;
- strategy 3: improving human capital;
- strategy 4: improving the living conditions of vulnerable groups, and victims of HIV/AIDS and sexually transmitted diseases (STD);
- strategy 5: restoring and safeguarding ecosystems.

All the development actions to be undertaken by the different development stakeholders over the next 15 years will be implemented within the framework of the National Poverty Reduction Strategy. This strategy takes account of the international context and, above all, the national context.

This chapter of the Integrated Plan for Chad's Water Development and Management, in accordance with the above-mentioned strategies and the costed objectives defined by the government, identifies the equipment and the accompanying measures to be implemented between now and 2020. Evaluation of these needs depends mainly on demographic projections and takes account of the assessment-diagnosis carried out in Chapter 1. When compared to investments already planned with the corresponding funding obtained, the SDEA reveals a deficit.

The main difficulty in overcoming this deficit remains the poverty of the country and its people. The restrictions to be overcome concern:

- the mobilisation of internal and external funds;
- insufficient human resources to support the programmes;
- weaknesses in the skills of local private sector companies.

Methodology: after identifying water and equipment requirements up to 2020, the sections below will assess the impact of the developments planned by the SDEA on water resources and the environment, and the impact of financial and capacity constraints. The policy and strategies which will address these constraints will be described in chapter 3, and the corresponding action plan and costings will be studied in chapter 4.

2 EVALUATION OF REQUIREMENTS IN THE DIFFERENT SUBSECTORS

2.1 Village water supply requirements

There is a major requirement for drinking water points in village areas. The requirements are evaluated according to the following criteria: 20 litres of water per day per inhabitant; one hand pump supplies, on average, 400 people; a self-contained unit (solar or thermal) supplies 1600 people and a well supplies 600 people. Projections on village population growth (see table 1) and the number of villages, have been drawn up using data from the 1993 census. In 2000, the drinking water requirements for the total village population were 43.6 million m^3; they will rise to 53.6 million m^3 in 2010 and 64.65 million m^3 in 2020.

2.1.1 Evaluation of drinking water point requirements in 2000

[2] *HP equivalent: One water point equipped with a hand pump supplies 400 people whereas a village well supplies 600 people. The HP equivalent involves converting the supply capacity of all types of water point to the capacity of a hand pump. Thus, one well corresponds to 1.5 HP equivalent.*

To allow for the populations' capacity to pay for the equipment, the number of water points to be constructed and the technical characteristics of the different types of pumping devices that can be installed on the boreholes, the populations have been grouped into one of four classes of village: those with fewer than 150 inhabitants, those with between 150 and 299, those with between 300 and 1200 and those with between 1201 to 2000 inhabitants. Table 15 lists the drinking water point requirements in hand pump (HP) equivalents[2] for each class of village in 2000.

Table 15: Drinking water point requirements (HP equivalent) in village centres in 2000

Size of village	Number of villages	Total estimated population	Population supplied in 2000	WP needs in HP equivalents	Remarks
Fewer than 150 people	16 000	694 000			Construction of 2000 covered wells or 2000 auger holes
150 to 300 people	6 187	1 373 820	143 500	5 613	
300 to 1200 people	5 814	3 166 577	710 400	6 334	
1200 to 2000 people	483	738 833	135 600	1 516	Replacement of 1400 HPs by 350 individual units
Total	28 484	5 973 132	989 500	13 463	Rounded up to 13 500 WPs

Source: SDEA 2001

Villages with fewer than 150 inhabitants

It is difficult to estimate the number of villages with fewer than 150 inhabitants, because the 1993 census counts communities of between 5 and 10 people as villages. However, these small villages do not meet the standards needed to qualify for financial contributions and the installation of water tanks as required by the institutional donors and by the Directorate of Hydraulic Affairs in the context of major water supply infrastructure construction projects. It is suggested, therefore, that this class of village be equipped with water points consisting of small diameter closed wells, and/or boreholes drilled by auger, fitted with locally manufactured water pumps. This type of equipment and civil work is justified for all villages with few inhabitants, since the demand for water from the pump and water points would consequently be low. Another solution is to group together certain villages, where these are not too far apart, so that they have the financial means to maintain a borehole type water facility equipped with a hand pump. Considering only the population of this class of village and not taking into account the spatial distribution of the villages, the drinking water supply equipment requirements amount to approximately 2000 sets.

Villages with between 150 and 300 inhabitants

In theory, this class of village does not meet the current standards governing the allocation of modern drinking water points. However, because 23% of the village population of Chad live in villages like this, it is important for these populations to obtain access to drinking water within the next two decades.

The drinking water supply equipment to be installed in these villages consists of boreholes fitted with hand pumps (HP). Because of the relatively low maintenance cost of hand pumps, the local populations are normally able to take responsibility for the management, maintenance and servicing of these water points. This is the essential prerequisite for the provision of water points in each village. in 2000, the equipment required to supply drinking water to all these villages was estimated at 5613 boreholes fitted with hand pumps.

Villages with between 300 and 1200 inhabitants

The drinking water supply equipment to be installed in this class of village consists mainly of boreholes fitted with hand pumps. Self-contained pumping units can also be envisaged where they would supply villages with more than 1000 inhabitants and where the local population can demonstrate the capacity to pay for this type of equipment. In 2000, the equipment required to serve all populations in this class of village was estimated at 6325 borehole/HP sets.

Villages with between 1200 and 2000 inhabitants

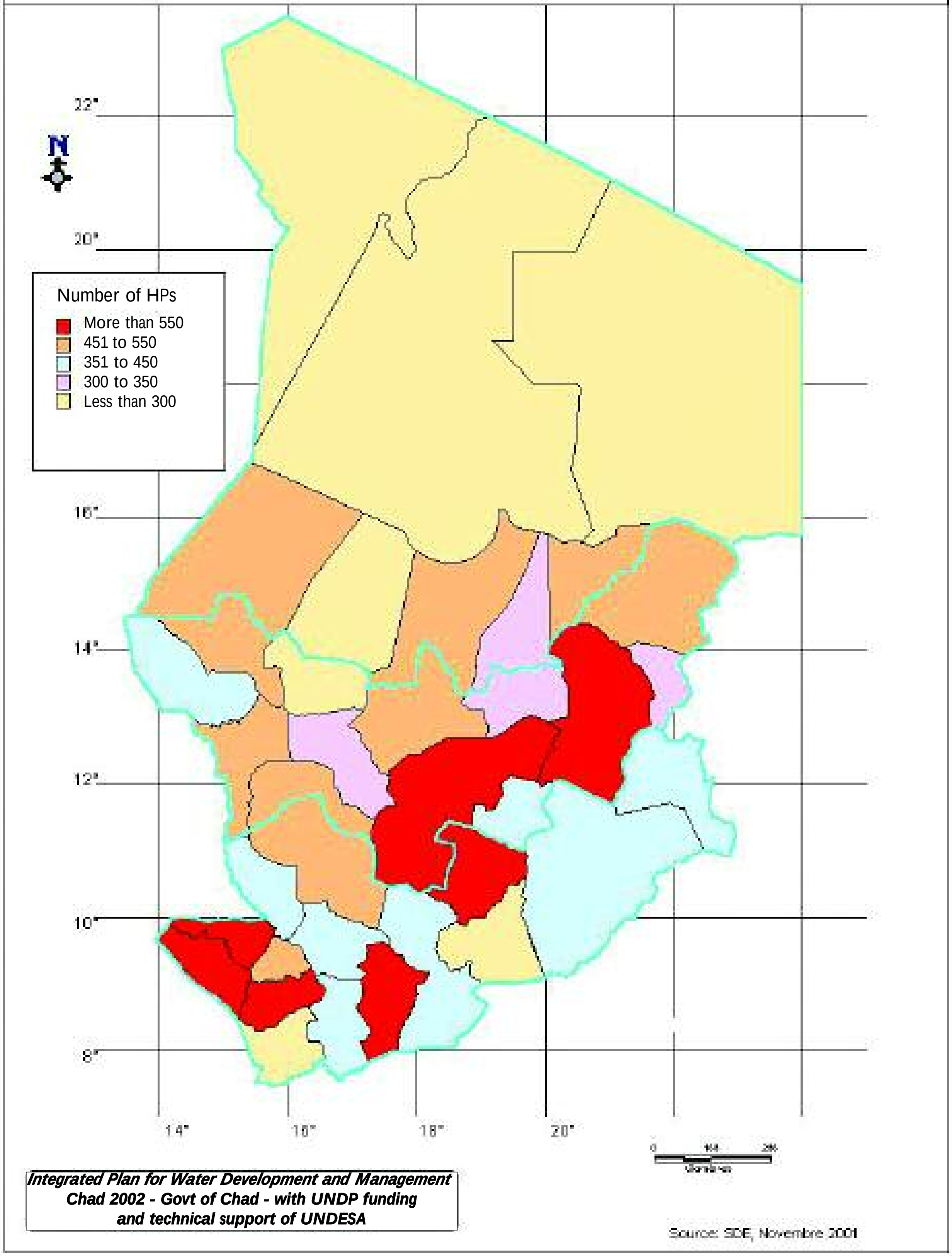
In view of the technical capacities of hand pumps (one hand pump supplies 400 people) and their construction costs, it is proposed, where the local population has the capacity to pay for these installations, to equip this class of village with self-contained units consisting of a borehole, a solar or thermal pumping station, a water tower and one or two stand-pipes, especially in villages with more than 1500 inhabitants.

In 2000, the drinking water supply equipment requirements for this class of village were estimated at 340 self-powered water points or 1516 hand pumps.

Figure 13 gives the estimated drinking water point requirements per department in 2000 in hand pump equivalents (one hand pump per 400 people). Moreover, the analysis of the water points to be constructed was based on estimated requirements and takes no account of actual demand. Taking current demand into account, fewer drinking water points would probably need to be constructed.

Republic of Chad

Figure 13: Village drinking water point requirements (HP equivalents) in the year 2000



2.1.2 Evaluation of village drinking water point requirements for 2020

The village population is expected to increase from 5 973 130 inhabitants in 2000 to 8 855 260; in 2020, in other words, approximately 2 882 130 extra inhabitants will need to be supplied by drinking water points. In HP equivalents, this extra village population represents 7200 new water points. However, considering that 15% of the village population would still be living in villages of fewer than 150 inhabitants, the theoretical number of drinking water points to be constructed to satisfy this extra requirement would be approximately 6125 (0.85 x 2 882 130 people = 2 450 000 people/400 people per HP = 6125 drinking water points).

Table 16 summarises the drinking water point requirements in HP equivalents for 2020.

Table 16: Summary of drinking water points for 2020

Drinking water point equipment scenario	Drinking WP needs in 2000 (HP equivalents)	Drinking WP needs from 2001-2020 (HP equivalents)	Total drinking WP needs in 2020 (HP equivalents)	Remarks
Scenario 1: villages with populations of between 300 and 2000 people	7 850	4 500	12 350	Rounded up to 12 500
Scenario 2: villages with populations of between 150 and 2000 people	13 500	6 125	19 625	Rounded up to 19 600
Scenario 3: villages with populations of between 75 and 2000 people	15 500	7 800	23 300	Rounded up to 23 500

Source: SDEA 2001

This table invites the following observations:

- Scenario 1 corresponds to the standards governing the allocation of drinking water points in 2001, i.e., the construction of a drinking water point in villages with populations of 300 or more. Using this standard, approximately 12 500 drinking water points are to be constructed by 2020 to supply all these villages. This represents approximately 70% of the village population of Chad. In order to meet the Millennium Goal, i.e., 60% of the village population with access to drinking water by 2015, it will be necessary, therefore, to construct 10 300 new water points.
- Scenario 2 consists in providing drinking water points in all villages with populations of 150 or more. For this to happen, the 2001 standards for allocation of drinking water points must be modified. According to this adjustment, 19 600 drinking water points must be constructed by 2020 in order to supply 85% of the Chadian village population.
- Scenario 3 consists in providing drinking water points in all villages with populations of between 75 and 2000 people. This would mean constructing approximately 23 500 drinking water points by 2020. However, the provision of drinking water points in villages with fewer than 150 inhabitants would fall mainly within the remit of NGOs and charitable organisations.

The number of HP equivalent drinking water points can be significantly reduced by installing self-contained pumping units in villages with 1200 inhabitants or more, and by grouping together certain small, closely located villages.

The funds currently obtained (2001) are sufficient to construct at least 7200 boreholes with hand pumps and 207 boreholes with solar or thermal-powered pumping stations during the period 2000-2008. Provision of these new water points will have a significant effect in increasing the proportion of the village population having access to drinking water. Depending on the scenarios selected for the allocation of new water points by department and by village, the percentage of the population with access to a drinking water point in 2010 will vary between 35% and 55%. This is because, in the event that the various projects are implemented on a large area (departmental) basis, in villages with 150 to 2000 inhabitants, the national percentage of villages with drinking water supplies would only be of the order of 35%. This is because most villages with fewer than 300 inhabitants (generally an average population of fewer than 200 people) will be provided with a water point. Therefore, considering that one hand pump normally supplies 400 people, the HP supply capacity would be halved. On the other hand, by extending the intervention areas of these projects to new departments and by working only in villages with more than 300 inhabitants, the nation-wide proportion of villages supplied with water in 2008 would be of the order of 55%. In this case the pumping equipment, consisting mainly of hand pumps, would be working at maximum capacity.

