

Water Use in Semi-arid Northeastern Brazil

Modeling and Scenario Analysis

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WAVES

Water **A**vailability and **V**ulnerability of **E**cosystems and **S**ociety in the Northeast of Brazil

Brazilian-German cooperation program

financed by CNPq and BMBF

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Report No 3 – Water Use in Semi-arid Northeastern Brazil

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Abstract

If water is a scarce resource like in the semi-arid Northeast of Brazil, the water use as well as water quality must be managed in a proactive manner. In order to achieve a sustainable development of the region, water management decisions should be based on an assessment of future water use which includes the long-term effects of current activities and policies. In order to support water management decisions, we performed a scenario analysis of future water use in Piauí and Ceará in 2025 by

1. compiling, analyzing and integrating information about water use and water management in Piauí and Ceará,
2. developing the large-scale water use model NoWUM which covers the whole of Piauí and Ceará and provides sectoral water use estimates for each municipality, and, using NoWUM,
3. computing current (1996/98) water use,
4. deriving water use scenarios for the year 2025, which reflect different possible societal development paths and water demand management options, and
5. computing water scarcity indicators which show which municipalities will suffer most from water scarcity.

For all sectors, the increase of water use between today and 2025 is higher in case of the *Coastal Boom and Cash Crops* scenario than in case of the *Decentralization* scenario. Due to increased water use (in 99% of the municipalities), water scarcity will become more severe in the future, even though runoff will increase in more than 50% of the municipalities due to climate change (average climate 2011-2040). The development of water use will predominantly be influenced by the development of the irrigation sector, above all the extension of irrigated areas. As a first indicator of water, scenarios of municipal nitrogen loads were computed. Future municipal nitrogen loads could be smaller than today's if 70% of the waste water in the capitals of the municipalities is subject to secondary treatment, as steep increase from today's coverage. The presented scenario analysis can form the basis for further investigating the effect of water management measures on water use, water scarcity and water quality.

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1 Introduction

Scarcity of water is a major constraint for development in semi-arid Northeastern Brazil, a region characterized by recurrent droughts which are related to the El Niño phenomenon. In particular the rural population, mainly subsistence farmers, suffers from these droughts due to the loss of crops and livestock. During the last decades, irrigated agriculture has been regarded as the privileged development option for rural areas, with plans for a multitude of irrigation projects which have rarely been realized. Nevertheless, the irrigation sector has become the largest water user in Northeastern Brazil. Today, hopes are high that an extended production of irrigated fruits for export will strongly improve rural incomes.

For the rural population, access to safe drinking water is difficult and becomes even more difficult during droughts, as only the urban population (or rather a part of it) is connected to the public water supply. The public water supply system has, in most cases, problems with serving the ever increasing number of urban dwellers who, given the convenience of tap water, consume relatively high amounts of water. In some areas today, and probably more in the future, industry and tourism are important water user that compete for water with the irrigation sector.

Under the described conditions in Northeastern Brazil, it is necessary to manage both water supply and water demand. While the construction and proper management of water infrastructure is the necessary basis for a secure water supply, a concurrent water demand management is essential for a sustainable economic and social development of the region. Only by a proactive demand management can the scarce resource water be used efficiently.

Water demand management requires an assessment of present and future water use in which water use is related to development paths and policy options. Such an assessment is preferably supported by a water use model which computes sectoral water uses at the appropriate spatial and temporal resolution. On the one hand, the water use model provides estimates of water use under current conditions, e.g. how much water is required for irrigated areas in both climatically average and drought years. On the other hand, it helps to derive scenarios of future water use which are a decision support for water managers and policy makers.

In this report, we present a water use model for two states in Northeastern Brazil, Piauí and Ceará. The model computes sectoral water uses in all municipalities. We show the current water use situation and analyze water use scenarios for the year 2025 which reflect different possible development paths and water demand management options. A detailed description of the model, the data and the scenario assumptions is given in Appendix A. Taking into account the runoff

modeled by the hydrological modeling group of the WAVES project (Axel Bronstert and Andreas Güntner, Potsdam Institute for Climate Impact Research), we computed a water scarcity index in water use is compared to water availability. Water use generally leads to a degradation of water quality; as a first rough indicator for the pollution of surface waters by domestic waste water, we present scenarios of domestic nitrogen emission.

Our research was conducted in the framework of the Brazilian-German cooperation program WAVES, financed by the Brazilian research ministry CNPq and the German research ministry BMBF. The goal of WAVES is to identify possible sustainable development paths for the two Brazilian states of Piauí and Ceará. Typical for Northeastern Brazil, these states are characterized by recurrent droughts that strongly affect subsistence farmers, leading to migration to the metropolitan areas of the country. Within WAVES, a dynamic systems analysis of the relationship between water availability and migration is done. A singular feature of WAVES is the development of an integrated model to simulate scenarios of the future of Piauí and Ceará. The model is created by an interdisciplinary team, in which each specific group is responsible for one submodule like, for example, our water use model or a hydrological model. The objective is to provide a tool for regional water management planning and thus to support decision makers in both states.

Acknowledgments: We are grateful for the support by our Brazilian cooperation partners Prof. Dr. José Carlos de Araújo (UFC), Prof. Dr. Francisco Veloso (UFPI), Eng. Margarita López Gil (DHME), Prof. Marcos Airton Freitas (UNIFOR) and the following Brazilian institutions who provided us with the necessary data and made our work possible: in Piauí, AGESPISA, DHME, FIEPI, FUNASA, PIEMTUR, SEMAR, UFPI, and in Ceará, CAGECE, COGERH, DNOCS, FNS, IPLANCE, SDU, SEAGRI, SEMAR, SEPLAN, SETUR, SISAR, SOHIDRA, SRH, UFC. Besides, we thank the German partners of the WAVES project.

2 Methodology

2.1 Large Scale Water Use Model NoWUM

The water use model NoWUM (Nordeste Water Use Model) simulates monthly values of withdrawal and consumptive water use in all 332 municipalities of Piauí and Ceará (Fig. 1). Withdrawal water use is the quantity taken from its natural location, while consumptive water use is the quantity of water lost to evapotranspiration. NoWUM is a stand-alone model as well as a module of the integrated model SIM of the WAVES project. The model distinguishes five water use sectors: irrigation, livestock, households, industry and tourism (Fig. 2). Irrigation water use is

calculated according to the methodology of FAO as a function of climate, irrigated area and type of irrigated crop (nine different crop classes). Livestock water use is calculated from the number of animals per species and a species specific water use for Northeast Brazil. We distinguish 11 different livestock species. For calculating the domestic water use, we differentiate households connected to public water supply and self-supplied households. The water use per capita in a connected household is calculated from municipality-specific data provided by the water supply agencies AGESPISA, FNS, CAGECE, SISAR in Piauí and Ceará. Future per capita domestic water use of connected households is assumed to be a function of income and water price. The economic concept of elasticities is used to compute the decreasing per capita water use in case of increasing water price (price elasticity) and the increasing per capita water use in case of increasing incomes (income elasticity). As no information on water use in unconnected households is available, a per capita withdrawal water use of 50 l/d is assumed. Industrial water use is a function of the industrial output and the industrial mix; we consider 19 industry branches and their branch-specific industrial output per municipality. Future industrial water use is also influenced by the water price. Like in the case of domestic water use, the application of water-saving technology is assumed to be driven by the water price. Tourism water use is a function of the touristic overnight stays. A detailed model description, which includes the parameterization and the data sources, can be found in Appendix A.

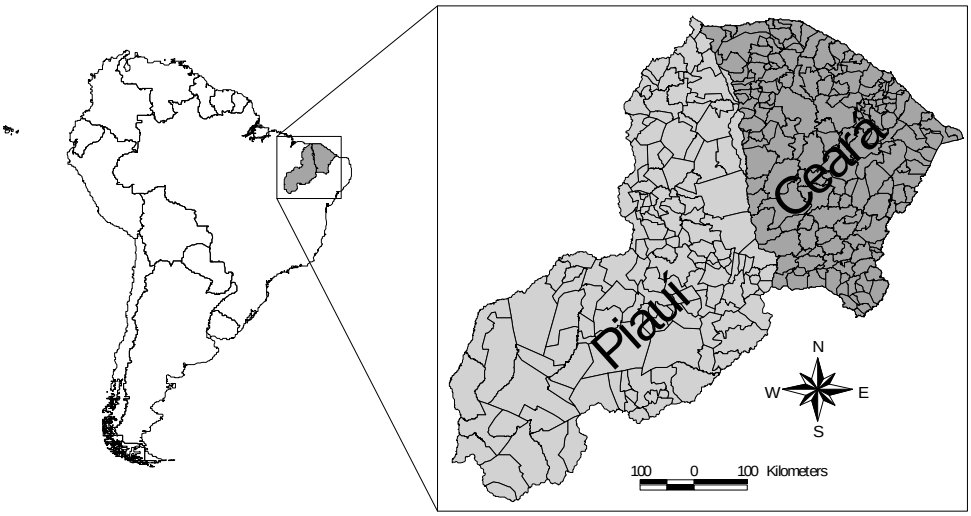


Figure 1: The research region Piauí and Ceará, two federal states in Northeastern Brazil.

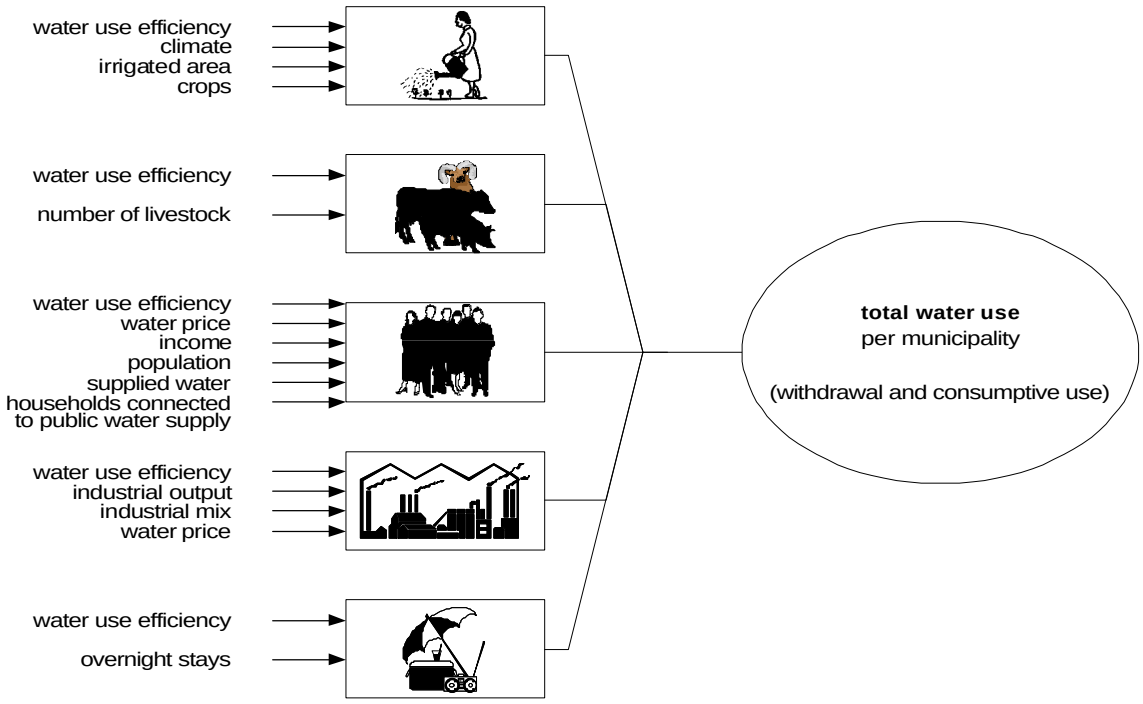


Figure 2: Scheme of the large-scale water use model NoWUM with modeled sectors and driving forces.

2.2 Estimation of nitrogen loads

The return flow is the part of the withdrawn and used water that does not evapotranspirate but is returned to the environment. If the return water is of appropriate quality it can be reused. Thus, a water use model would ideally include the quality of the returned water in order to indicate the water consumption, i.e. the amount of water that cannot be used by a downstream user due to both evapotranspiration and pollution. Here, as a first indicator for pollution of surface water the nitrogen load from domestic waste is estimated for every municipality as a function of population and the existence and efficiency of waste water treatment:

$$N - input_i = P_i * k_N * (1 - F_i * w_s)$$

i: municipality of interest
P_i: number of persons living in municipality i
k_N: N content of human waste in Europe (15 g N/p/d (de Wit and Schmoll, 1999))
F_i: fraction of cleaned waste water
w_s: efficiency of treatment plant (primary: minus 15% N, secondary: minus 30% N)

Nitrogen loads from manure (livestock) and mineral fertilizers are not yet taken into account.