In addition, in order to increase drinking water supplies to village populations in accordance with the principle of national equity defined by the Water Code, scenario 1 is to be preferred for the period 2000-2010, whereas the application of scenario 2 will increase the density of village drinking water points during the period 2011-2020.

On the basis of the requirements for drinking water supply equipment mentioned above, 10 300 new drinking water points (HP equivalents) will have to be constructed in villages by 2015 to reach the Millennium Goal[3]. In view of the funding obtained in 2002, this goal will probably be met.

[3] The Millennium Goal is to halve the percentage of people without access to drinking water between 2000 and 2015. In the case of rural Chad, this would represent a reduction from 83.4% (in 2000) to 41.7% (in 2015).

Considering the current rate of capital investment and assuming that it is maintained, the objective set by the Directorate of Hydraulic Affairs is to guarantee that the proportion of village people with access to drinking water reaches 85% by 2020. This corresponds to the construction and equipping of 19 600 drinking water points (HP equivalents). In 2002, approximately 8000 drinking water points are being constructed or at least have funds available. Therefore, 11 600 remain to be built between 2002 and 2020, an average of 650 new water points per year. Moreover, starting in 2015, it will be necessary to devote part of the capital investment to renewing existing boreholes (about 250 per year).

2.2 Urban and semi-urban water supply requirements

Table 17 presents urban and semi-urban water consumption hypotheses for 2000, 2010 and 2020 in the STEE concessionary sector and the non-concessionary sector.

Tableau 17: Specific water consumption hypotheses

Sectors	2000	2010	2020	Remarks
Concess. excl. N'Djaména	45 l/day/inhab.	75 l/day/inhab.	100 l/day/inhab.	Competition between village water points & DWS
N'Djaména	75 l/day/inhab.	100 l/day/inhab.	150 l/day/inhab.	Consumption including services
Non-concessionary	35 l/day/inhab.	60 l/day/inhab.	75 l/day/inhab.	Competition between village water points & DWS

Source: SDEA 2001

Based on these hypotheses and assuming that all inhabitants of towns and centres with populations of more than 2000 have access to a drinking water supply (DWS) distribution system, the urban and semi-urban water requirements are estimated at 34.75 million m^3 for 2000, rising to 73.2 million m^3 in 2010 and 135 million m^3 in 2020. Table 18 presents the requirements expressed as water volumes by department and for sites with more than 2000 inhabitants for the period 2000-2020.

Table 18: Estimated urban and semi-urban water requirements

	2000				2010				2020			
Dept.	No. of sites	Popul.	L/ inhab/d	Needs in 2000	No. of sites	Popul.	L/ inhab/d	Needs in 2010	No. of sites	Popul.	L/inhab/d	Needs in 2020
Batha Est	1	14 508	35	185 340	2	19 969	60	437 321	2	24 529	75	671 481
Batha Ouest	5	31 118	35	397 532	6	43 191	60	945 883	10	57 978	75	1 587 148
Borkou	1	10 405	45	170 902	1	11 034	75	302 056	1	11 678	100	426 247
Ennedi	1	3 816	35	48 749	2	7 583	60	166 068	4	15 381	75	421 055
Tibesti	0	0	0	0	0	0	0	0	0	0	0	0
Biltine	6	23 665	35	302 320	6	30 678	60	671 848	11	45 580	75	1 247 753
Baguirmi	10	47 793	35	610 556	11	72 102	60	1 579 034	13	92 490	75	2 531 914
Dababa	4	29 715	35	379 609	5	37 545	60	822 236	7	47 041	75	1 287 747
Hadjer Lamis	18	64 401	35	822 723	21	106 083	60	2 323 218	25	126 757	75	3 469 973
Guéra	12	68 073	35	869 633	19	106 230	60	2 326 437	27	141 829	75	3 882 569
Kanem	2	17 822	35	227 676	2	20 262	60/75	554 672	2	21 783	75/100	795 080
Barh El Gazal	1	19 130	35/45	314 210	1	23 285	60/75	637 427	2	26 618	75/100	971 557
Lac	5	22 345	35	285 457	11	39 343	60	861 612	13	54 169	75	1 482 876
Logone occidental	13	154 053	35/45	2 530 321	27	230 309	60/75	6 304 709	51	343 435	75/100	12 535 378
Logone oriental	8	48 283	35/45	793 048	17	84 535	60/75	2 314 146	25	125 606	75/100	4 584 619
Mont de Lam	3	20 208	35	258 157	3	23 405	60	512 570	3	28 161	75	770 907
Mayo Boneye	4	37 474	35/45	615 510	8	53 293	60/75	1 458 896	11	63 106	75/100	2 303 369
Kabia	16	48 801	35/45	801 556	29	82 354	60/75	2 254 441	48	149 406	75/100	5 453 319
Mayo Dala	14	73 758	35	942 258	30	147 231	60	3 224 359	56	243 495	75	6 665 676
Lac Iro	2	16 773	35	214 275	5	28 693	60	628 377	12	54 895	75	1 502 751
Barh Kho	9	113 058	35/45	1 856 978	13	162 379	60	3 556 100	22	211 698	75	5 795 233
Mandoul	16	81 444	35	1 040 447	28	129 408	60	2 834 035	46	200 679	75	5 493 588
Assongha	1	9 689	35	123 777	2	14 494	60	317 419	3	19 251	75	526 996
Ouaddaï	5	75 364	35/45	1 237 854	6	92 111	60/75	2 521 539	13	123 143	75/100	4 494 720
Sila	3	8 065	35	103 030	4	11 949	60	261 683	5	15 365	75	420 617
Salamat	9	45 768	35	584 686	13	72 879	60	1 596 050	15	93 614	75	2 562 683
Tandjilé Est	7	35 778	35	457 064	11	56 941	60	1 247 008	17	76 711	75	2 099 964
Tandjilé Ouest	9	65 809	35/45	1 080 913	16	97 200	60/75	2 660 850	28	136 593	75/100	4 985 645
Total	185	1 187 116		17 254 583	299	1 804 486		43 319 990	472	2 550 991		78 970 862
N'Djaména	1	639 000	75	17 492 625	1	818 600	100	29 878 900	1	1 024 000	150	56 064 000
Grand total	186	1 826 116		34 747 208	300	2 623 086		73 198 890	473	3 574 991		135 034 862

Source: SDEA 2001

2.2.1 Equipment requirements for the non-concessionary sector

The 175 sites in the non-concessionary sector represent a total population of 783 055 inhabitants in 2000, i.e., an average of 4500 individuals par site (see tables 4 and 18). Considering the funding that is being or has been obtained, and the constraints hindering sector development and the urgency of providing these populations with access to drinking water, it is proposed to equip non-concessionary sector towns with mini water supply networks. These would consist of a borehole, a submerged pump, an electricity generator or solar energy station, a water tower and a small-scale distribution network consisting of several stand-pipes. These basic supply units (BSU) can supply populations of between 2000 and 3000 people on average. Depending on investments and the populations' ability to pay, some of these BSUs could later be connected together to form a complete water supply network, with connections to individual houses.

In 2000, based on this criterion and considering that approximately 200 000 people are already supplied by such systems, 292 basic supply units must be constructed on 175 sites with over 2000 inhabitants (783 055 people (total population) – 200 000 people (population supplied) = 583 055 people/2000 people per BSU = 292 BSU). In 2010, 259 BSUs will have to be constructed and, by 2020, 324 new units will have to be fitted. Between 2000 and 2020, the number of sites needing to be equipped with BSUs will rise from 175 to 462. Over the same period, to provide the entire resident population of the non-concessionary sector with drinking water supplies, 875 BSUs spread over 462 sites will have to be constructed. However, considering sites which are currently within the village water supply domain (44) but which will, by 2020, be in the semi-urban water supply domain, and including the BSUs already financed (205) and those already being constructed, the number of BSUs to be installed by 2020 amounts to about 625. In 2000, the average cost of one BSU was FCFA 60 million; to guarantee a drinking water supply for the entire population of the non-concessionary sector, funding of FCFA 37.5 billion must be found. It should be noted that this evaluation is based on "supply" and not "demand". Moreover, the criterion of 2000 people per "centre" for a BSU to be installed, takes into account economic considerations (investment costs, service costs, maintenance and renewal charges) in relation to the population's capacity to pay, this capacity remaining the main condition for authorising the construction of a BSU in a town.

In addition, in order to meet the Millennium Goal, 62% of the non-concessionary sector population must have access to drinking water by 2015, i.e., approximately 975 000 people. In water supply equipment terms, this represents 488 BSUs. Regarding the 2020 target set for the SDEA, the objective is 70% of the non-concessionary population having access to drinking water by 2020, i.e., approximately 1 100 000 people, which will require the construction of 550 BSUs. In view of the funds obtained and the ongoing installation programmes for this type of water point (250 BSUs), these objectives can be met. In 2002, funds still had to be found to construct 238 BSUs, to meet the Millennium Goal, or 300 BSUs to meet the target set for the non-concessionary sector by 2020.

2.2.2 Concessionary sector equipment requirements

The STEE concessionary sector includes 11 towns with a total population of 1 043 061 in 2000. According to data obtained from STEE, the drinking water supply rate is, at best, 40% of the population of each town, apart from Faya where the network is currently being rehabilitated. This water supply rate does, however, seem high. Even so, equipment requirements remain extensive.

Additionally, within the framework of the STEE long-term capital investment plan, works are planned to rehabilitate, extend, renew and upgrade the water networks in N'Djaména and in some other towns. Thus, in the capital, 1000 connections per year are planned as well as the installation of 12 stand-pipes in the same period. In all, this corresponds to almost 10 000 more inhabitants with access to drinking water per year whereas, taking only demographic growth projections into consideration, the population of the town is expected to rise by at least 20 000 inhabitants per year.

In STEE centres other than N'Djaména, almost the same number of inhabitants will be provided with access to drinking water. The total population of these centres is of the order of 405 000 inhabitants. Population growth in these centres is bound to be slower than in N'Djaména; however, a 3% increase represents 12 000 people, which shows that, here again, the efforts made by STEE will not improve the proportion of the population with access to drinking water. These schemes will, at most, maintain the supply rate at the current (2001) rate. However, in 2002, the schemes programmed in the long-term capital investment plan have still not obtained funds.

While waiting for the funds and resources (studies, town planning reports, DWS network development plans for each town, etc.), required to extend the different networks and to improve the supply rate, it is proposed to repeat the Water and Service project being implemented in the districts surrounding N'Djaména (provided that the experiment is successful) in the other concessionary sector towns. These mini-DWS, each of which can serve an average of 10 000 people in densely populated districts, should be designed so that they can be interconnected once the financial and technical resources become available, thereby providing a complete drinking water supply network in each town of this sector.

In 2000, based on a rough calculation, 626 000 people required access to drinking water in the concessionary sector, which represents, theoretically, 63 mini-DWS. Since the estimated installation cost of each mini-DWS is FCFA 250 million, the total funding to be found is FCFA 15.75 billion, which, in theory, would enable the total population of the concessionary sector in 2000 to be served. Between 2000 and 2020, approximately 60 new mini-DWS would need to be installed. In parallel with these actions, it is vital to continue efforts to install complete DWS networks. However, given the current level of knowledge (2001), it is difficult to quantify the capital investment necessary to extend and set up complete drinking water supply networks for the entire concessionary sector in order to increase the current supply rate (40%) to 70% in 2015, and to maintain it and increase it by 2020.

To set up mini-DWS, 114 drinking water supply systems of this type would have to be constructed in order for the set objective to be achieved; this new equipment would supply drinking water to approximately 1.14 million people. Funding for these 114 mini-DWS amounts to approximately FCFA 28.5 billion.

Table 19 summarises the objectives to be met for the concessionary and non-concessionary sectors by 2020.

Table 19: Urban and semi-urban water supply objectives to be met by 2020

Sector	Population 2000	% access	Population supplied	Population 2020	Access % to be reached	Population to be supplied
Concessionary	1 043 061	40	417 225	1 625 900	70	1 140 000
Non-concess.	783 055	26	204 000	1 949 091	70	1 365 000
Total	1 826 116		621 225	3 574 991		2 505 000

Source: SDEA 2001

2.3 Sanitation requirements

2.3.1 Sanitation requirements in rural areas

The great majority of Chadian households in rural areas do not have toilets, and systems for disposing of excreta, solid waste and wastewater are almost non-existent. As a consequence, 10.6% of households use a rudimentary latrine, 0.6% use a ventilated and improved pit latrine and 88.5% of households relieve themselves in the open. Moreover, there are no waste collection services in the villages and domestic animals roam free. Finally, between 65% and 70% of rural households consume water from traditional wells and only 17% of the rural population has access to a drinking water point.

Other than those funded by UNICEF, there are few projects being implemented in the field of rural sanitation. Most of the large infrastructural water projects include population awareness-raising and education campaigns relating to water/hygiene/health issues. But these efforts do not result in concrete improvements in population behaviour since they make little or no connection between the illnesses which afflict them, and their drinking water, sewage removal and waste disposal methods. Moreover, none of these projects plays a role in the construction of latrines and in the implementation of measures and infrastructure which could improve the sanitary environment in rural communities.