2.3 Water use scenarios for 2025

Within the WAVES Program, two reference scenarios for the year 2025 were developed. An interdisciplinary working group on scenarios developed the narrative storylines and quantified the driving forces. For a detailed description of the storylines and a complete quantification of the driving forces please consult Döll et al. (2000). Based on the general storylines and the driving forces, we derived additional driving forces that are specific to water use modeling. Then, using the driving forces as input to NoWUM, we developed scenarios of water use in the year 2025 which are consistent with the WAVES reference scenarios. We generated two reference scenarios, and an intervention scenario which simulates a higher number of households connected to the public water supply.

2.3.1 Storylines of the two reference scenarios

Both reference scenarios are rooted in current societal developments. Scenario A, the *Coastal Boom and Cash Crops* scenario, can be regarded as the business as usual scenario; it represents a continuation of current trends and reflects general expectations of the future that exist in Piauí and Ceará. Scenario B, the *Decentralization* scenario, reflects the beginning development and increasing attractiveness of the medium-size towns in Piauí and Ceará, the regional centers which is caused by an improved infrastructure (e.g. universities) in these towns and a decreasing quality of live in the large metropolitan areas of the country.

Scenario A: Coastal Boom and Cash Crops

In Scenario A, the globalization trend is dominant. The economic, social and cultural differences between and within countries become smaller and smaller. Economic and technological growth is rapid, and the global trade strong. Environmental protection and resource conservation is done only reluctantly.

In such a globalized world, there is a strong economic development in the coastal regions of Ceará and Piauí (which has a very short coastline only). The main development focus is the metropolitan area of Fortaleza, with booming commerce and industry. Fortaleza, however, is also subject to the typical problems of fast growing cities. The infrastructure is always lacking behind the needs of the population, and the favelas at the outskirts of the city grow. In addition, tourism is becoming an important economic sector along the coast. The capital of Piauí, Teresina, is only developing slowly due to its unfavorable location. In those areas of the Hinterland where water is available, the production of cash crops by large companies dominates over subsistence farming. In the remote South of Piauí, large scale commercial husbandry is performed.

Scenario B: Decentralization: Integrated Rural Development

In Scenario B, the world is more heterogeneous than in Scenario A. The emphasis is on local solutions to economic, social and environmental problems. Globally, the economic development is not as strong as in scenario A, whereas environmental protection and social equity more important.

In such a world, the Northeast of Brazil becomes more or less decoupled from the dominating centers of Brazil in the South. In Piauí and Ceará, the development is characterized by regional centers, attractive medium-sized towns with improved infrastructure which become the markets for local and regional agricultural products. Besides, the agricultural products are processed and refined by small-scale industry in the regional centers. Economic growth is somewhat weaker than in Scenario A, and strongest in the water-rich Hinterland where local farmers, due to credits and education, have increased their productivity. The farmers are supported by the World Bank and other international institutions who wish to improve the living conditions in crisis-prone semi-arid regions. Tourism at the coast is increasing due to an increasing number of tourists from within the two states, but not as strong as in Scenario A.

2.3.2 Spatial resolution of the scenario driving forces

Scenario regions are those spatial subunits of Piauí and Ceará that are assumed to develop in a homogeneous fashion. The two states were divided into eight scenario regions (Fig. 3):

1. Teresina, the capital of Piauí
2. Metropolitan area of Fortaleza, the capital of Ceará + Port of Pecém
3. Coastal region
4. Southern part of Piauí
5. Region with relatively large potential water resources in Ceará
6. Region with relatively large potential water resources in Piauí
7. Region with small potential water resources in Ceará
8. Region with small potential water resources in Piauí

The scenario regions were derived by taking into account

- similar (agro)economic conditions
- administrative boundaries
- natural conditions (sedimentary vs. crystalline subsurface, location within the river basin, precipitation)

In case of conflict, the assignment of a municipality to a scenario region was based on the characteristics that appears to dominate its future development.

For each scenario region, the driving forces of the scenarios were quantified. For most driving forces, all the municipalities within a scenario region are assumed to be subject to the same percentage changes of the driving forces.

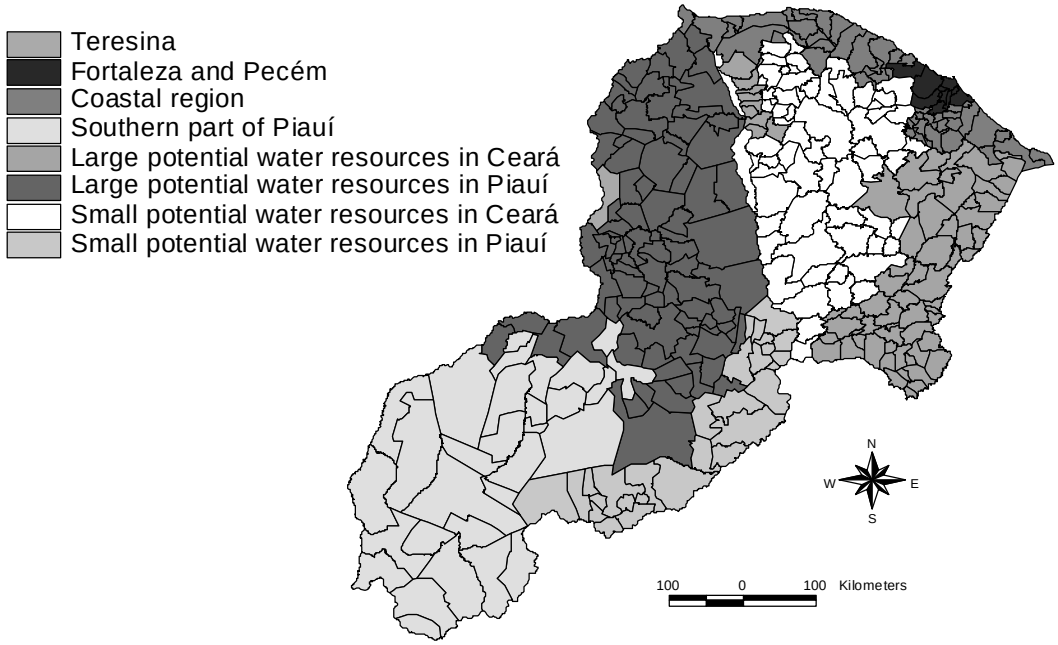


Figure 3: The eight scenario regions

2.3.3 Quantifying the driving forces

The driving forces of water use are shown in Fig. 2. For each scenario region, the driving forces were quantified for both scenarios by taking into account their development in the past (data from 1991 and 1996, in most cases). All the municipalities within a scenario region are assumed to be subject to the same changes of the driving forces (an exception is the change in irrigated area where irrigation projects that are planned for certain municipalities are implemented in the model). If, for example, the annual growth of gross domestic product (GDP) is, in Scenario A, is 2.7% per year in the Coastal region, the GDP in each municipality in the coastal region increases with this rate, no matter what the current GDP of the municipality is today.

Climate in 2025 is the average of the climate from 2010-2040. The climate scenario was generated by the WAVES climate group (Gerstengarbe, Potsdam Institute for Climate Impact Research) by downscaling the results of the global circulation model ECHAM4-OPYC (Röckner et al., 1996), which are based on the IS92a greenhouse gas emission scenario (Leggett et al., 1992). Downscaling was done by a cluster analysis of the different climate variables. For detailed

listings of all driving forces of water use per scenario region compare Appendix A and Döll et al. (2000).

Table 1 shows the assumed changes of important driving forces of the water use scenarios between today and 2025, for both Scenario A (RSA) and Scenario B (RSB). Only the aggregate values over all eight scenario regions are shown here. The change of most driving forces is stronger in Scenario A than in Scenario B. Only the total population increase is equal but the distribution between scenario regions (in brackets) differs. The intervention scenarios assume an even larger expansion of the public water supply as already assumed in the reference scenarios. ISA represents the intervention scenario to RSA and ISB to RSB, respectively (Table 8 in Appendix A).

Table 1: Assumed change of selected driving forces between today (1996/98) and 2025 for the whole or Ceará and Piauí and the two reference scenarios [%]

	RSA: Coastal boom and cash crops	**RSB: Decentralization**
irrigated areas	+ 440	+ 200
population	+ 25 (-27 to +70)	+ 25 (+4 to +37)
connected population	+ 70	+ 60
industrial gross domestic product	+ 220	+ 150
tourist overnight stays	+ 250	+ 170

3 Results

Appendix B contains tables with modeled consumptive and withdrawal water uses in each of the 332 municipalities, distinguishing the five water use sectors. Model results are for 1996/98 and 2025 (reference scenario A *Coastal Boom and Cash Crops*, reference scenario B *Decentralization: Integrated Rural Development* scenario and intervention scenario with extended public water supply).

3.1 Water use in 1996/98

3.1.1 States

Table 2 shows the withdrawal and consumptive water use per sector under current conditions (1996/98), aggregated for the whole of Ceará and the whole of Piauí. In both states, the two most important water use sectors are irrigation and households. With respect to consumptive use, the irrigation sector is clearly dominating, which is due to the higher fraction of the withdrawn water that evapotranspirates during use. In Piauí, livestock water use is a larger fraction of total water

use than in Ceará. In Ceará, the industry and the tourism sector use nearly 10% of the water, their use is negligible in Piauí. The total withdrawal water use in Ceará is twice the water use in Piauí. This can be explained by the fact that the main driving forces of water use are higher in Ceará than in Piauí (Table 3). During a year, water use varies by a factor of 3 to 4 between the month with the lowest and the month with the highest water use; the seasonal variation is caused by the irrigation sector.

Table 2: Withdrawal and consumptive water use per sector in 1996/98 as modeled with NoWUM.

	Ceará		**Piauí**	
Sector	withdrawal use [10^6 m^3/yr]	consumptive use [10^6 m^3/yr]	withdrawal use [10^6 m^3/yr]	consumptive use [10^6 m^3/yr]
irrigation[1]	324.0	194.4	127.5	76.5
livestock	81.2	81.2	65.1	65.1
households	225.5	45.1	123.6	24.7
industry option 1	25.6	5.1	0.9	0.2
industry option 2	46.2	9.2	4.1	0.8
tourism	16.7	3.3	2.1	0.4
minimal and maximal annual value[2]	673.0 - 694.0	329.1 - 333.2	319.1 - 322.4	166.9 - 167.6
minimal and maximal monthly value[3] [10^6 m^3/month]	28.9 - 91.9	15.4 - 36.4	9.6 - 41.2	5.8 - 16.1

[1] calculated with irrigation areas of 1996/98 as average of irrigation requirements computed with climatic time series 1951-1980
[2] minimal value with industry option 1 and maximal value with industry option 2
[3] data for the month with minimum and the month with the maximum water use.

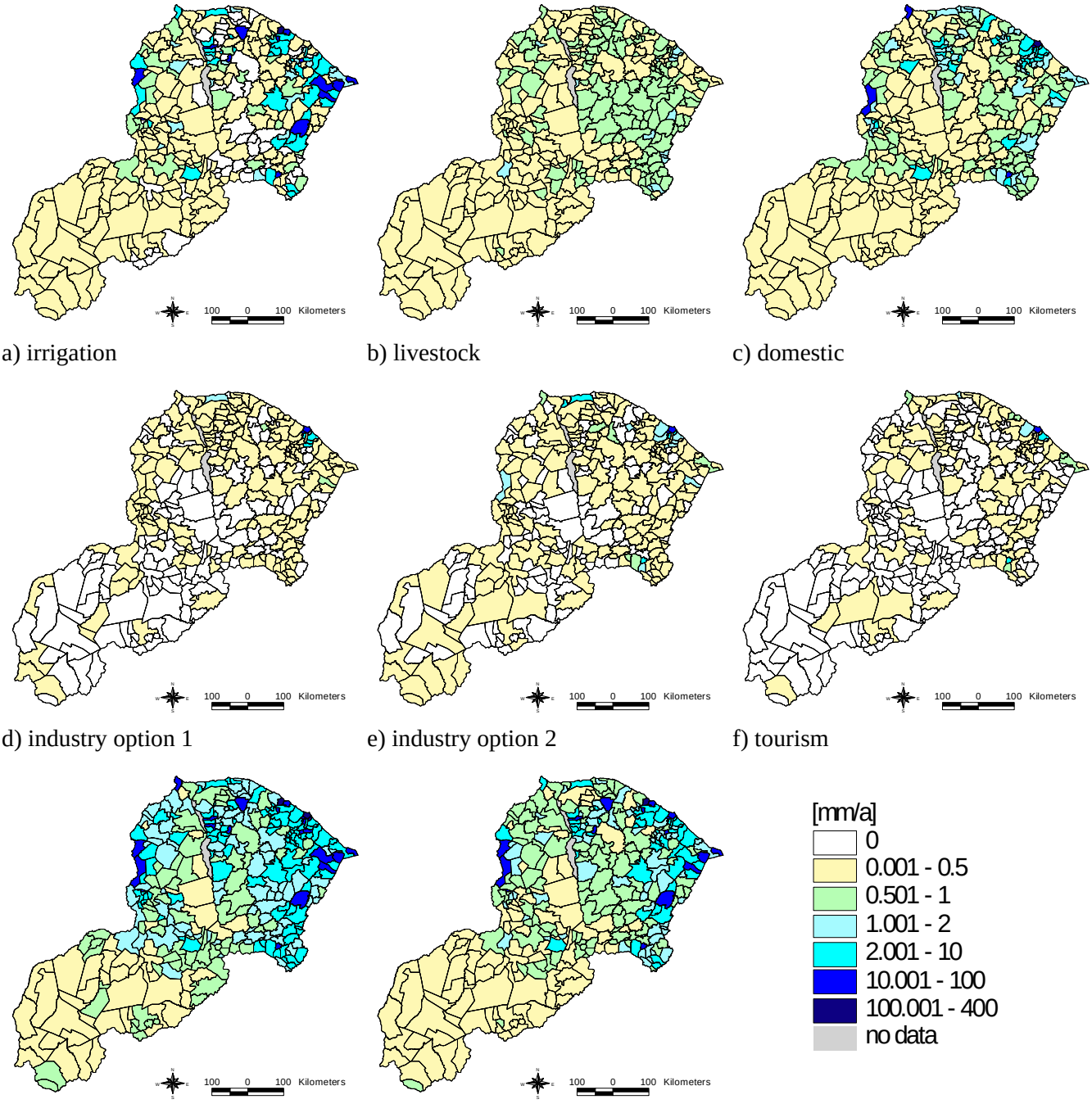
Table 3: Driving forces of each water use sector in Ceará and Piauí 1996/98

	Ceará	**Piauí**
Irrigated area [ha]	43024	13170
Cows / pigs / sheep [10^6 m^3]	2.4 / 1.1 / 1.6	1.7 / 1.4 / 1.3
Population[10^6 m^3]	6.7	2.7
Industrial gross domestic product [[10^6 ´1995 US$/yr]	2843	363
Tourist overnight stays [10^6 m^3/yr]	36.3	3.8

3.1.2 Municipalities

For water management both at the state and the drainage basin level, it is important to have spatially resolved water use information. NoWUM provides information on water use for each of the 332 municipalities in Piauí and Ceará. Fig. 4 shows the annual withdrawal water use 1996/98 in each municipality, for all water use sectors. Water use is expressed in mm/yr, i.e. it is normalized with the area of the municipality and is thus directly comparable to water availability expressed as runoff in mm/yr. The spatial pattern of irrigation water use (Fig. 4a) is explained by

1) the fraction of the area of the municipality that is irrigated, b) the percentage of crops that are grown all year round (banana, fruit trees, grass, sugar cane) and c) the interpolated climate data, which, however, have high uncertainty in the south of Piauí, in the Serra de Ibiapaba and in the Cariri. Large irrigated areas with fruit trees and vegetable cultivation occur in and around Teresina, in the Serra de Ibiapaba, in the Curu valley, along the Jaguaribe and in the Cariri region (Fig. 4a). The Sertão region of Ceará, with its high cattle density, emerges in the livestock water use map (Fig. 4b). Although the south of Piauí is economically dominated by animal husbandry, the per area livestock water use is low. The highest domestic water uses occur in the urban centers of Teresina, Parnaiba and Picos (Piauí) and in the metropolitan area of Fortaleza, Sobral, the Serra de Ibiapaba and the Cariri (Ceará) (Fig. 4c). Industrial water use also has maximum values in the urban centers. Industrial water use calculated with option 2 (industry type specific water intensities from Germany and industrial output from 19 industry types) is in most municipalities higher than option 1 simulations (direct information on industrial water use from water works) (Fig. 4d and 4e). The reality might be somewhere in between these two estimates. In 23 municipalities, option 2 provides information on industrial water use whereas it is zero under option 1. The most attractive coastal municipalities, the metropolitan area of Fortaleza and the pilgrims hot spot Juazeiro do Norte (Cariri) become evident in the tourism water use map (Fig. 4f). For all water use sectors, water use in Ceará is more intensive than in Piauí. Fig. 4g and 4h show the total withdrawal water use and the total consumptive water use of all water use sectors per municipality, respectively.



a) irrigation b) livestock c) domestic

d) industry option 1 e) industry option 2 f) tourism

g) total withdrawal water use h) total consumptive water use

Figure 4: Sectoral withdrawal water uses 1996/98 [mm/a] per municipality calculated with NoWUM: irrigation under average climatic conditions 1951-1980 (a), livestock (b), households (c), industry option 1 (d), industry option 2 (e), tourism (f), total withdrawal with industry option 2 (g) and total consumptive water use 1996-98 with industry option 2 (h).

3.2 Water use in 2025

3.2.1 States

Fig. 5 shows the total withdrawal water use in Ceará and Piauí modeled with NoWUM, in 1996/98 and, for the two reference scenarios, in 2025. In the future we see an increase of water use in both scenarios in all sectors compared to the present state. The strongest percentage increase is found in the irrigation, the tourism and the industrial sector. For the state aggregates, there is a stronger increase in water use in A than in B. It seems in terms of water use the decentralization scenario is more favorable.

The very small percentage increase of domestic water use is remarkable. Even though an additional two million people will live in the area, more households are connected to public water supply systems and people have a higher income than today, domestic water use will barely increase. This is due to the modeled effect of the pricing of water, assuming a relatively high price elasticities between -0.55 and 0.3 (decreasing with time) and a yearly increase in the water price of 6%. In the past ten years, the average annual water price increase in Ceará was 11%. Without price control the domestic water use in Ceará in the coastal boom scenario would increase from 226 · 10^6 m³ (1997) to 550 · 10^6 m³ instead of 297 · 10^6 m³ computed with price control. Thus, the pricing of water can contribute to water saving.

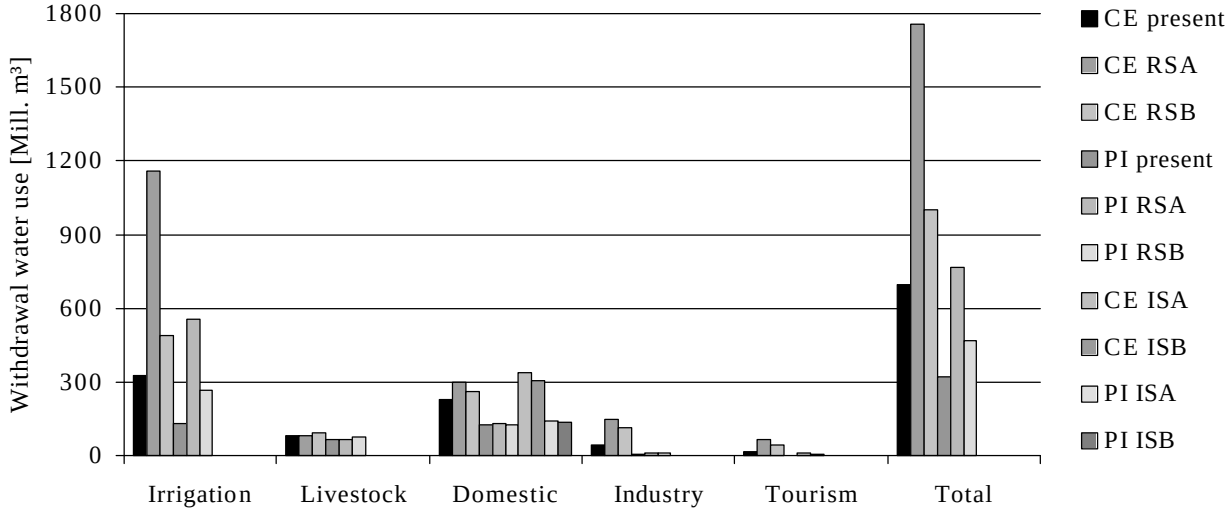


Figure 5: Sectoral withdrawal water uses in Ceará (CE) and Piauí (PI) 1996/98 and 2025, for reference and intervention scenarios A and B [10^6 m³].

Increasing the number of households connected to the public water supply beyond the increases in RSA and RSB (intervention scenarios ISA and ISB) increases domestic water use. This is due to the fact that approx. two million people more are connected and each connected person consumes

more water per capita than a self-supplied person. In Ceará, the intervention raises domestic water use by 14% in A with regard to the reference scenario, and 17% in case of B. In Piauí, the respective numbers are 7% and 10%. The intervention scenario shows that safe drinking water for over 80% of the total population in Piauí and Ceará, realized in the intervention scenarios, only results in a small increase of domestic water use if public water supply is subject to an efficient water price policy. The increase of total water use by the intervention is insignificant, because it is dominated by the change of irrigation water use.

3.2.2 Municipalities

For the two reference scenarios RSA and RSB, Figs. 6 to 11 present the difference between annual water use in 2025 and in 1996/98. Green colors mark a decrease of water use in the future, yellow and red an increase.

Irrigation: Consumptive irrigation water use in 2025 is higher than today for both reference scenarios (Fig. 6c and 6d). Consumptive water use is affected by climate change, by the increase in irrigated areas, and by the crop mix. RSA and RSB only differ with respect to the irrigated area. Fig. 6b shows the impact of climate change only, which overall leads to a (rather small) decrease of water use. For the simulations we used the 30-year climate normal 1951-80 to represent present day climate conditions and the climate normal 2011-2040 for 2025 climate. In each case, 30 years of irrigation requirements were computed and then averaged. Average precipitation 2011-2040 is larger than the 1951-1980 average in the north and in large parts of Ceará (Fig. 6a). However, the effect of the extension of irrigation by far outweighs the effect of climate change. The spatial pattern of consumptive irrigation water use in both scenarios (Figs. 6c and 6d) correlates well with the maps of extended irrigated areas (Figs. 6e and 6f). The increase in irrigated area in case of Scenario B is smaller than in case of Scenario A as not all the irrigation projects planned in 1998 are assumed to be implemented and also the extension of private irrigation is smaller than in scenario B. The strongest increases in irrigation water use occur in those municipalities where new public irrigation project are implemented.

Livestock: Fig. 7 shows the difference of withdrawal livestock use in future compared to the present state. The spatial pattern in both scenarios reflect the change in the distribution of (human) population, because in both scenarios the change in livestock populations is assumed to be proportional to the change in human population.

Domestic: Changes of domestic water use in future compared to the present state (Fig. 8) result from 1) the change of total population per municipality, 2) an increased number of persons

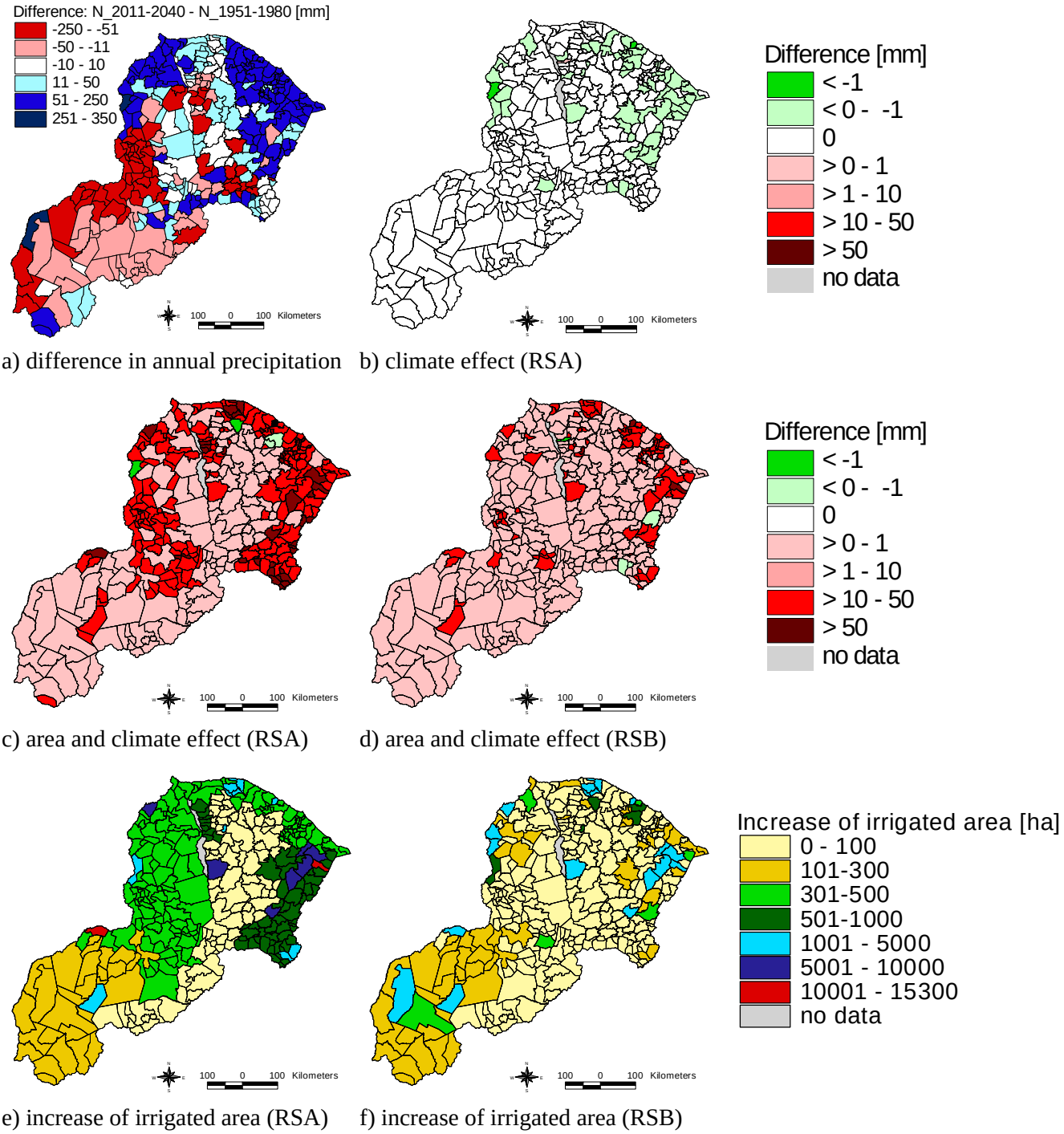
connected to public water supply and 3) a decrease of per capita domestic water use of supplied persons subject to water price and income increase. Domestic water use decreases in 45% and increases in 55% of all municipalities in the *Coastal Boom and Cash Crops* scenario RSA (Fig. 8a). In the *Decentralization* scenario RSB we found a decrease in only 25% of the municipalities and increase in 75% (Fig. 6b), which is due to a less intensive concentration of population in the coastal region than in RSA. As result of the smaller GDP increase in RSB, the total increase of domestic water use on state level is less in RSB than in RSA (Fig. 5).