Basic infrastructure development requirements are substantial in village areas and everything remains to be done.

In view of the immensity of these needs, it is proposed to associate each village water supply project with a sanitation aspect which, in addition to environmental health education, will consist in fitting out basic sanitary infrastructure such as ventilated improved pit latrines for families, ventilated improved double pit latrines for schools and health centres, soakaways for wastewater disposal, etc. In order to integrate the sanitation aspect with that of water supply, the basic sanitary equipment could possibly be considered as the villagers' contribution in return for the development of drinking water points in their village.

As an indication and in order to evaluate approximately the basic sanitary infrastructure requirements in rural areas, it is assumed that each household has a ventilated improved pit (VIP) latrine; therefore, there would be approximately 1 million VIP latrines to be built in Chadian villages. At a basic unit price of FCFA 25 000, investments would amount to FCFA 25 billion.

2.3.2 Sanitation requirements in urban and semi-urban environments

Although knowledge of this field is localised and incomplete, it can be asserted that, in 2000, the entire urban and semi-urban population requires modern, conventional urban and semi-urban sanitation.

Collection and treatment of domestic wastewater

Collection and treatment of wastewater remains to be established in all urban and semi-urban areas. The average cost per linear metre of sewerage pipes is much higher than that of drinking water pipes: this cost ratio can be 10 to 1. With this hypothesis, the cost of a sewerage network, including installation, varies between FCFA 320 000 and 420 000 per metre.

To give a simple idea of the funds needed, equipping only the four largest towns (2020 population) could reach almost FCFA 36 billion.

Therefore, realistically, self-contained sanitation will have to remain policy for the coming years, to be fitted systematically where space permits in the concessionary sector. Where this is not possible, as is the case in many densely populated suburban areas, this type of sanitation would be fitted on public sites.

Furthermore, the current situation is not satisfactory for groundwater, which is known to be over-exploited by the same users.

Improvements will be achieved:

- for excreta (fecal matter and urine), through the general use of modern sealed, ventilated and improved double pit latrines (which, under normal circumstances, only produce dry, hygienic matter which is easily disposed of);
- for domestic wastewater, through the general use of systems to remove stored materials into sealed pits and no longer into cess pits;
- as a priority, through the provision of a communal sanitary outlet for all these materials. As always in this regard, the organisation of the removal of these materials must be considered from the outset.

This should significantly improve the current situation in the towns.

Collection of solid waste

It is of the utmost urgency to start by assigning a suburban area to be used for managed solid waste dumping. It is completely illusory to think that sustainable cleanliness in towns or public health in urban centres could be achieved without first having a clearly defined and easily accessible waste outlet.

Whereas efforts with regard to stormwater drainage studies have started to bear fruit, no study on solid waste treatment has been identified. Field surveys of the main towns, especially N'Djaména, report the concerns of municipal leaders. The technical services of the capital have taken steps to rationalise waste collection and the recovery of all items that are easy to sort.

In nearly every case, the inhabitants in the end use "transfer stations" which are basically waste dumps located within the inhabited area. Since it is not systematically removed, the waste stagnates. The chain of measures put in place to protect public health is broken at the worst point, from a health point of view, when waste gathers in town centres.

It is, therefore, a question of finding resources not just for removing the waste regularly but also for transferring it to a recognised and appropriate site sufficiently close to each town to be accessible (perhaps even by animal transport) and of sufficient area to allow the material to be spread out rather than piled up, a solution which, moreover, presents technical difficulties.

In terms of requirements, there were approximately 200 towns and population centres with more than 2000 inhabitants in Chad in 2000. On this basis and according to the size of these centres, suitable studies need to be carried out to identify 200 managed solid waste dumping sites.

Following these studies, the sites will have to be developed and solid waste collection organised. It is clear that the problem of solid waste disposal is much more complex in the larger Chadian towns than in the secondary centres with populations of between 3000 and 4000 people.

Stormwater collection and disposal

This is the highest-priority water-related issue for the inhabitants of the main towns, and represents the major part of the work to be done in the years to come. This is an aspect which represents considerable investment and, for the most part, is beyond the reach of local authorities. Nothing effective can be achieved without starting with the downstream equipment, which is the most costly and most complex. In particular, this requires that the ground surface be mapped and levelled. These schemes are not possible without regional coordination.

It is suggested that, for stormwater collection, priority for capital investment should be placed on the primary main drains and on flood relief basins; priority must be given to this infrastructure in order to take maximum advantage of natural flow channels.

Furthermore, there are no primary or secondary stormwater drainage networks. The tertiary network in operation is underdeveloped and seems to have been built without overall planning. However, it appears that creating more drainage channels is not a realistic solution because firstly, most of the annual rain falls in downpours over only about two months of the year and, secondly, the local population throws waste into the channels, which become blocked once the rainy season starts.

In this context, the most appropriate solution seems to be to make best use of the existing natural flow channels. In towns, roads themselves can serve as stormwater drains; they must merely be levelled to prevent the accumulation of standing water. The investment required is relatively low and the primary drainage networks can thus be constructed in the low points.

The cost of installing drainage channels across N'Djaména to provide drainage for the town has been roughly estimated at FCFA 7 billion per 100 000 inhabitants. This estimate is based on the following calculation: there is, on average, one road per hectare and since one hectare is a square of 100 m side length and since the road crossing it will be 100 m long, then 100 m of drainage channel needs to be constructed per hectare. At FCFA 100 000/m, this represents a cost of FCFA 10 million/ha. In addition, since the population is of the order of 150 inhabitants per hectare, around 700 hectares would need to be drained for a population of 100 000 inhabitants.

2.3.3 Sanitation requirements in industrial areas

The few industries in Chad are concentrated in N'Djaména, Moundou and Sarh. Little is known about the volumes and chemical content of the wastewater discharged by these industries. However, the vast majority of these industries discharge their wastewater into watercourses (Chari and Logone in particular) without pre-treatment.

In view of this data shortage, it is not possible to make an exhaustive inventory nor evaluate the requirements, except to say that everything remains to be done. All industrial wastewater has different properties; it can be difficult to establish the appropriate treatment methods beforehand.

Moreover, there is no national legislation covering the type and composition of industrial emissions. A first step to be taken is to draw up national standards relating to the composition of industrial effluent and wastewater and to implement control and monitoring procedures. In addition, each industry could be required to produce a periodic report on the characteristics of its emissions.

Initially, efforts must be made to mobilise public funds to draw up standards. Industries must then subsequently comply with these standards by installing appropriate treatment equipment, at their own cost.

2.4 Pastoral water supply requirements

2.4.1 Assessment of pastoral water supply requirements

The assessment of pastoral water supply requirements is based on the current Chadian livestock numbers expressed as tropical livestock units (TLUs). Each TLU corresponds to 30 litres of water per day. On this basis, table 20 assesses the pastoral water supply requirements for the period 2000 to 2020.

Table 20: Assessment of pastoral water supply requirement per geoclimatic zone

	2000		2010		2020	
Geoclimatic zone	TLU	Needs m^3/year	TLU	Needs m^3/year	TLU	Needs m^3/year
Saharan	1 044 610	11 438 475	1 400 563	15 336 165	1 906 308	20 874 069
Sahelian	12 271 104	134 368 592	15 869 346	173 769 341	21 362 895	233 923 697
Sudanian	2 748 516	30 096 252	3 482 850	38 137 204	4 758 992	52 110 958
Total	16 064 230	175 903 320	20 752 759	227 242 711	28 028 194	306 908 724

Source: SDEA 2001

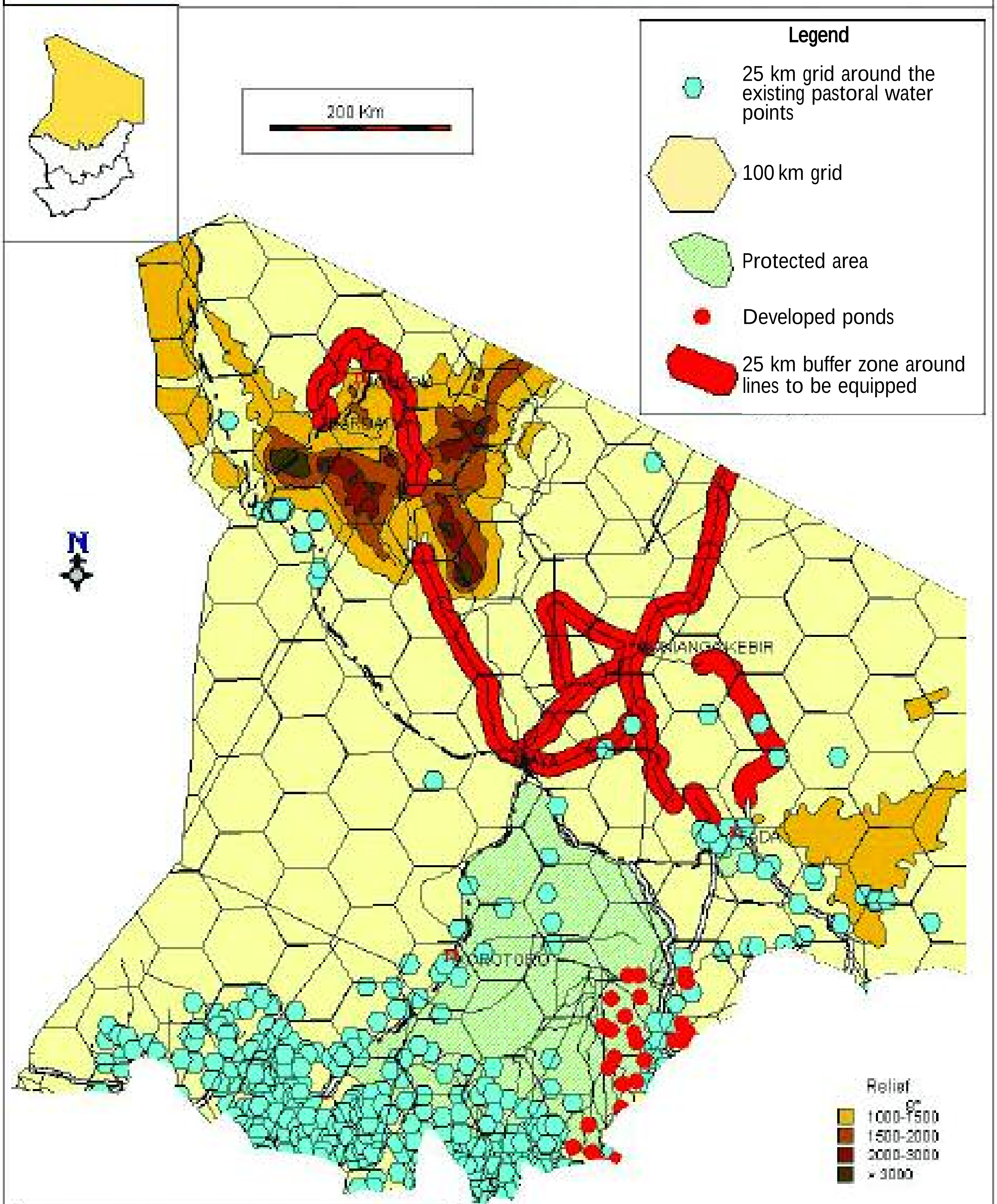
It may be deduced from this table that pastoral water supply requirements in 2000 were 176 million m^3/year; these requirements will rise to 227 million m^3/year in 2010 and 307 million m^3/year in 2020. It should be remembered that these water volume estimates are based on the high-end hypothesis of livestock numbers expressed as TLUs and that these estimated requirements, especially for 2020, do not into take account the carrying capacities of the pastoral land which must be evaluated before then, as must livestock numbers. Therefore these water supply requirements are probably overestimates; however, as a precaution, they will be retained for the remainder of this document.

Moreover, of this estimated water volume, approximately 57 million m^3 (33%) is derived from surface water and 119 million m^3 (67%) is abstracted from groundwater sources.

2.4.2 Assessment of pastoral water point requirements

A lack of basic data, such as livestock numbers, pastoral resources, and the location and operation of pastoral water points (especially those exploiting surface water and traditional wells), makes it impossible to estimate the current and future requirements for pastoral water supply equipment with a minimum degree of reliability. In order to overcome this major difficulty, the methodology implemented in assessing water point requirements consists in defining a hexagonal reference grid centred on the existing, georeferenced wells. The ponds with basic facilities developed in eastern Chad have also been marked on these maps (see figures 14, 15 and 16). However, in the following pages, when reference is made to pastoral water points, this refers first and foremost to wells since they guarantee access to water at all times, which cannot be said for ponds, which only provide water for cattle for a few months of the year, .

Republic of Chad
Figure 14: Estimation of pastoral water point requirements
Saharan zone



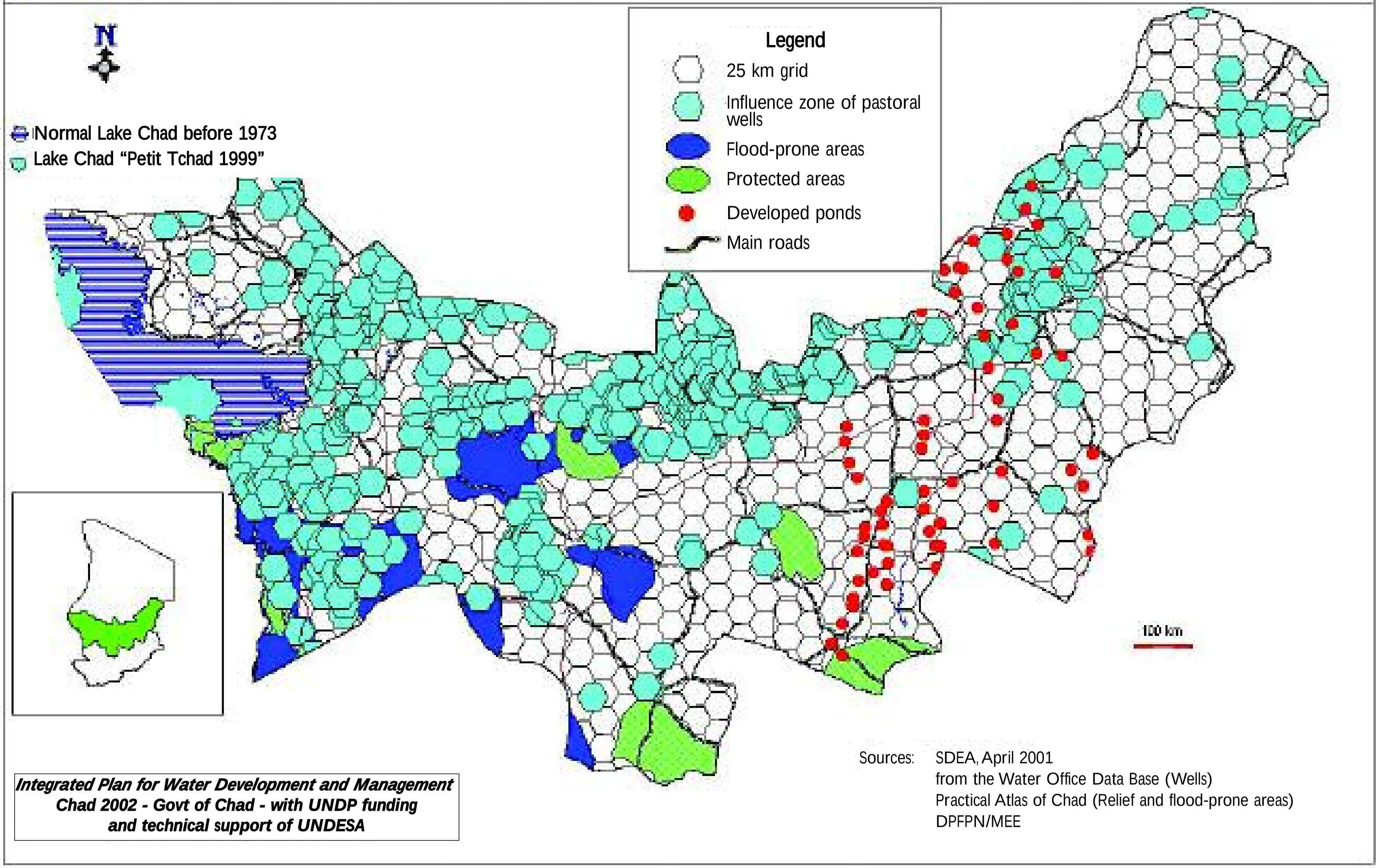
Integrated Plan for Water Development and Management
Chad 2002 - Govt of Chad - with UNDP funding
and technical support of UNDESA

Sources: Water Office Data Base (Wells)
Practical Atlas of Chad (Relief and flood-prone areas)
DPFPN/MEE

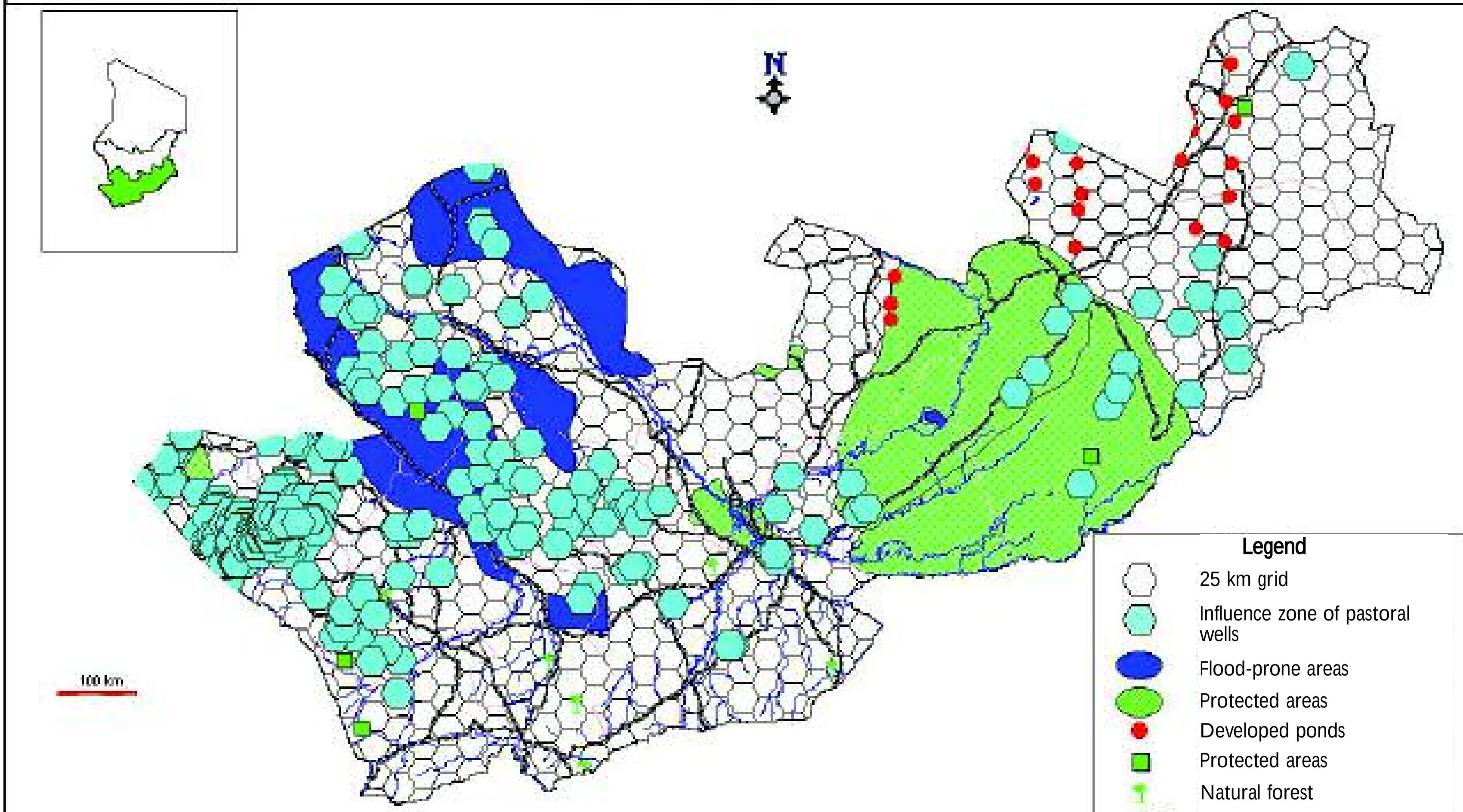
Republic of Chad

Figure 15: Estimation of pastoral water point requirements

Sahelian zone



Republic of Chad
Figure 16: Estimation of pastoral water point requirements
Sudanian zone



Integrated Plan for Water Development and Management Chad 2002 - Govt of Chad - with UNDP funding and technical support of UNDESA

Sources: SDEA, April 2001
from the Water Office Data Base (Wells)
Practical Atlas of Chad (Relief and flood-prone areas)
DPFPN/MEE

For the Sahelian and Sudanian zones, each hexagon is drawn inside a 25 km diameter circle. Assuming that the entire territory has this density of pastoral water points, each person would be placed less than 12.5 km from a pastoral water point. At the moment, this reference grid is only useful for forecasting and development, with the accuracy depending on the unit size of the hexagonal grid. This enables:

- grids and areas devoid of pastoral water points to be precisely located, and priority status to be established for schemes in the medium and long-term perspectives;
- grids and, therefore, sectors to be pinpointed that have sufficient water point provision and do not require specific, immediate schemes;
- water point locations to be determined along the migration moukhals and trade routes to be adequately evaluated;
- in relation to existing or future water supply structures, local stakeholders to be grouped according to the structures which concern them; these stakeholders will eventually become managers and coordinators of actions taken within the context of agro-pastoral activities based on wells.

It is appropriate to stress that, for the entire Saharan zone, the grid adopted includes larger mesh sizes since, at these latitudes, the hexagons are located in circles 100 km in diameter which, still from the perspective of a network of fully installed pastoral water points, would place all potential users less than 50 km from a pastoral water point. This density of water points governing access to fodder resources has been used for the following reasons:

- many stockbreeders do not live all year in the BET;
- in northern Chad, only camels and goats, requiring less frequent watering, are raised;
- there are no pasture maps for the Saharan zone and, as a consequence, few data on the potentially available carrying capacity.

Therefore, from the sustainable development perspective, it is felt that an excessive density of wells should not be proposed, otherwise too many herds would be attracted. By standing on the land all year round, the livestock could cause irreversible erosion of the pasture which does not necessarily grow again if there is no rainfall. This being the case, it should be noted that, in view of the low cattle numbers in these regions, once all the water points are located using the 100 km spacing, there will still be time, after consultation and a detailed survey of the pastoral load carrying capacity of the Saharan region carried out by the national agrostology department, to consider whether it is appropriate to reduce the reference grid unit size in this zone down to 50 km or less.

While the necessary mapping and inventory work is being carried out, a development reference frame based on a regularly spaced grid of water points offers numerous advantages, including in particular:

- compatibility with the custom of locating water points by a system of sexagesimal coordinates as practised by the water supply and agrostology departments;
- the ability to integrate with a geographical information system (GIS) or database without significant modification of the data entry fields;
- to list and group together similar sets of grids able to accommodate particular schemes, corresponding to the detailed phases of the development actions;
- to plan the various actions to be managed starting from previous typologies, according either to time or to the level of equipment to be installed in the geographical sectors identified;
- to be used as a geographical reference frame for associations and/or local stakeholder associations responsible for the durability of the water supply structures, their operation and their management in easily delimited environmental sectors. All groups are fully aware of the water point locations which, unlike the uncertain and/or contested cantonal boundaries, constitute indisputable markers of position, the neighbourhoods that they enclose and the understandings that they suggest;

- to provide donors and decision-makers as well as institutions, technical departments and grass-roots associations with the same working framework, on the scales being used, in order to plan, choose, decide on and set down a regulatory framework for regional development based on an accurate grid provided by the water point network.

Saharan zone

Applying the calculation method defined for the Saharan zone, i.e., a grid of pastoral water points initially 100 km apart, the number of water supply structures to be built is estimated at 150 pastoral water points based on wells or boreholes fitted with appropriate pumping equipment.

Sahelian zone

Applying the calculation method defined for the Sahelian zone, i.e., a grid of pastoral water points initially 25 km apart, the number of water supply structures to be built is 465. However, as a second stage and after conducting the appropriate studies, applying a grid with 12 km between each water point (a distance of 6 km between each well), the number of water supply structures to be built would be 1860. The water points to be constructed are wells or boreholes fitted with appropriate pumping equipment. Ponds with basic facilities can also be created, especially in sectors where hydrogeological and hydrological studies and the implementation of the latest technical resources have demonstrated a low potential for groundwater resources.

Sudanian zone

As figure 16 shows, the modern wells are concentrated in the western Sudanian zone and over 85% of these wells are used in villages. Applying a unit grid size of 25 km between wells, there would be 535 pastoral water supply structures to be built. Reducing this grid size to 12 km, the number of structures required would rise to 2140. It must be remembered that these numbers are given as an indication only and that they take no account of the current soil and land use, normally agriculture and cotton growing. The number of pastoral water points to be constructed in this zone as well as the type of structure (pastoral stations, wells, connections to water points several kilometres from the existing DWS network, etc) must be the subject of discussion or negotiation and must be part of the more general regional development framework. It should also be remembered that the western part of the Sudanian zone is the sector where oil exploitation is developing.

Summary of pastoral water point requirements

Table 21 summarises the number of pastoral water points (wells) to be constructed, based on a 25 km grid, with 12 km between water points for the Sudanian and Sahelian zones and a 100 km grid for the Saharan zone.

Table 21: Estimated number of pastoral water points to be installed

Grid	Saharan zone	Sahelian zone	Sudanian zone	Total
100 km	150	0	0	150
25 km	0	465	535	1 000
12 km	0	1 860	2 140	4 000

Source: SDEA 2001

This table shows that 1150 pastoral wells (1000 in the Sudanian and Sahelian zones and 150 in the Saharan zone) would need to be installed, based on a 25 km grid, and 4150 water supply structures would be built, based on a 12 km distance between each water point. However, considering the current land use intended for agriculture in the Sudanian zone, the number of pastoral water points to be constructed would most likely be between 3000 and 3500.