An enforced extension of public water supply to the whole urban and 15% of the rural population in the intervention scenarios (IS), leads to an increase of domestic water use in 99% of all municipalities compared to their respective reference scenarios (Fig. 6c and 6d). However, the increase is in most municipalities very small (<= 1 mm). The strongest increase is found in Fortaleza, where the intervention increases domestic water use from 386 mm to 432 mm (RSA) and from 305 mm to 339 mm (RSB).

Industry: Industrial withdrawal water use increases in future due to an increase in industrial output (expressed as IGDP) (Fig. 9). The industrial mix is assumed to remain the same. In both RSA and RSB, the strongest absolute increases occur in Teresina, municipalities in the metropolitan area of Fortaleza as well as Camocim, Itapagé, Crato and Barbalha, as these municipalities have a relatively high industrial water use today. The increase in RSA is stronger than in RSB due to the stronger increase of the industrial gross domestic product (IGDP). In both scenarios, increase of IGDP is assumed to be equal to the increase of GDP. In municipalities without industry 1996/98, no industry is assumed to be established until 2025.

Tourism: Tourism water use increases in future above all in the coastal municipalities in the coastal boom scenario (Fig. 10a) and less strong in the decentralization scenario (Fig. 10b). The water use scenarios do not include establishment of tourism in non-touristic municipalities and municipalities without tourism potential (classified by EMBRATUR), because tourism water use would be negligible compared to the domestic water use there.

Total withdrawal water use: In RSA, total withdrawal water use decreases in the water scarce regions of Piauí and Ceará (Fig. 11a), where population decreases. In both scenarios, the strongest water use increase occurs in the coastal region, the metropolitan area of Fortaleza and the regions of Piauí and Ceará with relatively large potential water resources (Figs. 11a and 11b). Besides, the municipalities for which irrigation projects are planned require much more water than today (comp. Fig. 6).

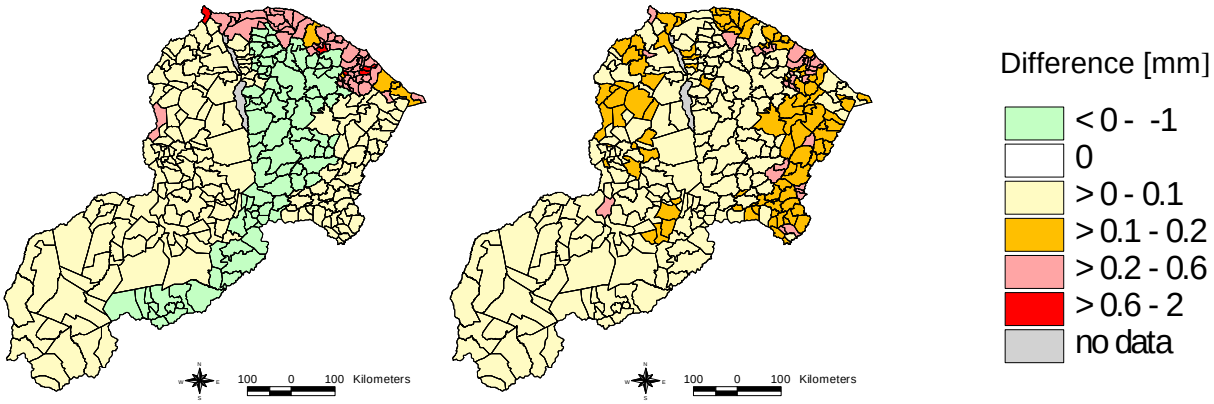


a) difference in annual precipitation b) climate effect (RSA)

c) area and climate effect (RSA) d) area and climate effect (RSB)

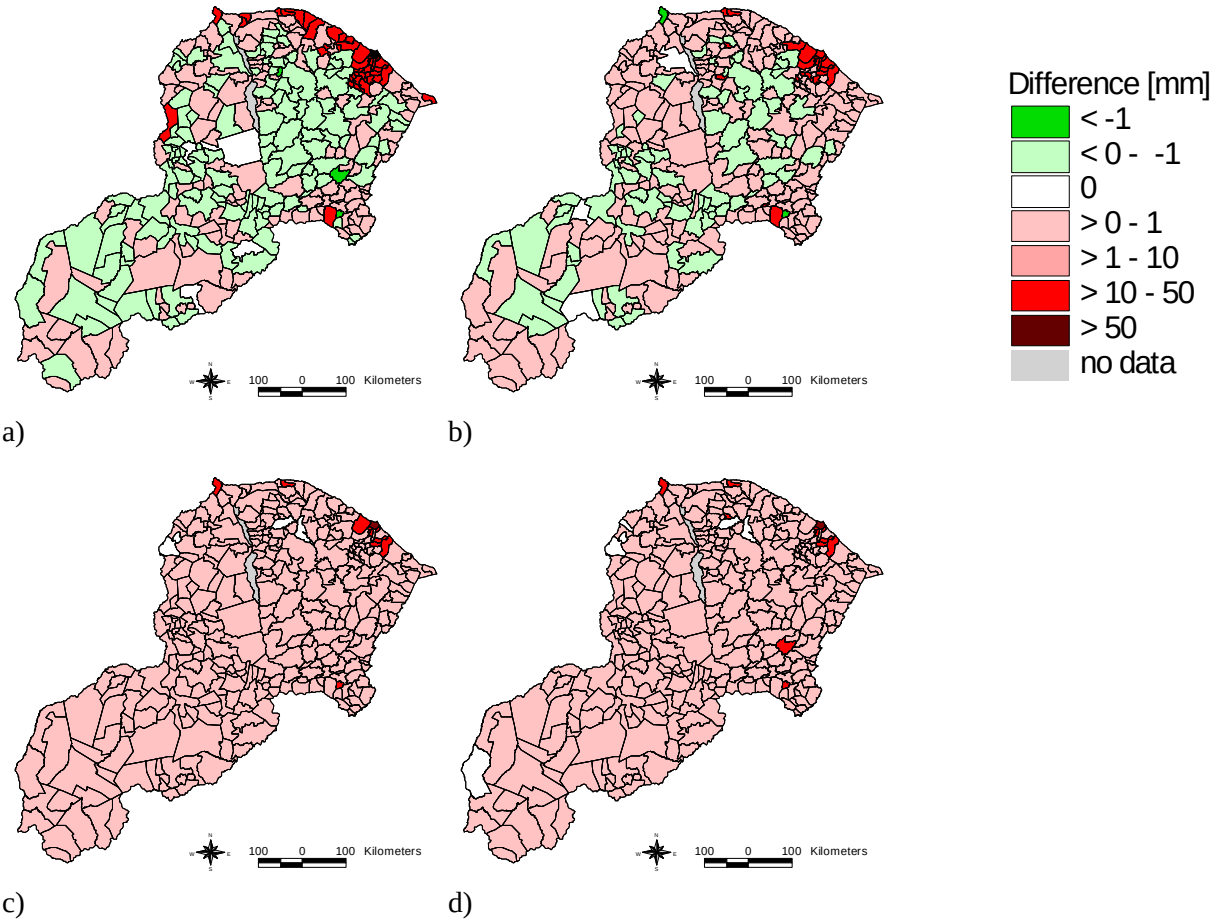
e) increase of irrigated area (RSA) f) increase of irrigated area (RSB)

Figure 6: Difference of long-term average precipitation between 2011-2040 and 1951-1980 [mm] (a). Absolute difference of consumptive irrigation water use between 2025 and 1996/98 [mm/a] for reference scenarios A (c) and B (d). The 2025 scenario was simulated with irrigated areas of 2025 and climate data 2011-2040, present state with areas of 1996/98 and climate data 1951-1980. Impact of climate change only: both simulations with irrigated area of 1996/98, but different climates (2011-2040 and 1951-1980) (b). Increase of irrigated areas from 1996-1998 to 2025 [ha] (Scenario A: e and Scenario B: f).



a) b)

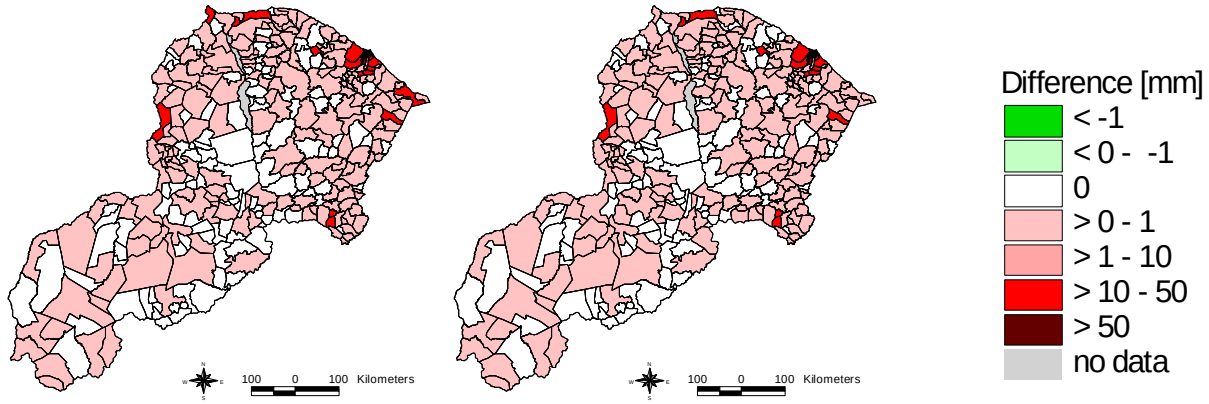
Figure 7: Difference of livestock withdrawal water use between 2025 and 1996/98 for reference scenarios A (a) and B (b).



a) b)

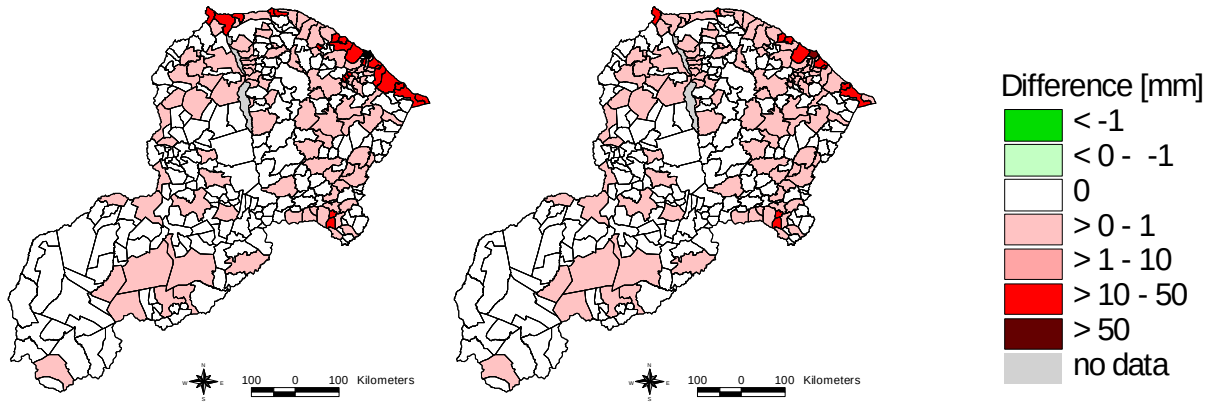
c) d)

Figure 8: Difference of domestic withdrawal water use between 2025 and 1996/98 for reference scenarios A (a) and B (b). Difference of domestic withdrawal water use in 2025 between the reference and intervention scenario A (c) and between the reference and intervention scenario B (d).