2.5 Agricultural water supply requirements

2.5.1 Changes in food needs

Table 22 summarises cereal, fruit and vegetable production by geoclimatic zone in 2001. The data in the table were extracted from various reports concerning agriculture in Chad.

Tableau 22: Estimated production in 2001

	Cereals		Vegetables		Fruit	
Geoclimatic zone	Total production (t)	Irrigated production (t)	Total production (t)	Irrigated production (t)	Total production (t)	Irrigated production (t)
Saharan	300	300	1 000	1 000	15 000	15 000
Sahelian	240 000	46 000	71 500	71 500	15 000	5 000
Sudanian	570 000	85 000	100 000	100 000	25 000	7 500
Total	810 300	131 300	172 500	172 500	55 000	27 500

Source: SDEA 2001

Table 23 summarises the estimated change in consumption of cereals, fruit and vegetables by geoclimatic zone between 2000 and 2020.

Table 23: Estimated change in consumption per inhabitant between 2000 and 2020

Geoclimatic zone	Cereals (kg/inhabitant/year)			Vegetables (kg/inhabitant/year)			Fruit (kg/inhabitant/year)			Sugar (kg/inhabitant/year)		
	2000	2010	2020	2000	2010	2020	2000	2010	2020	2000	2010	2020
Saharan	100	110	130	7	10	20	5	7	12			
Sahelian	229	220	200	24	25	30	4	5	10	9	10	12
Sudanian	166	160	150	24	25	30	6	7	12	9	10	12

Source: SDEA 2001

Table 2 shows the population per geoclimatic zone. Based on the assumed consumption figures given in table 23 coupled with demographic changes, the requirements for various food products are presented in table 24.

Table 24: Estimate of requirements for various food products between 2000 and 2020

Geoclimatic zone	Cereals (t/year)			Vegetables (t/year)			Fruit (t/year)			Sugar (t/year)		
	2000	2010	2020	2000	2010	2020	2000	2010	2020	2000	2010	2020
Saharan	21 950	30 400	44 000	1 500	2 775	6 760	1 100	1 950	4 050			
Sahelian	617 100	748 700	837 900	64 700	85 000	125 700	10 800	17 000	41 900	24 250	34 000	50 300
Sudanian	705 000	873 500	1 100 000	101 900	136 500	206 300	25 475	38 200	82 500	38 200	54 600	82 500
N'Djaména	146 350	180 000	204 800	15 300	20 500	30 720	2 500	4 100	10 250	5 750	8 200	12 300
Total	1 490 400	1 832 600	2 186 700	183 400	244 775	369 480	39 875	61 250	138 700	68 200	96 800	145 100

Source: SDEA 2001

Moreover, by comparing production in 2000 with the estimated requirements and their change over time, it can be seen that:

- the increased demand for fruit and vegetables is not an insurmountable problem; the increase in irrigated land area and enhancement of operator technical skills, on one hand, and the improvement in the downstream segment of the activity and road quality, on the other, should suffice to achieve this;

- however, satisfying the growth in basic cereal requirements of over 600 000 tonnes in 2000 and over 1.3 million tonnes by 2020 from local production might cause a problem. This can be avoided only if priority is placed on developing flood-recession farming, systematically developing lowland areas, implementing an ambitious programme to develop mountain catchment areas and increasing productivity. Another potential solution lies in the intensification of rain-fed cash crops (cotton, peanuts, sesame) or irrigated crops (sugar cane), the profits made being used on international markets to counter the shortfall in cereals. But there are good reasons to think that the overall solution would consist of a combination of these different possibilities.

The particular situation of the Saharan populations means that the potential rise in their food needs will have to be treated separately, the solution depending largely on irrigation, especially for protein foods (meat and milk) and carbohydrate foods (dates), which is not the case in other regions. The rise in requirements for these three foods is presented in table 25 with reference to the standards proposed above.

Table 25: Predicted rise in the consumption of dates, milk and meat in the Saharan zone (values given in tonnes)

Product	2000	2010	2020
Dates	13 934	16 820	18 377
Meat	2 754	3 533	4 453
Milk	2 135	2 776	3 498

Source: SDEA 2001

Date production is currently sufficient to provide for the food requirements of the Saharan populations, except in years of shortage. There is frequently a surplus of several thousand tonnes in Borkou. In the medium and long term, the moderate rise in demand should not pose any problems. However, a solution must be found at all costs to a fundamental problem: future funding for the purchase of cereals, which has always depended on the sale (or barter) of date surpluses.

There is the same concern for protein food. By 2020, demand for meat will have risen by 1700 tonnes and for milk by about 1400 tonnes. However, increasing the areas of irrigated land would have only a marginal effect on providing these extra food requirements, since the proportion devoted to fodder crops would feed only a limited number of goats for an annual production of a few hundred tonnes of meat and milk, provided that a programme of stock-rearing improvement were initiated in parallel with an agricultural sector development programme.

2.5.2 Agricultural water and equipment requirements

In agriculture, water requirements cannot be considered in the same way as drinking water requirements. This is because there are no limits to unit requirements as is the case with human consumption (a few dozen litres per day). In theory and up to a certain point, the higher the volume of water mobilised, the higher the tonnages produced, thereby making it possible either to improve food security or to develop cash crops. On the other hand, considering the prices at which agricultural products can be sold, the cost of mobilising water resources is a fundamental parameter of the water resource access development strategy.

The agricultural water issue cannot be separated from the agriculture issue itself or, more precisely, from the returns from agricultural investment. Therefore, despite wide variations in rain-fed agricultural production from one year to the next, the average annual growth rate of cereal production over the last 20 years has been about 2%. This rate is 0.5% per year less than the annual population growth rate, estimated at 2.5%; some recent studies even report a 3% annual population growth rate. Cereal production in 2000 barely covers 56% of the requirements, estimated at around 1.5 million tonnes. By 2020, this requirement for cereals will have risen to approximately 2.2 million tonnes. Increasing productivity and crop yields, developing new irrigation schemes and training operators are all essential if the current coverage (56%) of the populations' cereals requirements is to be maintained and increased.

Based on the assessment-diagnosis and considering the major constraints on agricultural development in Chad, it is proposed that an objective be set to develop 100 000 hectares of land, irrespective of irrigation type, by 2020. This corresponds to the development of 5000 new hectares per year.

Based on the hypothesis above, agricultural water requirements by 2020 are estimated by considering the irrigation of 100 000 new hectares at the rate of 15 000 m^3/ha/year, equivalent to 1.5 billion m^3 of water. To this volume of water an extra 600 million m^3 must be added for other schemes, giving a total volume of 2100 million m^3 of agricultural water by 2020. This corresponds to an increase of approximately 108% over the volume used in the sector in 2000. Agricultural water requirements estimated according to this hypothesis are considered to be high.

Estimates of changes in agricultural water requirements between 2000 and 2020 according to the hypothesis above are shown in Table 26.

Table 26: Changes in agricultural water requirements between 2000 and 2020

	2000			2020			
Climatic zone	Surface water (million m^3)	Ground-water (million m^3)	Total (million m^3)	Surface water (million m^3)	Ground-water (million m^3)	Total (million m^3)	% increase
Saharan		127	127	6	204	210	65.35
Sahelian	117	63	180	319	81	400	122.22
Sudanian	683	20	703	1402	88	1490	111.95
Total	800	210	1010	1727	373	2100	107.92

Source: SDEA 2001

By 2020, over 80% of agricultural water will be provided by surface water. It should be stressed, however, that depending on whether or not surface water exists in sufficient quantities, as well as the cost of constructing and operating these schemes, groundwater can be used to make a significant contribution, especially in the Sudanian zone where there are large aquifers.

3 BALANCE BETWEEN WATER REQUIREMENTS AND RESOURCES AND ENVIRONMENTAL IMPACTS OF IMPLEMENTING THE SDEA

3.1 Constraints arising from mobilisation of water resources

3.1.1 Surface water

The main constraints arising from surface water resource mobilisation are:

Strong pressure on endoreic basins: this particular situation demands a different approach to water management and use. All abstraction from river basins has an impact downstream in other parts of the country, sometimes also affecting other countries surrounding the Conventional Lake Chad Basin. The sustainability of the lakes depends on how upstream water is managed. All polluting or toxic substances likely to be carried by the water eventually end up in the low points of the different river basins (Lake Chad, Lake Fitri) and the Ennedi wadi basins. Therefore, these low points collect and concentrate waste resulting from human activities. Qualitative and quantitative water management must be conducted in parallel.

Climatic constraint: evaporation plays a dominant part in the overall surface water balance. Losses through evaporation are compensated for by rainfall. Due to the currently observed global warming, evaporation could increase, whereas rainfall could in future become less frequent. In the medium term, as far as agriculture is concerned, this climate change would limit rain-fed crop growing and increase risks of land erosion. As regards surface hydrology, more very low flow levels and shorter periods of river flooding are predicted.

International constraint: the natural scale used for surface water management is that of the catchment area. Numerous aquatic systems cross Chadian borders, requiring concerted management by the countries which share these water basins. A number of agreements have been signed for this purpose. To a certain extent, they restrict the degree of freedom for the countries managing these resources.

Economic constraint: in general, the high cost of implementing the various types of scheme which aim to control or exploit surface water resources, can constitute a major constraint.

3.1.2 Groundwater

Ignorance of the main relationships between different aquifer systems, on one hand, and the relationships between aquifers and rainfall, on the other, certainly restricts the mobilisation of groundwater. In addition, the lack of monitoring data at national level on the exploitation of aquifers shared with other countries represents a constraint on sustainable resource manageability.

However, considering that groundwater resources exist throughout Chad, apart from a few sectors, the main constraints governing their mobilisation are technical (depth, flow rate, success/failure rate), qualitative and economic.

After processing existing data, the average depths and specific discharges expected from building water abstraction facilities are presented in Figures 17 and 18, by aquifer and by sector. Figure 17 shows that the static water level is between 10 m and 35 m below ground in most large hydrogeological units. There is, however, a marked reduction (over 60 m) in the North Continental Terminal and the West Pleistocene in the centre of the country (north of the town of Ati), in the departments of Dababa, Batha Ouest and Batha Est. Another reduction in the static level can also be seen in the North, in the Nubian sandstone.

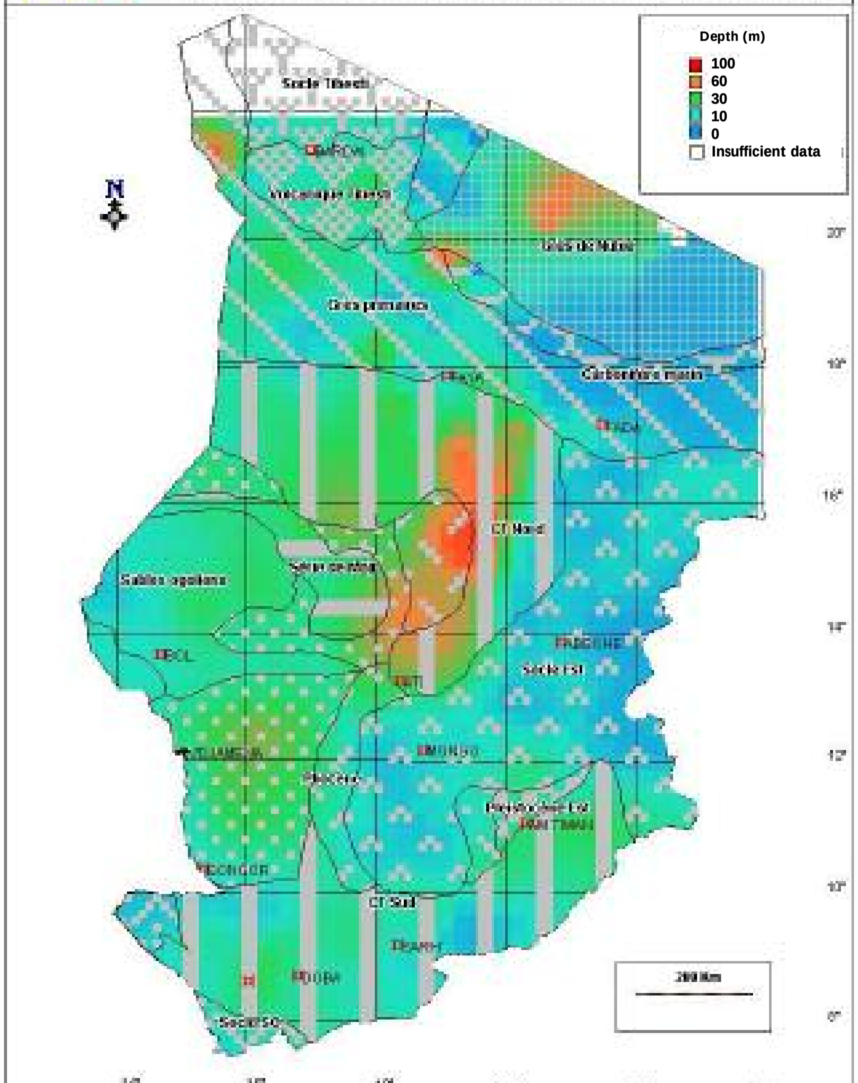
Interpolation of the specific borehole discharges (figure 18) reveals that specific discharges greater than 5 $m^3/h/m$ are obtained in the Ogolian Sands, West Pleistocene and South Continental Terminal. Low specific discharges are obtained in the southern part (Mongo town) of the Eastern Basement (less than 1 $m^3/h/m$) and in the South-west basement zones and in the volcanic areas of Tibesti. The boreholes drilled in the North Continental Terminal and in part of the Paleozoic Sandstones have specific discharges of between 1 and 5 $m^3/h/m$.

The aquifer water quality is generally good (see figures 19 and 20). The exception is a sector which lies in an arc east of the Ogolian Sands, where conductivity is below 2000 micro-Siemens/cm, thereby meeting the WHO drinkability standard. Figure 20 also shows that the pH value lies between 5 and 8.5. Acidic water is encountered in southernmost Chad, the eastern centre and towards the north of the country. The aquifer water of the Eastern Basement and the Pleistocene generally has pH values between 6.5 and 7.5.

Figures 21 and 22 link the technical characteristics of the water abstraction structures to economic aspects. The map showing accessibility to groundwater through boreholes was drawn using the borehole depths divided by the success rate for each sector. This map shows that the sectors in the eastern centre (the East Modji and North Continental Terminal sector) and some sectors of the Eastern Basement correspond to zones which are unsuitable for groundwater abstraction. The boreholes are too deep and/or the failure rate is high, making water abstraction more expensive. However, it should be noted that the abstraction of groundwater via boreholes from the aquifers of the Plio-Quaternary and the South Continental Terminal can, in general, be described as moderately favourable to favourable.

The groundwater exploitability map was drawn using the ratio of the average specific discharge of each water supply structure to the depth of the static water level. In this way, the exploitability of the aquifers may be defined in terms of pumping costs and productivity. From this figure it can be concluded that, with the exception of the basement and North Continental Terminal zones and the western Paleozoic Sandstones, the exploitability of the large hydrogeological units is described as favourable to very favourable.

Republic of Chad
Figure 17: Interpolation of static level depth



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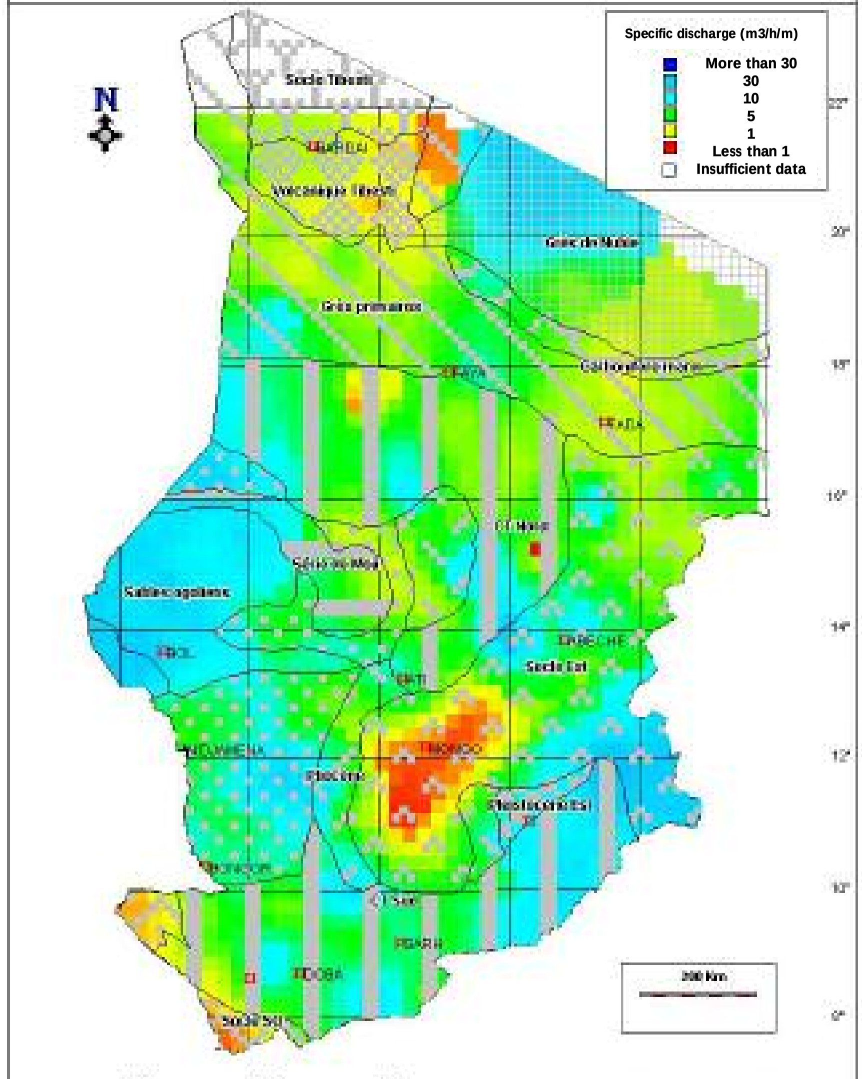
Republic of Chad
Figure 18: Specific discharge interpolation



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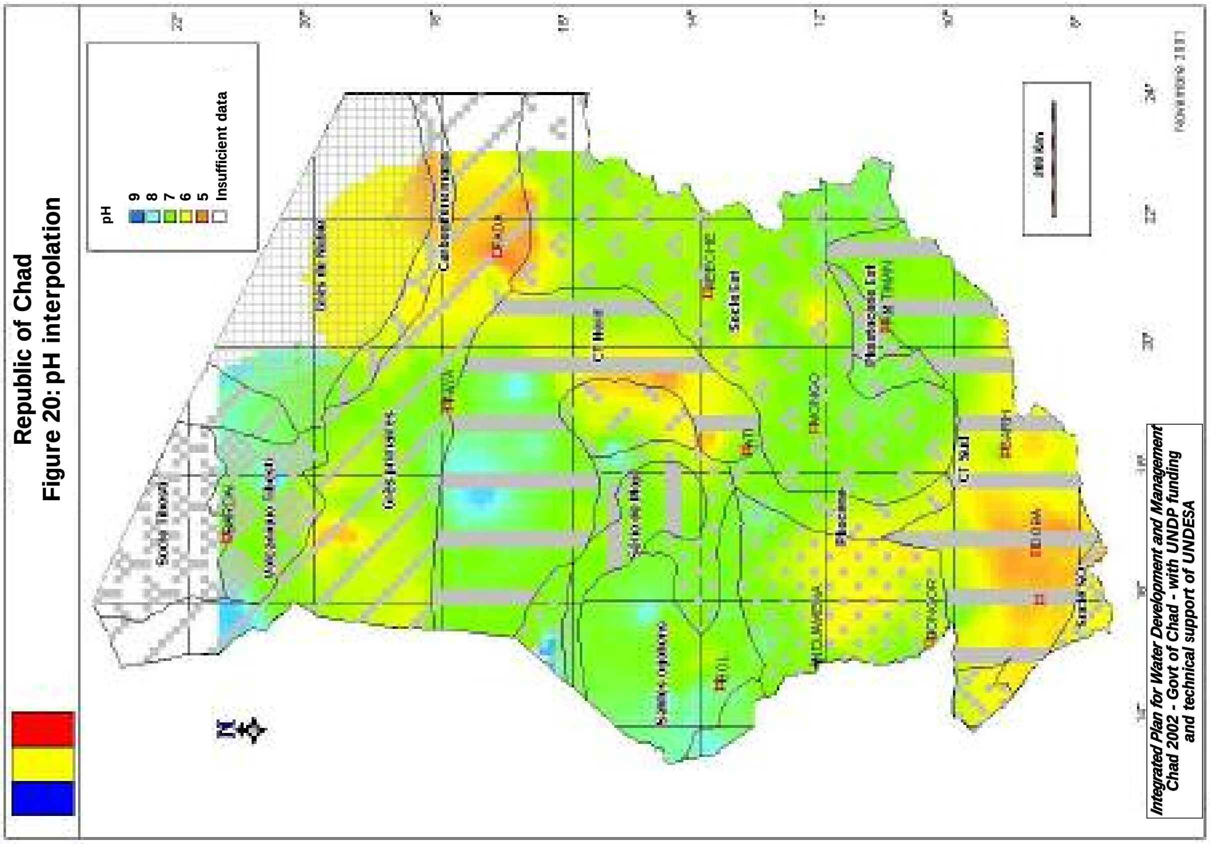
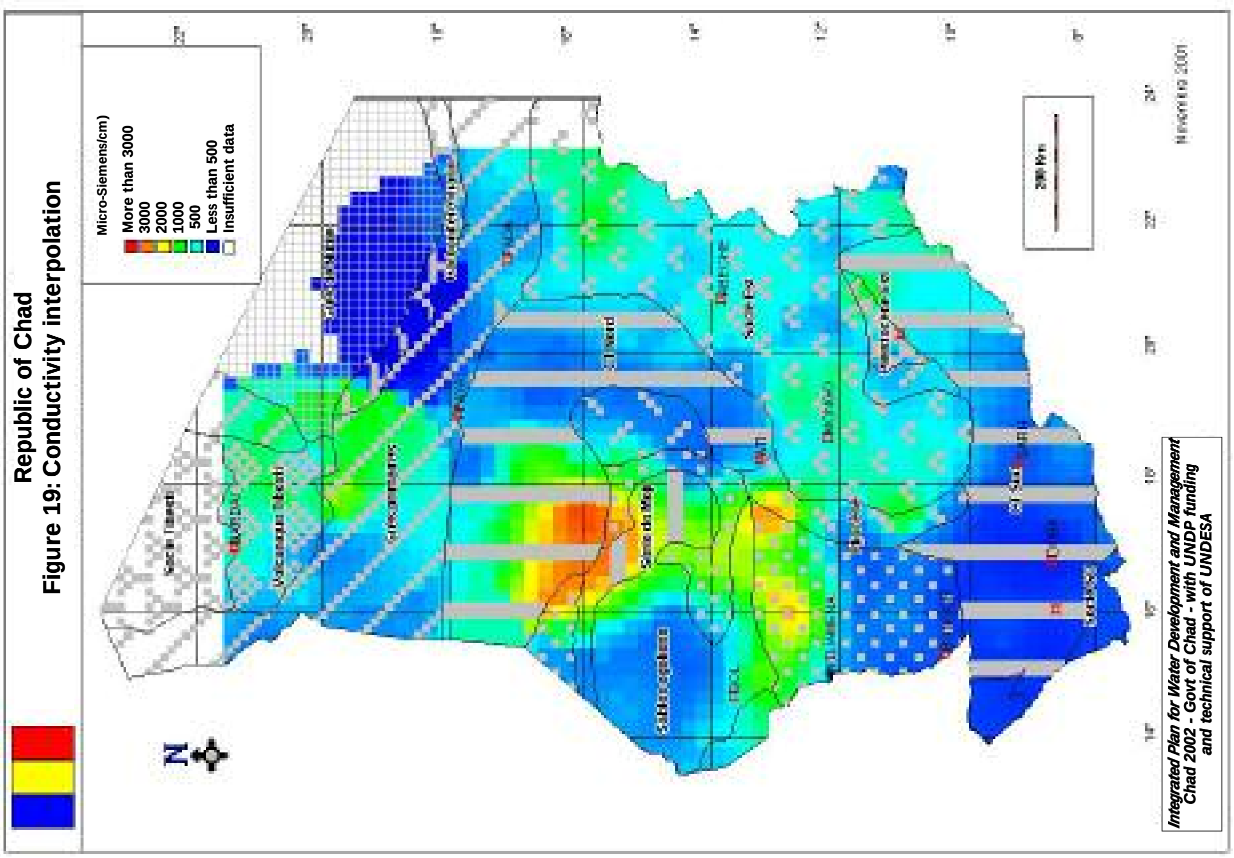
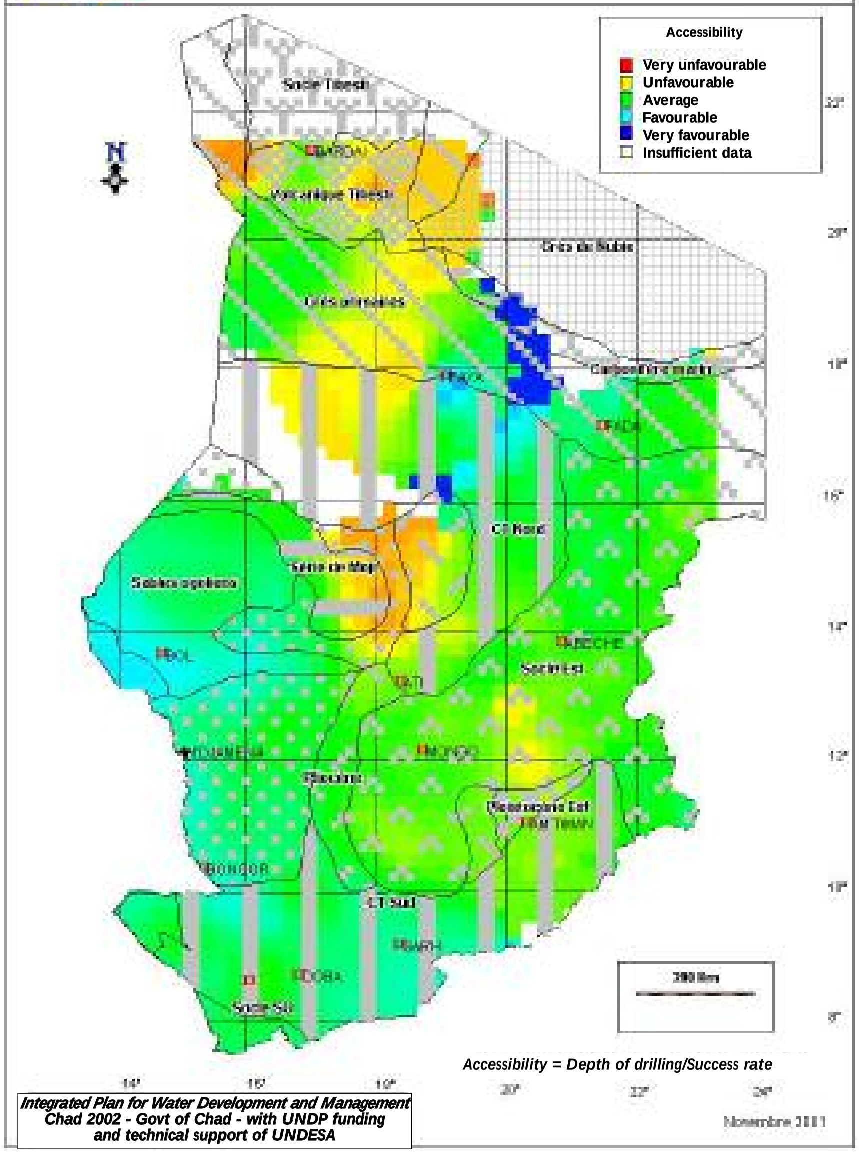
Republic of Chad
Figure 20: pH interpolation