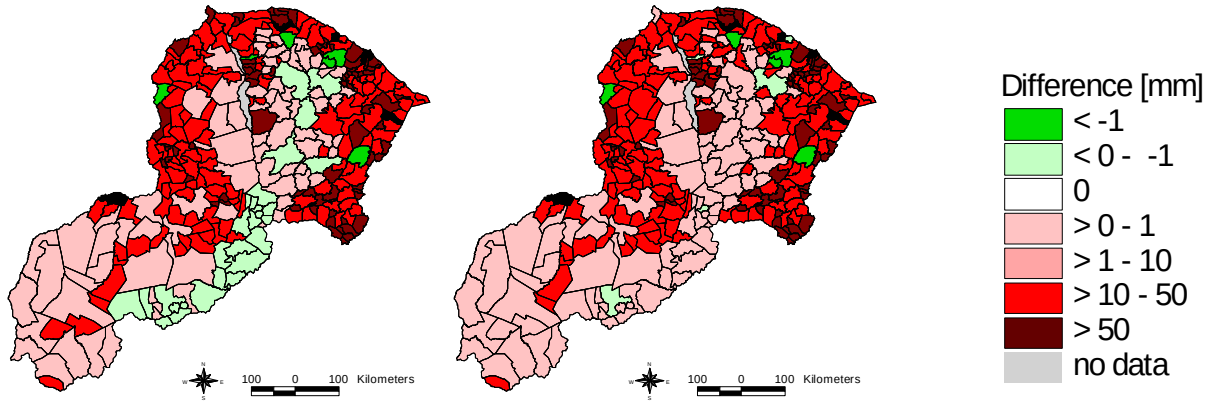
a) b)

Figure 9: Difference of industrial withdrawal water use, calculated with option 2, between 2025 and 1996/98 for reference scenarios A (a) and B (b).



a) b)

Figure 10: Difference of tourism withdrawal water use between 2025 and 1996/98 for reference scenarios A (a) and B (b).



a) b)

Figure 11: Difference of total withdrawal water use, with industry option 2, between 2025 and 1996/98 for reference scenarios A (a) and B (b).

3.3 Water scarcity

Indicators describe quantitatively the state of a system and are therefore helpful to identify and describe changes of the system. As simple index for water scarcity, we chose the ratio of withdrawal water use and the water availability in the municipality of interest. Water availability in a municipality is defined as the total runoff in all upstream municipalities minus the consumptive water use in all municipalities upstream of the municipality of interest:

$$Index_water_scarcity_m = \frac{total\ withdrawal\ water\ use_m}{runoff_m - \sum_1^n consumptive\ water\ use_n}$$

m: *municipality for which the index is calculated*

n: *municipality upstream of* m

Consumptive and withdrawal water use are model results from the water use model NoWUM, while runoff per municipality is simulated by the large-scale hydrological model HYMO-WA (Bronstert and Güntner) using the 1951-80 climate time series. The higher the index, the more stress is placed on available water resources by water use. If a large part of the available water is withdrawn, the usage of water by downstream users can be impaired due to 1) the decreased streamflow and 2) the low water quality of the return flow. At this time, there is no objective basis for defining threshold values of the water scarcity index which, for example enables us to distinguish areas with high water stress from areas of low water stress. If the index is based on long-term average annual values of runoff and water use (Fig. 12a), a ratio of 0.4 and higher might indicate severe water stress (Alcamo et al., 2000). However, areas suffering from water scarcity are better identified by looking at the ratio in a typical dry year (Fig. 12b); this takes into account that in the case of two areas with the same average ratio but different interannual climate variability, the area with the higher variability suffers more from water scarcity than the area with a relatively equable climate. In a typical dry year, water scarcity occurs mainly in those areas in Ceará and Piauí with small potential water resources. Beyond this, some municipalities, for example in the Picos and the Cariri region, belong to the areas with large potential water resources and have critical water scarcity indices. These municipalities have large groundwater resources, that are not considered to calculate this index, because groundwater resources are not quantifiable, finally.

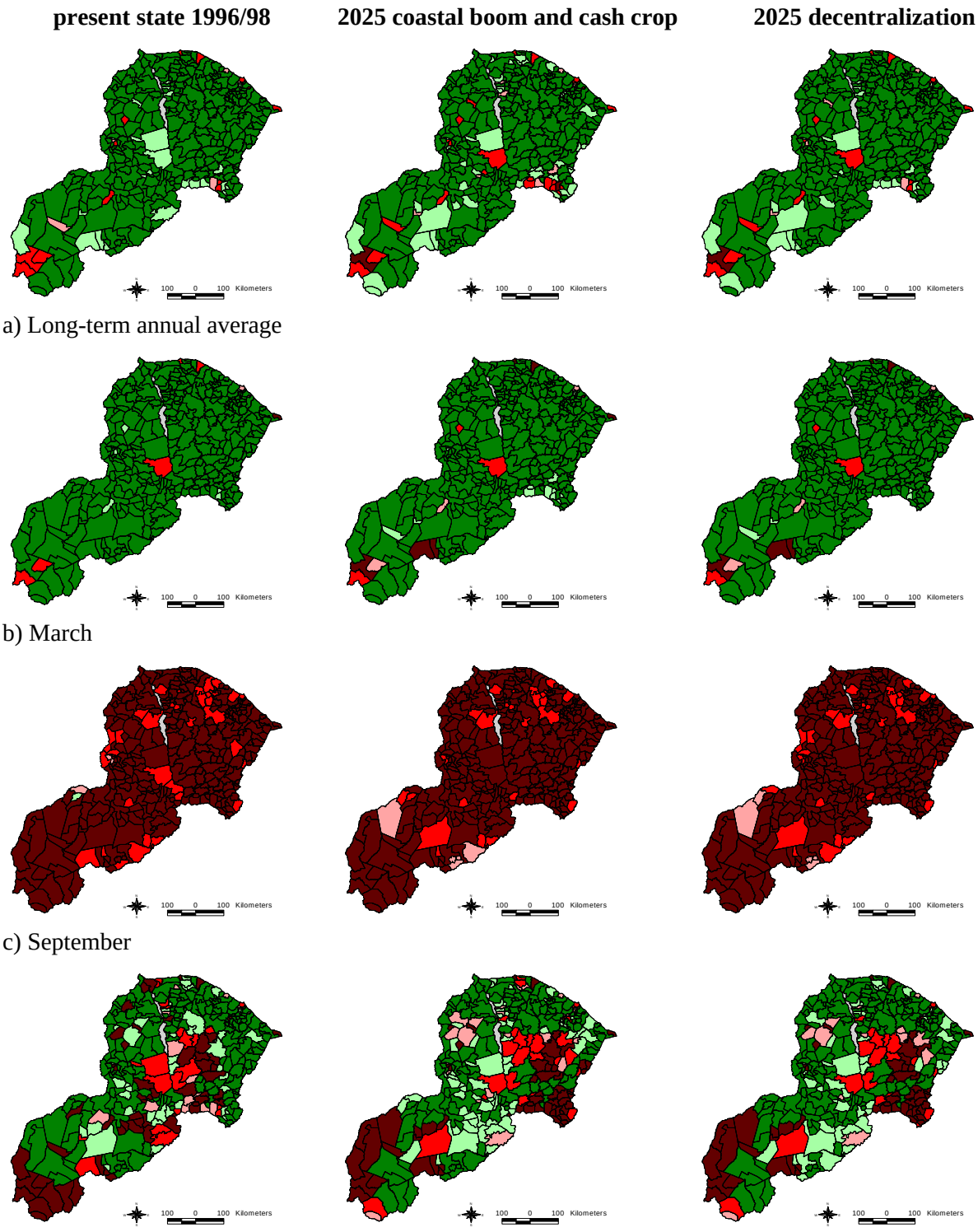


Figure 12: Water scarcity indices: long-term annual average (a), long-term average for March (rainy season) (b) and September (dry season) (c) and annual value of typical dry year (1970 and 2037, respectively) (d) for the present state 1996/98 and for the two reference scenarios of 2025 under average climatic conditions of 1951-1980 and 2011-2040, respectively.

If long-term annual average of water availability and water use are taken into account, water scarcity (critical value > 0.4) is identified only in 5% of the municipalities (Fig. 12 a). Obviously, a water scarcity indicator based on long-term annual average cannot represent the nature of water scarcity in Northeastern Brazil. There are two reasons. First, water scarcity is a seasonal problem, and second, the high interannual climate variability leads to recurrent drought years.

During the rainy season, in March (Fig. 12 b), only few municipalities have a critical water scarcity index. In the dry season, in September (Fig. 12 c), there is no rainfall and therefore no runoff in nearly all 332 municipalities. Fig. 13 shows the increasing percentage of municipalities with critical water scarcity index (> 0.4) from 4% in the rainy season to 100% in the dry season. Since the natural runoff without considering the large reservoirs is used to calculate the scarcity index, the seasonal climate variability shapes the curve. In reality, in the dry season, water is withdrawn from groundwater, large reservoirs and rivers made perennial by reservoir management. Therefore the water supply situation is less negative than shown here. Nevertheless, every dry season the governments of Ceará and Piauí need to deploy water trucks to supply persons in rural areas with drinking water.

The more facilities exist to store the runoff of the wet season for the dry season, the more appropriate it is to take into account a water scarcity index based on annual averages. Such an annual index should be derived for the conditions of a typical dry year (year with an annual rainfall which is exceeded in 90% of all years) and not for long-term average climate, as water cannot be stored over many years. In the year 1970, 28% of the municipalities suffer much more from water scarcity (Fig. 12 d) than the 5% under long-term average climatic conditions.

In the future, annual and monthly water scarcity increases in both scenarios compared to the present state 1996/1998 (Figs. 12 and 13). With respect to annual values, the percentage of municipalities with a critical water scarcity index increases 2025 in the case of RSA by 6% and by 1% in RSB compared to the present state (Fig. 13). With respect to the monthly water scarcity index, differences are highest in the months between the rainy and dry season. In most municipalities, the increase of runoff due to climate change cannot balance the increase of water use; water use increases in 90% of the municipalities, and runoff in only 53%. Water scarcity increases more strongly in the *Coastal Boom and Cash Crops* scenario than in the *Decentralization* scenario, which is mainly due to the different increases of irrigated areas.

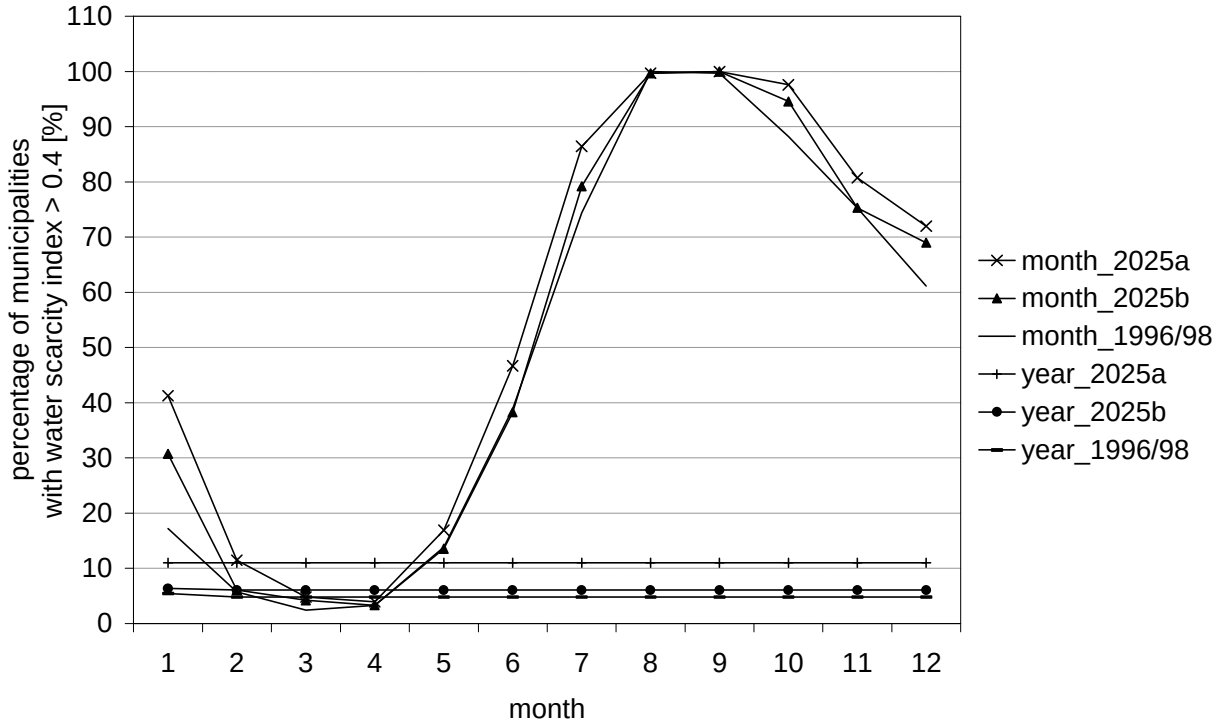


Figure 13: Monthly variation and annual mean value of water scarcity for the present state 1996/98 and for the two reference scenarios of 2025 under average climatic conditions of 1951-1980 and 2011-2040, respectively.

3.4 Water quality

Scenarios of future nitrogen emissions to surfaces water show the effect of an extended and improved treatment of municipal waste water. Here, we only present the results for reference scenario B. In 1997 only 11 out of 332 municipalities had waste water treatment plants, and approximately 2-44% of the waste water of this municipalities was treated. For RSB it is assumed that in 2025 all capitals of municipalities have a wastewater plant, and that 30% of their wastewater is cleaned. For the intervention scenario (ISB), the fraction is 70%. Figure 14 shows the changes of nitrogen emissions to surface water in 2025 compared to the present state. Due to the increased number of treatment plants, municipal nitrogen emissions to surface waters increase less than the number of inhabitants (Fig. 14). The emission reduction is stronger if the treatment efficiency is higher (difference between primary and secondary treatment). The effect of secondary treatment of 30% of the waste water of the capitals of the municipalities (RSB, secondary treatment) is similar to the effect of a primary treatment of 70% of the waste water (ISB, primary treatment). If 70% of the waste water undergoes secondary treatment (ISB, secondary treatment) nitrogen loads in five out of the eight regions would be smaller than today.

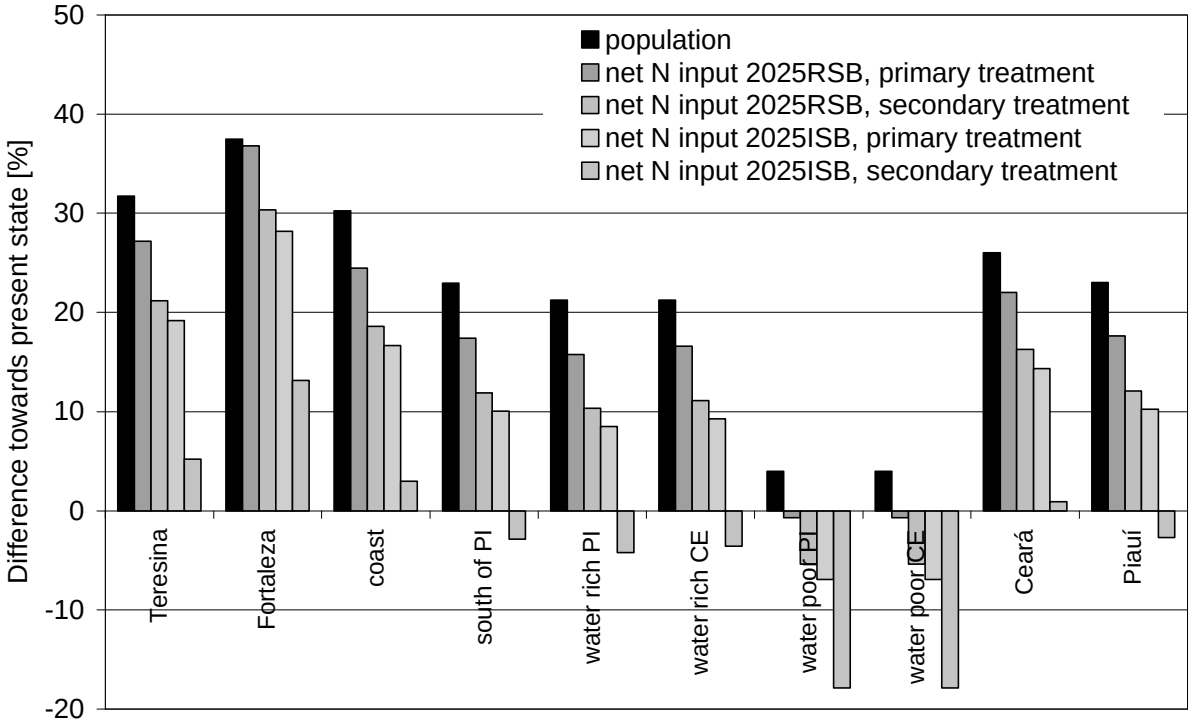


Figure 14: Differences [in % of values 1997] of population and nitrogen input in surface waters in the decentralization scenario as well as for the corresponding intervention scenario per scenario region and on state level. The elimination of nitrogen through treatment plans was calculated for 1997 for a primary treatment (minus 15% N), for the scenarios of 2025 for a primary and a secondary (minus 30% N) treatment, respectively.

4 Summary and conclusions

A scenario analysis of future water use and water scarcity in the semi-arid states Piauí and Ceará in the semi-arid Northeastern Brazil was performed. The analysis was done with the help of the newly developed water use model NoWUM which computes withdrawal and consumptive water use in each of the 332 municipalities, distinguishing five water use sectors. The scenario analysis shows how water use might develop between today and the year 2025, taking into account changes of climate, population, income, industrial output and water prices as well as changes in irrigation (areas, crops, water use efficiency) and public water supply (connected households). For the first time, municipality-specific estimates of current water use are provided. For all sectors, the increase of water use between today and 2025 is higher in case of the *Coastal Boom and Cash Crops* scenario than in case of the *Decentralization* scenario. Due to increased water use (in 99% of the municipalities), water scarcity will become more severe in the future, even though runoff will increase in more than 50% of the municipalities due to climate change (average climate 2011-2040).

The development of water use will predominantly be influenced by the development of the irrigation sector, above all the extension of irrigated areas. If all the now irrigation projects planned in 1998 will be implemented by the year 2025 and private irrigation increases in a similar fashion than in the last decade (*Coastal Boom and Cash Crops* scenario), irrigated area will increase by a factor of 4.5 and irrigation water use by a factor of 3.8 (withdrawal water use) and 4.1 (consumptive water use). Then, irrigation would account for 68% of the total water withdrawal of 2513 km^3/yr in Piauí and Ceará compared to 44% of 1016 km^3/yr today. In the alternative *Decentralization* scenario, irrigated area increases by a factor of 2, and irrigation water use (withdrawal) by a factor of 1.7. In this scenario, the irrigation sector uses 51% of the total withdrawn water (1466 km^3/yr) in 2025. The impact of climate on irrigation water use is small.

Domestic water use increases where population increases but due to the high price elasticity and the increase of water price, increases are low. In an exemplary fashion, the impact of a water management measure on water use, here the extension of public water supply to a larger number of household, is shown. This measure increases domestic water use in urban centers, but does not significantly effect total water use (Fig. 5).

Although industrial water use becomes more important in the future, above all in Ceará, irrigation and households remain the dominant water users. In Ceará, industrial water use will become the third most important sector, switching its rank with the livestock sector.
There is a strong interdependence between water use and water quality. When water is withdrawn, used and then returned to the river, its quality usually decreases, sometimes to a degree that precludes a further use downstream. An indicator for the impact of domestic water use on water quality is the nitrogen load which can be decreased by waste water treatment. Scenarios of future nitrogen emissions to surfaces water show the effect of an extended and improved treatment of municipal waste water. If in 2025 (*Decentralization* scenario), 70% of the waste water produced in the capitals of the municipalities will be subject to secondary waste water treatment, nitrogen loads in five out of the eight scenario regions would even be smaller than today (even though population increases).

The presented scenario analysis can form the basis for further investigating the effect of water management measures on water use, water scarcity and water quality. New intervention scenarios could explore the consequences of, for example, implementing or not certain irrigation projects, with certain areas, crop types and irrigation water use efficiencies. In order to assess the impact of to technical measures to increase water availability, e.g. new reservoirs, on water scarcity, the scenarios of future water use (or demand) must be taken into account. With respect to water

quality, it will necessary to assess not only the domestic nitrogen loads, but also the agricultural loads. Then, the interplay between land use and water quality could be analyzed.

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Appendix A

Large-scale water use model NoWUM

for modeling water management in Ceará and Piauí

Model description, data and scenario assumptions

Version 1.0
January 2000

1 Overview

The water use model NoWUM (**No**rdeste **W**ater **U**se **M**odel) calculates both withdrawal water use (quantity of water withdrawn from its natural location) and consumptive water use (quantity of water lost to evapotranspiration). The use quantity best suited for the assessment of water scarcity, water depletion (quantity of water used that cannot be reused), is a quantity in-between withdrawal use and consumption use, which due to the lack of information on water quality is not yet computed in the present model version 1.0. Within NoWUM, five water use sectors are distinguished: irrigation use, livestock use, domestic use, industrial use and tourism use.

The irrigation water use is calculated with the methodology of FAO (FAO, 1992). Livestock water use is computed as a function of livestock-specific water use and numbers of the different livestock types. With respect to domestic water use, the specific water use of people connected to the public water supply and those not connected are differentiated. Two methods are used to calculate the industrial water use: one based on the assessment of different water sources (public supply, self-supply, raw water supply); the second multiplies the industrial gross domestic product with a water use intensity per industrial branch. Multiplying the touristic overnight stays with a touristic water use per overnight stay gives the water use in the tourism sector.

Computations are performed on the municipal scale for all municipalities of Ceará and Piauí in the reference year 1996. Here, Ceará consists of 184 and Piauí of 148 municipalities. The municipalities in Ceará are numbered sequentially from 1 up to 184, those of Piauí from 185 to 332. The output of NoWUM are monthly sectoral withdrawal and consumptive water use values in each municipality. However, in the case of livestock water use and industrial water use, the monthly values are derived from annual averages, while in the case of irrigation they are the sum of 10-day-values.

2 Irrigation water use

2.1 Method

The consumptive irrigation water use (net irrigation requirement) is computed following the method of CROPWAT (FAO, 1992). The crop-specific net irrigation requirement within one growing period I_c is calculated as

$$I_c = \sum_{i=1}^{n} K_{c,i} E_{p,i} - P_{eff,i} \qquad \text{(F 2.1)}$$

i: *10-day-period*
n: *number of 10-day-periods within the growing period (crop-specific)*
K_c: *crop coefficient (crop-specific) [-]*
E_p: *potential evapotranspiration [mm/d]*
P_{eff}: *effective precipitation [mm/d]*

Using effective precipitation instead of total precipitation P takes into account that not all the rain is available to the crops. According to the USDA Soil Conservation Service Method (as given in FAO, 1992),

$P_{eff} = P(4.17 - 0.2\,P) / 4.17$ for $P < 8.3$ mm/d
$P_{eff} = 4.17 + 0.1\,P$ for $P \geq 8.3$ mm/d

2.2 Climate data input

NoWUM requires daily values of precipitation and potential evapotranspiration, which are provided by the WAVES-subproject *Large-scale Hydrologic Model*.
As the FAO approach uses 10-day time steps, NoWUM aggregates daily values of precipitation and evapotranspiration into 36 time steps per year. The *Integrated Model SIM* of WAVES handles with 365 or 366 days per year, respectively. Hence, NoWUM sums up three times 10 days (April, June, September, November); 10, 10 and 11 days (January, March, May, July, August, October, December); in February 10, 10 and 8 or 9 days to get three time steps per month.

2.3 Input of crop data

The crop data required are:
1. irrigated areas per crop in each municipality
2. crop-specific data like planting date, growing periods and crop coefficients per growing period.

First, we determined nine main irrigated crops classes (Table 1). The crop-specific planting date was derived from annual schedules of DNOCS irrigation perimeters in Ceará and Piauí (DNOCS 1994a, 1995a, 1996a) and the recent Agricultural Census (IBGE 1998a, 1998b), while data on crops coefficients and length of growing period are taken from CROPWAT (FAO, 1992).