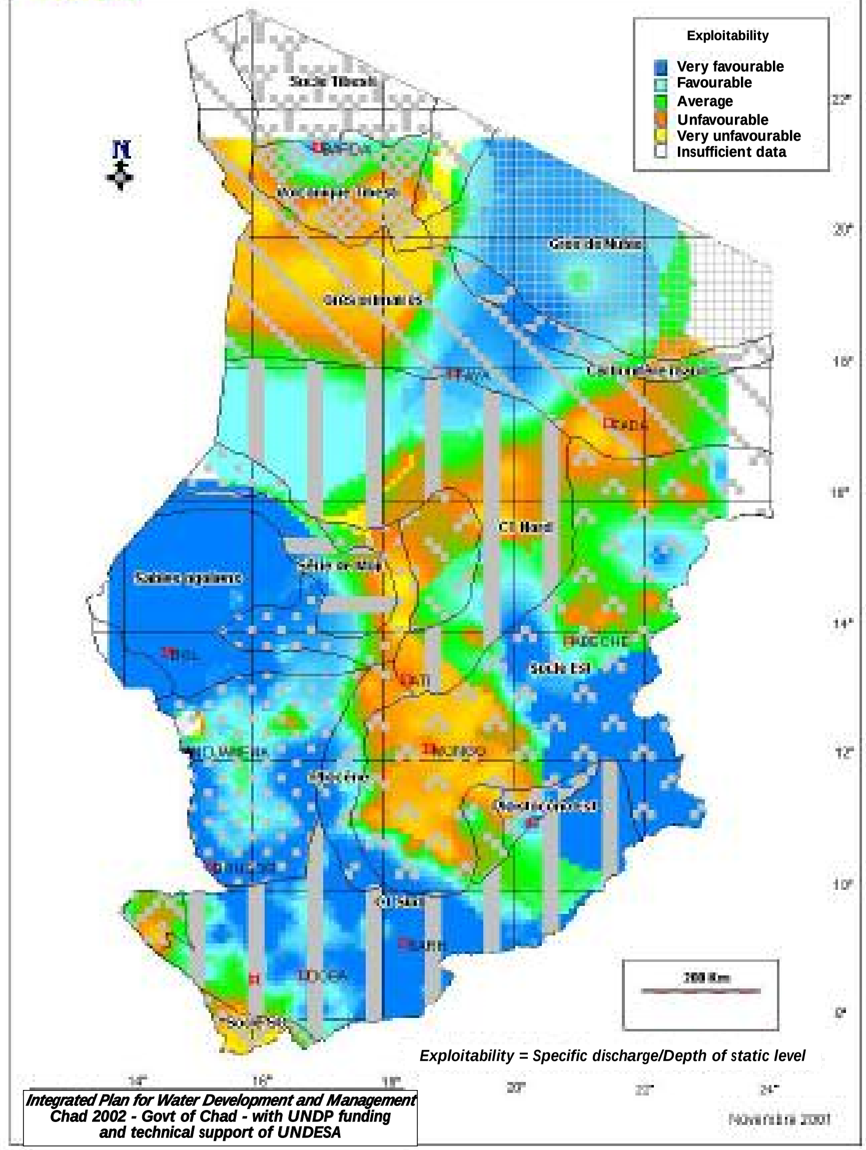
Republic of Chad
Figure 19: Conductivity interpolation



Republic of Chad
Figure 21: Groundwater accessibility by borehole



Republic of Chad
Figure 22: Groundwater exploitability



3.2 Summary of water resources by large climatic zone

Figure 23 presents a summary of water resources in terms of estimated requirements for 2000 and 2020 by large climatic zone. This figure makes a distinction between groundwater resources and surface water resources in addition to the various uses and functions of the water. In addition, Table 27 presents, for each large climatic zone, an estimation of the potential water resources (both surface and groundwater) and an estimate of the increase in requirements to satisfy the different water uses throughout the period 2000 to 2020. Additionally, Figure 24 illustrates all the Chadian water resources. These issues are discussed below.

Saharan zone

Few data exist on surface water; its potential, estimated at 300 million m^3, needs to be studied in detail. In 2000, this resource was used mainly to satisfy pastoral water requirements, estimated at approximately 1 million m^3, which represents approximately 0.3% of the estimated potential surface water resources. In 2020, provided that surface water studies have been carried out and better knowledge of their potential is available, surface water abstraction should be approximately 8 million m^3, or around 2.7% of the estimated resources; this abstraction would be used mainly to satisfy agricultural water requirements.

Groundwater is drawn from reserves estimated at more than 100 billion m^3; there are no renewable resources. In 2000, abstraction from this resource (139 million m^3) was mainly used to satisfy agricultural water requirements, estimated at 127 million m^3, whereas drinking water requirements are of the order of only 1.7 million m^3. Only about 0.14% of the potential groundwater resources was exploited in 2000. According to projected requirements for 2020, only about 0.25% of these reserves will have been tapped. Nonetheless, it should be noted that their mobilisation or availability might occasionally pose certain problems, especially in the aquifers of the Tibesti volcanic basement.

Water requirements, all uses combined, were estimated at about 140 million m^3 in 2000, of which 139 million m^3 was abstracted from groundwater and 1 million m^3 abstracted from surface water, representing just over 0.14% of the potential estimated water resources (ground- and surface water).

In 2020, water requirements are estimated at 233.5 million m^3, or approximately 0.25% of estimated resources.

Sahelian zone

The surface water of the Sahelian zone must also be studied in order to determine more accurately its actual potential, estimated at 4 billion m^3. Abstraction from this resource in 2000 was estimated at over 153.6 million m^3, of which 117 million m^3 (76%) fulfilled agricultural water requirements. In addition to its normal use, surface water in the Sahelian zone has an important role: biodiversity conservation. In 2020, to meet the total requirements, surface water abstraction will be of the order of 406 million m^3, i.e., 10.1% of the estimated resources.

In general, groundwater in the Sahelian zone is abstracted directly from the renewable resources estimated at over 8 billion m^3. In 2000, water abstraction from this resource was estimated at approximately 200 million m^3, or approximately 2.5% of the annually renewable resources, of which 98 million m^3 was to fulfil pastoral water requirements. In 2020, water abstraction is estimated at over 330 million m^3, or approximately 4.1% of the renewable groundwater resources. Adding renewable and non-renewable resources, the groundwater potential in the Sahelian zone is 90 billion m^3; water abstraction in 2020 represents only 0.36% of this potential.

Water requirements, all uses combined, were estimated at 353 million m^3 in 2000 of which a little over 199 million m^3 was abstracted from groundwater sources. This abstraction corresponds to approximately 3% of the estimated potential renewable water resources in the Sahelian zone.

In 2020, water requirements are estimated at a little over 736 million m^3 of which 406 million m3 will be abstracted from surface water. These abstractions will tap a little over 6% of the estimated potential renewable water resources (ground- and surface water) of this zone.

Table 27: Summary of water resources and estimated abstraction by use

Zone	Estimated resources (billion m^3)	Subsector	2000 Ground-water (m^3)	2000 Surface water (m^3)
Saharan zone	Surface water:	Village water supply	1 493 879	0
	0.30? (potential to be studied)	Urban water supply	195 700	0
	Groundwater	Agricultural water supply	127 000 000	
	Renewable: 0	Pastoral water supply	10 498 326	940 149
	Reserve: 100	Industrial water supply	0	0
		Total	139 187 905	940 149
Sahelian zone	Surface water:	Village water supply	15 243 247	300 000
	4.0? (potential to be studied)	Urban water supply	22 062 495	300 000
	Groundwater	Agricultural water supply	63 000 000	117 000 000
	Renewable: 8	Pastoral water supply	98 294 127	36 074 465
	Reserve: 82	Industrial water supply	700 000	0
		Total	199 299 869	153 674 465
Sudanian zone	Surface water:	Village water supply	26 866 738	700 000
	22.4	Urban water supply	12 489 013	700 000
	Groundwater	Agricultural water supply	20 000 000	683 000 000
	Renewable:11.2	Pastoral water supply	10 130 840	19 965 412
	Reserve: 82	Industrial water supply	626 000	2 000 000
		Total	70 112 591	706 365 412
Total			408 600 365	860 980 026
National total abstraction by subsector	Surface water:	Village water supply	43 603 864	1 000 000
	26.7	Urban water supply	34 747 208	1 000 000
	Groundwater	Agricultural water supply	210 000 000	800 000 000
	Renewable: 19.20	Pastoral water supply	118 923 293	56 980 026
	Reserve: 264	Industrial water supply	1 326 000	2 000 000

Source: SDEA 2001

Note: estimates of the percentage of total groundwater abstraction in the Sahelian and Sudanian zones are calculated on the basis of renewable resources whereas, for the Saharan zone, the percentage is calculated on the basis of non-renewable resources (reserves).

Sudanian zone

Water resources in this zone are the most understood. Here, the median surface water flow rate for the period 1972-2002 is 22.4 billion m^3 per year, with an absolute minimum of 6.7 billion m^3 which occurred in 1984-1985. Surface water resources are relatively plentiful in this zone; they are used mainly to satisfy agricultural water requirements (683 million m^3) and, to a lesser extent, pastoral and industrial water requirements, estimated (in 2000) at 20 million m^3/year and 2 million m^3/year respectively. In 2000, total surface water abstraction in the Sudanian zone was estimated at over 706 million m^3, which corresponds to 3% of estimated resources. Water abstraction envisaged for 2020 is estimated at 1.4 billion m^3, or 6.5% of the resources. Moreover, the surface water resources in the Sudanian zone also have a role in conserving and sustaining biodiversity which is difficult to quantify.

As far as groundwater is concerned, renewable resources are estimated at 11.2 billion m^3/year and the reserves at 82 billion m^3. In 2000, water abstraction from this resource was estimated at 70 million m^3 (0.6% of the renewable resources); this will reach 206 million m^3 by 2020, or 1.8% of the renewable resources.

Water requirements for the Sudanian zone, all uses combined, were estimated at 776.5 million m^3 in 2000, of which a little over 70 million m^3 was abstracted from groundwater sources.

In 2020, water requirements are estimated at slightly over 1.6 billion m^3, 1.4 billion m^3 of which would be abstracted from surface water to be used mainly to satisfy agricultural water requirements. This abstraction of surface and groundwater corresponds to 4.7% of the potential renewable water resources in this zone.