Table 1: NoWUM crop classes of irrigated crops: relation of single crops to crop classes, growing period of crop classes and used crop data set (crop coefficients K_c and growing periods) per crop class from FAO (1992).

class no	crop class	included crops	growing period [days]	crop type in FAO (1992), for which crop-specific data are used
1	banana	banana	360	banana
2	beans	beans	90	beans
3	cotton	cotton	140	cotton
4	fruit trees	acerola, cajá, coconut, guava, graviola, jaca, orange, lemon, mango, papaw, passion fruit, urucum, uva	360	citrus
5	grass	grass	360	grass
6	maize	maize	130	maize
7	rice	rice	120	rice
8	sugar cane	sugar cane	360	sugar cane
9	vegetables	melon, onion, pumpkin, tomato, water melon	120	tomato

2.3.1 Irrigated areas in 1996/98

Information about the size of irrigated areas at state level in Ceará and Piauí diverges widely. The Agricultural Census of Ceará and Piauí (IBGE 1998a, 1998b) provides information for all municipalities in both states, but Brazilian experts say that the total irrigated areas published by IBGE are strongly overestimated.

For Ceará, we used the most reliable information from COGERH (1995, 1998a) and SRH (1998), instead of data of the Agricultural Census. COGERH keeps a register of total irrigated farm land in some municipalities of the Curu and the Jaguaribe valley. SRH registers all irrigation licenses given to farmers in Ceará. These licenses include also the irrigated area per crop. The total irrigated area per municipality is taken from the COGERH and the SRH-register. The lacking data in 23 municipalities are filled with downscaled IBGE data considering expert knowledge. Because in the municipalities Ico and Morada Nova the registered data seem to be much to high, they are replaced with data from the Agricultural census. Here licenses are already given for public irrigation projects which will be implemented in the future.

In Piauí, data of irrigated areas are taken from the Agricultural Census, because more reliable data are lacking. There is no reasonable correlation between the total irrigated area per municipality and the sum of the harvested areas of significant irrigated temporary crops per municipality, both given in the Agricultural Census of Ceará and Piauí (IBGE 1998a, 1998b). In many municipalities the total irrigated area is considerably less than the sum of the areas of the temporary crops. Additionally the permanent crops should be integrated. That calls the given total irrigated area in question. Hence, the harvested areas of irrigated temporary crops per municipality are considered

as their irrigated areas in the year 1996. Furthermore, the harvested area of banana and all fruit trees are set as their irrigated areas assuming that these crops are always irrigated. The total irrigated area per municipality is calculated as the sum of the harvested area of the irrigated temporary crops, the harvested area of banana and the harvested area of fruit trees. The total irrigated area is scaled down to 13170 ha, because Brazilian experts do not regard 18148 ha of irrigated land in Piauí in 1996 to be realistic. For this purpose, the size of irrigated areas in the municipalities close to markets (Floriano, Miguel Alves, Oeiras, Parnaiba, Picos, Piripiri, São Raimundo Nonato, Teresina and União, all together 8625 ha) are retained. In all other municipalities the irrigated area is reduced by factor 3.

2.3.2 Irrigated areas in 2025

The increase of irrigated areas up to the year 2025 is designed for the two reference scenarios of WAVES, the *Coastal Boom and Cash crops* scenario *(RSA)* and the *Decentralization: Integrated Rural Development* scenario *(RSB)* (Döll et al., 2000). The total irrigated area is the sum of large public irrigation projects and private irrigation. The increase of both parts is considered differently in both reference scenarios. While the *Coastal Boom and Cash Crops* scenario continues the business as usual, the *Decentralization* scenario shows an alternative development. The present governments of Ceará and Piauí favor a strong increase of large public irrigation projects. These projects are already planned for years at locations best suited for irrigation and provide opportunities for the agro-industry, and middle-sized and small farmers. RSA reflects this policy. On the other hand, an increase of irrigated land of private farmers distributed upon the whole territory matches best the story line of RSB. In RSA, the total irrigated area of 1996/98 is increased until 2025 by a factor of 4.5, and in RSB by a factor of 2.

Coastal Boom and Cash Crops scenario (RSA)

For the year 2025 it is assumed that all large public irrigation projects planned in 1998 will be implemented in the specified municipalities given in Lopes Neto (1998). Additionally, an increase of the private irrigated area is assumed per scenario region such that by 2025 irrigated areas increased as listed in table 2. The additional total private irrigated area per scenario region is equally distributed to all municipalities of the region.

Decentralization scenario (RSB)

For the year 2025 is assumed that only a quarter of the large public irrigation projects planned in 1998 will be implemented in the specified municipalities. The reasoning is that these projects were begun in the end of the 90s, but not concluded under the political conditions of decentralization. The increase in private irrigation is also assumed to be smaller in RSB than in RSA.

The additional private irrigation area is distributed in each scenario region in the following way:
a) 50% of this area is distributed in proportion to the present irrigated area (assuming that existing irrigation occurs in best suited places), and
b) 50% of this area is equally distributed in all municipalities of the scenario region (assuming the promotion of a decentralized economic activity).

Table 2 summarizes the change in total irrigated area per scenario region for both reference scenarios.

Table 2: Scenarios of the increase of the irrigated areas

	irrigated area in ha			change of irrigated area in %	
Scenario region	1996/98	2025 RSA	2025 RSB	1996/98-2025A	1996/98-2025B
Teresina	1,018	4,072	1,527	+ 300	+ 50
Metropolitan area of Fortaleza and Pecem	695	4,170	2,085	+ 500	+ 200
Coastal region	10,476	41,904	20,952	+ 300	+ 100
South of Piauí	1,470	11,760	8,820	+ 700	+ 500
Region with high potential water resources (Piauí)	10,402	62,412	26,005	+ 500	+ 150
Region with high potential water resources (Ceará)	28,138	112,552	42,207	+ 300	+ 50
Region with low potential water resources (Piauí)	103	309	309	+ 200	+ 200
Region with low potential water resources (Ceará)	3,964	15,856	11,892	+ 300	+ 200
Total (Piauí and Ceará)	56,266	252,035	113,797	+ 348	+ 102

Not only the total irrigated area, but also the crop mix is changed in the scenarios. 50% of the new irrigated area per municipality gets the same crop distribution as in 1996/98. The other part is planted according to the standard crop mix of 2025. "Standard crop mix" means the average crop mix of a state (Piauí or Ceará). Brazilian experts expect that the percentage of banana, fruit trees, vegetables and cotton will rise, the percentage of beans, maize and grass will remain at the same size, and the percentage of rice and sugar cane will decrease (Table 3).

Table 3: Standard crop mixes 1996/98 and 2025 in Ceará and Piauí [in % per crop class]

crop class	CE 1996/98	CE 2025	PI 1996/98	PI 2025
banana	5.4	6	7.4	10
beans	18.0	18	6.2	9
cotton	3.9	7	0.2	5
fruit trees	21.2	25	8.8	25
grass	12.4	12	5.8	6
maize	5.2	5	6.1	7
rice	24.4	18	31.4	28
sugar cane	3.9	0	26.2	0
vegetables	5.6	9	4.3	10

2.4 Calculation of irrigation water use

In NoWUM, the net irrigation requirement *irr_req* of a planted area is calculated as

$$irr_req[i][l][k] = petp[i][l] * K_c[l][k] - raineff[i][l] \quad \text{(F 2.2)}$$

i: *municipality*
l: *ten-days-time-step of the year*
k: *crop class*
irr_req: *irrigation requirement [mm]*
petp: *potential evapotranspiration [mm]*
K_c: *specific crop coefficient [-]*
raineff: *effective precipitation [mm]*

The irrigation requirement is calculated for each municipality *i*, for every ten-day time step of the year *l* and for all crops *k*, which are planted in the municipality. The crop coefficient K_c varies within the growing season. It is 0 before the crop's planting and after its harvest. Altogether four development steps are distinguished with fixed crop coefficients during the first and the third step. The coefficient during the second and the fourth step augments or decreases linearly. During the second step it starts with the value of the first step and finishes with the value of the third step. During the fourth step it starts with the value of the third step and finishes with the given final value of the fourth step.
Table **4** shows an example:

Table 4: Planting date, duration and crop coefficients of growing phases of crop 1:

crop 1		phase 1	phase 2	phase 3	phase 4
planting day [day of the year]	10				
duration of growing periods [number of days]		30	40	50	30
crop coefficient K_c		0.5	$0.5 + \frac{1.1 - 0.5}{1 + 40/10} * n$ n: number of time steps	1.1	$1.1 + \frac{1.0 - 1.1}{1 + 30/10} * n$ n: number of time steps

If the irrigation requirement for a crop of each municipality [mm = l/m²] is multiplied with the municipal irrigated area of the respective crop, the water amount for irrigation water results.

$$wat_irr[i][l][k] = irr_req[i][l][k] * area[i][k] \quad \text{(F 2.3)}$$

i: *municipality*
l: *time step*
k: *crop type*
wat_irr: *water amount for irrigation [m³/time step]*
irr_req: *irrigation requirement [m³/m²]*
area: *planted area with crop k [m²]*

Summing over all crops and over each month, the monthly consumptive use of irrigation within one municipality *con_irr[i][j]* is obtained. The withdrawal water use is computed as

$$wd_irr[i][m] = \frac{con_irr[i][m]}{eff_irr[i]} \qquad \text{(F 2.4)}$$

i: municipality
m: month
wd_irr: total irrigation withdrawal water use [m³/month] per municipality
con_irr: total irrigation consumptive water use [m³/month] per municipality
eff_irr: irrigation water use efficiency of municipality [-]

NoWUM works with a constant water use efficiency of 0.6 for all municipalities in 1996/98 according to Brazilian expert knowledge. In the future Brazilian experts expect that the irrigation water use efficiency will increase to 0.7. The higher efficiency considers the technological change; since NoWUM does not include a price control of irrigation. Moreover, this version does not consider multiple cropping (planting crops with short growing periods two or three times a year) yet, consequently the irrigation water use is underestimated.

3 Livestock water use

Based on the Agricultural Census (IBGE 1998a, 1998b), eleven types of livestock are distinguished. For 1996 the number of animals per species are taken from the Agricultural Census. In the scenarios of the future animal populations grow with the same annual population growth rates as used for the human population per municipality. The withdrawal water use for livestock is computed by summing up the products of the livestock-specific water use (Table **5**) and the number of that livestock in each municipality. The consumptive water use is computed by multiplying the withdrawal water use with a typical livestock water use efficiency of 1.0 (USGS, 1998). Only yearly values are computed, which are - in order to obtain monthly values - just divided by twelve.

Table 5: Mean daily water volume consumed by livestock species [l/d/cap]. Values calculated from given minimum and maximum values in EMPRAPA-CPATSA/SUDENE (1984). For donkey and mule the value of horse is assumed; for rabbit, poultry and quails the value of chicken.

species	daily consumed water volume [l/d/cap]
cow	68.0
pig	11.0
horse, donkey, mule	54.5
sheep, goat	8.5
chicken, poultry, quail, rabbit	0.3

4 Domestic water use

4.1 Method

Domestic water use is the product of population and the water use per person. People connected to the public water supply (piped water supply) are differentiated from those that are not connected. While the water use of people connected to the public water supply is determined from municipality-specific monthly data on connected households and supplied volume, the water use of people not connected to the public water supply is assumed to be a constant in the present version of NoWUM. For the scenarios of the future the water use per capita of a person connected to the public water supply is modeled as a function of the water price and the average income of the person.

4.2 Input data of population and public water supply volumes

4.2.1 Present state

NoWUM requires data of the total population and the population connected to public water supply. The latest population data (total, urban and rural) are published in the Demographic Census of IBGE (1997), reference day 01-08-1996. With monthly growing rates of population per municipality, which we took from internal reports of the public water supply companies AGESPISA (1997) and CAGECE (1997), we computed monthly total and urban population for the year 1997. The supplied population is calculated as follows for every municipality:

$$popsupp = \begin{cases} hh_{conn} * hhsize_{urban} & if\ hh_{conn} * hhsize_{urban} < popurban \\ popurban & if\ hh_{conn} * hhsize_{urban} \geq popurban \end{cases} \qquad \text{(F 4.1)}$$

popsupp: *supplied population of municipality*
popurban: *urban population of municipality*
hh_{conn}*:* *amount of households connected to public supply*
$hhsize_{urban}$*:* *urban household size per municipality*

The data of amount of households connected to public supply were derived from internal reports of AGESPISA (1997), CAGECE (1997), FNS (1997), SISAR (1998), FUNASA (1998) and SOHIDRA (1999) as well as the data of urban household size from the Demographic Census on IBGE (1997). In the present model version, the supplied population is calculated outside of NoWUM.

For computing the specific water use of people connected to the public water supply, the produced water volume of the supply companies for each municipality are necessary. In the accessible internal reports of 1997 from AGESPISA, CAGECE and FNS, these data are only given by CAGECE for all months and by AGESPISA from January up to March 1997. Instead of this, we take the billed water volumes, provided by all companies for all months, as input data, although the billed water volume in general is smaller than the produced (and supplied) volume, in some municipalities up to factor 2. If households have no water meter, they pay for a fixed volume of 10 m³, although they probably consume more water. This could explain the large

difference between the two water volumes. Finally the water use efficiencies per municipality are read from a separate input file, although we have no local data yet.