	2020			Estimated % abstraction	
Total (m³)	Ground-water (m³)	Surface water (m³)	Total (m³)	2000	2020
1 493 879	2 127 116	0	2 127 116	Surface water:	Surface water:
195 700	518 704	0	518 704	0.30%	2.70%
127 000 000	204 000 000	6 000 000	210 000 000	Groundwater:	Groundwater:
11 438 475	18 786 663	2 087 406	20 874 069	Renewable: 0%	Renewable: 0%
0	0	0	0	Reserve: 0.14%	Reserve: 0.25%
140 128 054	225 432 483	8 087 406	233 519 889		
15 543 247	22 167 980	0	22 167 980	Surface water:	Surface water:
22 362 495	78 507 876	0	78 507 876	3.8%	10.1%
180 000 000	81 000 000	319 000 000	400 000 000	Groundwater:	Groundwater:
134 368 592	147 371 930	86 551 767	233 923 697	Renewable: 2.5%	Renewable: 4.1%
700 000	1 000 000	500 000	1 500 000	Reserve: 0%	Reserve: 0%
352 974 334	330 047 786	406 051 767	736 099 553		
27 566 738	40 348 266	0	40 348 266	Surface water:	Surface water:
13 189 013	56 008 282	0	56 008 282	3.1%	6.5%
703 000 000	88 000 000	1 402 000 000	1 490 000 000	Groundwater:	Groundwater:
30 096 252	20 844 383	31 266 574	52 110 958	Renewable: 0.6%	Renewable: 1.8%
2 626 000	1 000 000	3 000 000	4 000 000	Reserve: 0%	Reserve: 0%
776 478 003	206 200 931	1 436 266 574	1 642 467 506		
1 269 580 391	761 681 200	1 850 405 747	2 612 086 948		
44 603 864	64 643 362	0	64 643 362	Surface water:	Surface water:
35 747 208	135 034 862	0	135 034 862	3.2%	7.0%
1 010 000 000	373 000 000	1 727 000 000	2 100 000 000	Groundwater:	Groundwater:
175 903 319	187 002 976	119 905 747	306 908 724	Renewable: 1.4%	Renewable: 2.8%
3 326 000	2 000 000	3 500 000	5 500 000	Reserve: minimal	Reserve: minimal

3.3 Conclusions on the water resource and environmental impact assessment

Abstraction from water resources to fulfil the requirements for various water uses excluding the requirements of the aquatic ecosystems, were estimated at 1269 million m³ in 2000, representing 2.8% of the renewable resources. From this total, a volume of 408.6 million m³ of water (32%) is abstracted from different aquifers and about 861 million m³ (68%) from surface water. In addition, 269.5 million m³ of water, or 66% of the total abstraction from groundwater sources, is taken from recharged aquifers, whereas 139.1 million m³ of water (34%) is taken from aquifers which are not recharged.

In 2020, water requirements are estimated to be just over 2.6 billion m³, or approximately 5.7% of the estimated annually renewable resources. Of these abstractions, over 1.85 billion m³ will be from surface water and 761 million m³ from groundwater. This represents 7.0% of the surface water resources and 3.9% of renewable groundwater resources or 0.26% of all groundwater resources (renewable and reserves).

Therefore, water resource abstraction would not have a major impact on the environment, for two reasons. First, Chad has considerable water resources, and second, the planned developments, including those in the irrigation sector, remain modest. What is more, from the water quality viewpoint, the SDEA is not going to develop any polluting activities; on the contrary, it proposes an action plan and an approach to accelerate schemes needed to address rural, urban and industrial sanitation issues. The SDEA also recommends vigilance (the precautionary principle) with regard to industrial pollution risks, especially in the mining and oil industries.

Furthermore, it is recalled that the abstraction estimates do not include abstractions from these same resources by countries neighbouring Chad. For integrated and sustainable management, it is essential to take all abstraction into account. The LCBC has an essential role to play in providing coordination mechanisms between countries, to enable the shared resources to be monitored and exploited in a sustainable manner.

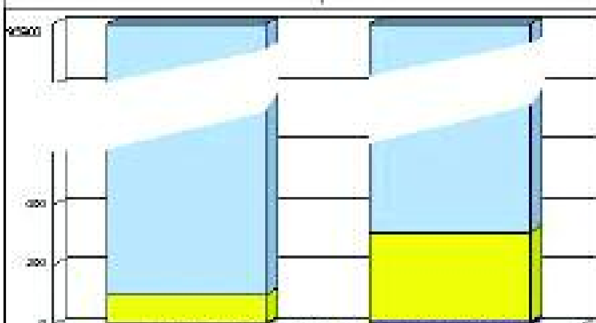
While bearing in mind the main constraints linked to the mobilisation of water resources and, above all, the unequal temporal and geographical distribution of rainfall and surface water as well as the lack of data on how the large aquifers function, it generally seems that, in 2001, this resource will not curb economic and social development in Chad. However, development of the water resources requires studies to be conducted to improve knowledge of the functioning of and relationships between the main hydrological hydrogeological systems, especially in the more sensitive semi-arid zones and also in zones highly suited to flood spreading. The integrated basin approach will be preferred, especially and preferably via the "The Integrated Plan for the Chari-Logone basin and its flood plains", which will ensure that the right balance will be struck between exploiting water resources, sustaining aquatic ecosystems and meeting the needs of economic and social development.

Republic of Chad
Figure 23: Resources/Requirements summary

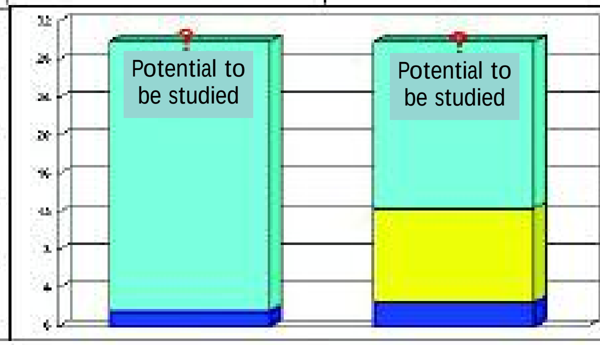
In calculating water requirements, allowance must be made for the needs of aquatic ecosystems (particularly flood-prone areas and lakes) which govern the sustainability of biodiversity, and also the essential resources for fishing, stock-rearing and traditional flood-recession agriculture. These needs are indicative and represented by the light-blue to white shading.

- Village water requirements
- Urban water requirements
- Pastoral water requirements
- Agricultural water requirements
- Industrial water requirements
- Groundwater resources
- Surface water resources

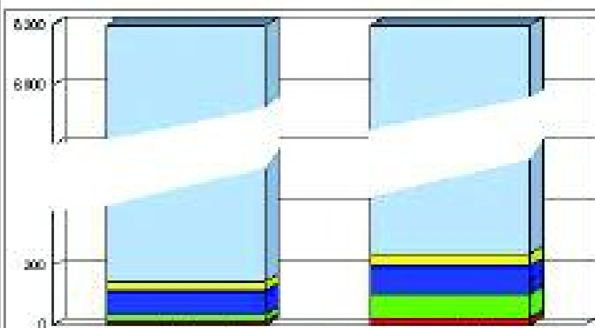
Groundwater (million m³)		Surface water (million m³)	
2000	2020	2000	2020



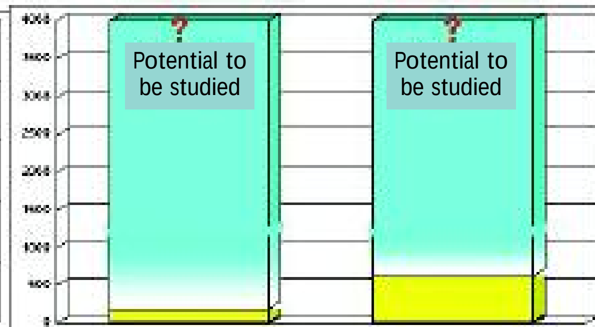
Use of groundwater reserves



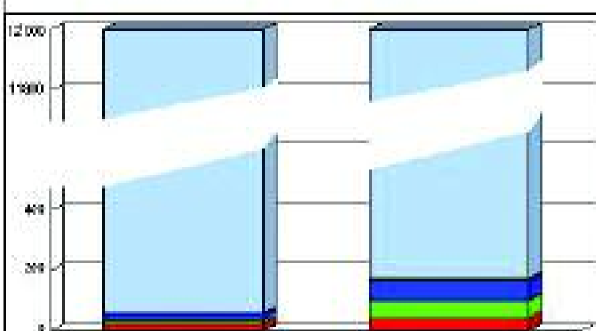
Saharan Zone



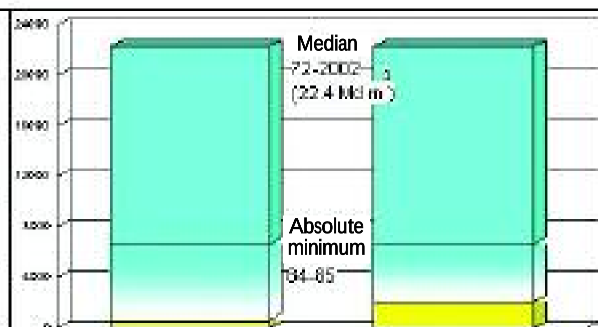
Use of renewable resources



Sahelian Zone



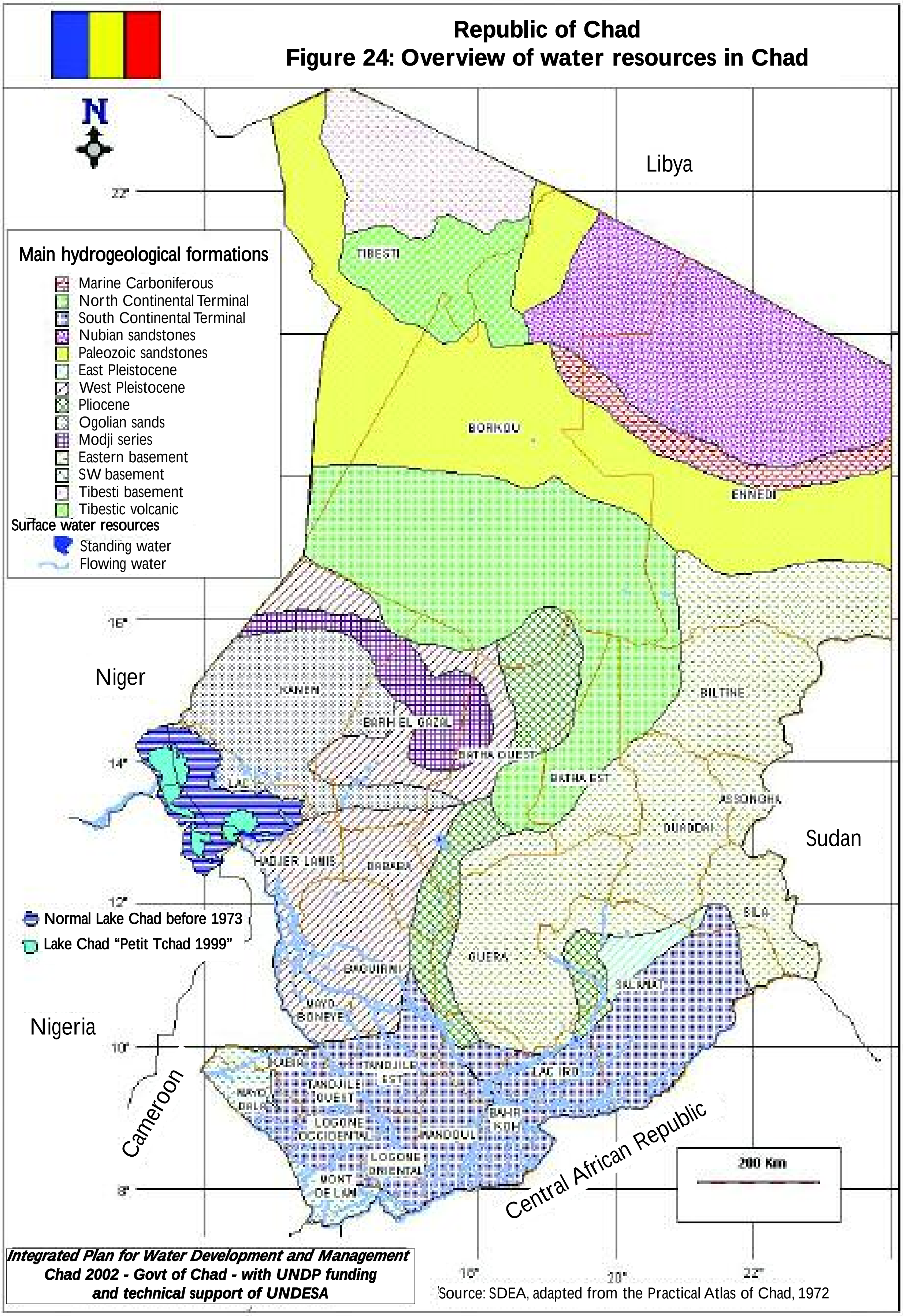
Use of renewable resources



Sudanian Zone

Integrated Plan for Water Development and Management
Chad 2002 - Govt of Chad - with UNDP funding and technical support of UNDESA

Novembre 2001



Republic of Chad
Figure 24: Overview of water resources in Chad
N
Libya
Main hydrogeological formations
Marine Carboniferous
North Continental Terminal
South Continental Terminal
Nubian sandstones
Paleozoic sandstones
East Pleistocene
West Pleistocene
Pliocene
Ogolian sands
Modji series
Eastern basement
SW basement
Tibesti basement
Tibestic volcanic
Surface water resources
Standing water
Flowing water
TIBESTI
BORKOU
ENNEDI
Niger
KANEM
BARH EL GAZAL
BATHA OUEST
BATHA EST
BILTINE
ASSONGHA
OUADDAI
Sudan
HADJER LAMIS
DABABA
SILA
Normal Lake Chad before 1973
Lake Chad “Petit Tchad 1999”
GUERA
BAGUIRMI
SALAMAT
MAYO BONEYE
Nigeria
LAC IRO
TANDJILE EST
TANDJILE OUEST
BAHR KOH
LOGONE OCCIDENTAL
MANDOUL
LOGONE ORIENTAL
MONT DE LAM
Cameroon
Central African Republic
200 Km
Integrated Plan for Water Development and Management
Chad 2002 - Govt of Chad - with UNDP funding
and technical support of UNDESA
Source: SDEA, adapted from the Practical Atlas of Chad, 1972