4.2.2 Scenarios

The WAVES working group Scenarios designed two reference and one intervention scenario up to the year 2025 for the eight scenario regions (Döll et al., 2000). The two reference scenarios are (A) the *"Coastal Boom and Cash Crops* scenario and (B) the *Decentralization: Integrated Rural Development* scenario. The report of working group Scenarios presents the story lines of the scenarios and detailed information on how the working group came up with the quantification of the driving forces in detail. The growth of the total population is the same in both scenarios (Table 6) but it is different in the scenario regions in scenario A and B (Table 7). In the field of water management scenarios, assumptions of the percentage of persons connected to public water supply were made for the reference and intervention scenarios (Table 8). The intervention scenario assumes an even larger expansion of the public water supply as already assumed in the reference scenarios. The explicit increase of the connections to public water supply expresses the structural change in the future.

Table 6: Population growth in Ceará and Piauí from 1996 to 2025 for the reference scenarios

year	total population (million)	year	total population (million)
1996	9.46	2011	10.91
1997	9.57	2012	10.99
1998	9.68	2013	11.07
1999	9.79	2014	11.14
2000	9.90	2015	11.22
2001	10.00	2016	11.29
2002	10.10	2017	11.37
2003	10.20	2018	11.44
2004	10.29	2019	11.51
2005	10.39	2020	11.58
2006	10.48	2021	11.65
2007	10.57	2022	11.72
2008	10.66	2023	11.79
2009	10.75	2024	11.86
2010	10.83	2025	11.93

Table 7: Fraction of total population in each scenario region [%]

Scenario region	1991	1996	RSA 2025*	RSB 2025*
Teresina	6.7	6.9	8.1	7.3
Metropolitan area of Fortaleza and Pecem	26.1	27.6	35.4	30.6
Coastal region	12.7	12.8	17.4	13.3
South of Piauí	3.1	2.9	2.4	2.9
Regions with high potential water resources	33.9	32.9	26.9	31.9
Regions with low potential water resources	17.6	16.9	9.8	14.0

Table 8: Population connected to public water supply

	Fraction of population connected to public water supply (in % of the urban population)				
scenario region	1997	2025 RSA*	2025 RSB*	2025 ISA*	2025 ISB*
Teresina	93.6 (100)	95 (98)	95 (98)	97	97
Metropolitan area of Fortaleza and Pecem	68.3 (70)	80 (82)	80 (82)	98	98
Coastal region	30.5 (57)	60 (80)	45 (64)	79	75
South of Piauí	41.6 (97)	50 (100)	50 (82)	58	66
Regions with high potential water resources (PI)	41.5 (87)	55 (92)	55 (79)	66	75
Regions with high potential water resources (CE)	37.1 (68)	50 (77)	50 (67)	70	79
Regions with low potential water resources (PI)	22.1 (76)	30 (81)	30 (71)	46	51
Regions with low potential water resources (CE)	33.7 (69)	40 (73)	40 (67)	62	66

* RS: reference scenario / IS: intervention scenario

For the future NoWUM calculates the water use per capita per person connected to public water supply as a function of prices and income (see below). The scenarios include rates of change in gross domestic product per capita per scenario region (Table 9) as well as an annual increase of the water price. In order to come up with a reasonable price increase, a ten year time series (1989-1998) of water tariffs from CAGECE was analyzed. In this period occurred several monetary reforms. The base tariff for the first 15 m^3 increased at 11% per year from 1989 to 1998. Nowadays, CAGECE's water price covers operation and maintenance costs (O&M costs), and it is expected that the O&M costs will rise in future. For the scenarios a constant water price increase of 6% per year is assumed for all scenarios in all scenario regions.

Table 9: Scenarios of the growth rate of per capita gross domestic product (GDP) in each scenario region. Constant annual rates are assumed between 1996 and 2025.

	annual growth of GDP per capita between 1996 and 2025 [%]	
Scenario region	RS A	RS B
Teresina	2.5	2.2
Metropolitan area of Fortaleza and Pecem	2.7	2.2
Coastal region	2.7	2.2
South of Piauí	2.7	2.2
Regions with high potential water resources	2.7	2.4
Regions with low potential water resources	2.5	2.2

4.3 Computation of domestic water use

In NoWUM, the specific water use of people connected to the public water supply and those not connected are differentiated. We have no information on the water use of people not connected to the public water supply. As a first estimate, we assume a value of 50 l/d/p, a value defined by Gleick (1996) as the basic human water requirement. This might underestimate water use particularly when people have their own private wells. Thus, the domestic withdrawal water use is computed as follows:

$$wd_domestic[i][m] = popsupp[i][m] * con_supp[i][m] + (poptotal[i][m] - popsupp[i][m]) * con_nsupp[i][m] \qquad \text{(F 4.2)}$$

i: *municipality*
m: *month*
wd_domestic: *total withdrawal use of municipal population [m³/month]*
popsupp: *supplied population [-]*
p_supp: *withdrawal use per supplied person [m³/month/p]*
poptotal: *total population of a municipality [-]*
p_nsupp: *withdrawal use per non-supplied person [m³/month/p]*

Consumptive water use is computed by multiplying the withdrawal water use with a typical domestic water use efficiency of 0.2, which is the average value for the USA (USGS, 1998)

Economists use the concept of elasticities to consider the responsiveness of consumers' purchases to varying price. A measure of this responsiveness, the elasticity of demand with respect to a demand determining variable, is defined as the percentage by which the demand changes in response to a one percent change in the variable. The most frequently used elasticity concept is the price elasticity, which is defined as the percentage change in water use if price is changed by one percent. The income elasticity of demand is a related concept: it measures the percentage change in quantity demanded associated with a one percent change in consumer income. Almost all estimates of long run price elasticity of residential water demand in the U.S. seem to fall between -0.3 and -0.7, meaning that other factors held constant, a ten percent increase in price would lead to a 3-7% decrease in the amount of water purchased (Young, 1998). Income

elasticity is found to be small but positive; an increase in income brings about a less than proportional increase in quantity consumed.

The future water use per capita per person connected to water supply is calculated as a function of the water price and the average income (GDP per capita). It is calculated for each municipalities as follows:

$$V_{j+1} = \left[\left(e_{p,j+1} * r_{p,j+1} + e_{i,j+1} * r_{i,j+1}\right) + 1\right] * V_j \qquad \text{(F 4.3)}$$

j: *year*
V_{j+1}: *volume consumed per person connected to public water supply in year j+1*
e_p: *price elasticity in year j+1*
r_p: *price rate in year j+1*
e_i: *income elasticity in year j+1*
r_i: *change rate of gross domestic product per capita in year j+1*

NoWUM uses a linear decreasing price elasticity from 1996 to 2025; it starts with -0.55 (value for Northeast of Brazil, (BNB/PBLM, 1997)) in 1996 and ends with -0.3 (average value for Europe and U.S.). According to Gomez (1987), NoWUM uses a constant income elasticity of 0.7. The Brazilian value of 0.78 was reduced, because the scenarios consider explicitly new connections.

5 Industrial use

5.1 Methods and calculation

Two methods were developed to calculate the range of the industrial withdrawal water use. With method 1, industrial water use is computed based on municipality-specific information of the waterworks (IWUWW) and from COGERH (IWURW) and a statewide estimate of the amount of water that is self-supplied. With method 2, the industrial output of 19 industry branches in each municipality is taken into account as well as industry-specific water use intensities (water use per industrial output) typical for Germany. For most municipalities, method 1 leads to a smaller value than method 2. The real values might be somewhere in between. The consumptive water use is calculated from withdrawal water use using an industrial water use efficiency of 0.2 (USGS, 1998).

5.1.1 Method 1

$$wd_industry_1 = \begin{cases} IWUWW + IWUSS + IWURW & if\ data\ available \\ wd_industry_2 * c & if\ no\ data\ available \end{cases} \qquad \text{(F 5.1)}$$

i: *municipality*
m: *month*
IWUWW: *industrial water supplied by waterworks [m³/month]*
IWUSS: *self-supplied industrial water use [m³/month]*
IWURW: *industrial raw water supplied by COGERH [m³/month]*
wd_industry_1: total industrial withdrawal water use [m³/month] per municipality calculated with method 1
wd_industry_2: total industrial withdrawal water use [m³/month] per municipality calculated with method 2
c: *correction factor [-] (diminishing wd_industry_2)*

5.1.2 Method 2

$$wd_industry_2[i][m] = \sum_{b=1}^{19} IGDP_b[i][m] * WUI_b \qquad \text{(F 5.2)}$$

i: *municipality*
m: *month*
b: *industrial branch (19 are distinguished)*
wd_industry_2: total industrial withdrawal water use [m³/month] per municipality calculated with method 2
IGDP: *industrial gross domestic product per industrial branch [US$ 1995]*
WUI: *water use intensity per industrial branch [m³/1000 US$ 1995]*
(adapted from German industrial data of 1995)

In the scenarios of the future the industrial water use is also a function of prices in both options as showed in the following.

$$V_{j+1} = \left[\left(e_{p,j+1} * r_{p,j+1}\right) + 1\right] * V_j \qquad \text{(F 5.3)}$$

j: *year*
V_{j+1}: *industrial water volume in year j+1*
e_p: *price elasticity in year j+1*
r_p: *price rate in year j+1*

Prices stand indirectly for technological change. Due to the lacking of industrial specific data, NoWUM uses also a price rate of 6% per year for the industrial water use scenarios as derived from CAGECE's data for the domestic water use. The price elasticity decreases linear between 1997 and 2025 from -0.74 (value for Northeast of Brazil, BNB/PBLM (1997)) to -0.4 (average value for Europe).

5.2 Input data

5.2.1 Input of industrial water use data

Industry gets water from different sources. Mostly the small industry is supplied by the public waterworks (IWUWW). Often industry additionally supplies itself from own wells or reservoirs (IWUSS). In Ceará water intensive industry like breweries and industrial districts buy raw water (IWURW) directly from COGERH, the state company of water management who manages the big reservoirs.

The IWUWW for municipalities of Piauí were averaged over data of AGESPISA for April 1998 and January 1999. For Ceará only data of CAGECE supplied municipalities were available; the monthly averages of 1998 were used.

Marwell Filho (1995) published the self-supplied industrial water use for the watersheds of Piauí. The author remarked that these data are probably too low, because making this investigation, firms were interviewed by telephone and not all firms answered. To get an IWUSS per municipality, the water was equally divided to all municipalities within a basin having firms in 1991. Piauí's capital Teresina has the biggest industrial concentration of Piauí. It's special position was taken into account assigning half of the self-supplied water in the "Poti" basin to

Teresina and the rest equally portioned to all other municipalities in the watershed. The IWUSS of Piauí is 1.57 times higher than the IWUWW of Piauí (state averages). This unique scale factor was used to compute the IWUSS for the municipalities of Ceará already having an IWUWW.

The IWURWs for the four municipalities of Ceará were taken from COGERH's bill 1998.

5.2.2 Correction factor

In some municipalities the situation is contradictory: according to the information from the waterworks, they do not have an industrial water use (IWU) but they do have an IGDP. Their IWU was computed by method 2 described above. Therefore, a correction factor c was necessary. It reduces the IWU to a size corresponding with the measured data of IWU. The $c_{Ceará}$ is 0.554 and $c_{Piauí}$ is 0.215. The c for one state each was calculated as

$$c = \frac{\sum_{i=1}^{n} IWUWW_i + IWUSS_i + IWURW_i}{\sum_{i=1}^{n} wd_industry_2_i} \qquad \text{(F 5.4)}$$

5.2.3 Input of industrial water use intensity

The application of method 2 needs an industrial water use intensity per industrial branch. Since these data are not yet available for Brazil, we used data from German industry. To link the Brazilian with German data, a common classification of industry branches was necessary. Even Ceará and Piauí have some differences in their classifications. Therefore, the German system was taken as basis and all data were transformed into this classification considering 19 industrial branches.

Table 10: Average water use intensity (WUI) per industrial branch for Germany 1995

Industrial branch	Average WUI [m³/ 1000 US$ ('95)]
Mining	110.58
Extraction and transformation of minerals (stones and clay)	29.10
Food products	9.35
Beverages	10.10
Tobacco	0.16
Textiles and clothing industry	15.32
Leather products	1.97
Wood products, except furniture	0.89
Paper and products, printing and publishing	27.52
Petroleum refineries and coal products	8.35
Chemical products	57.97
Rubber products	4.15
Plastic products	3.47
Glass and pottery products	3.50
Production and transformation of metals, metal products	13.25

Machinery, except electrical	0.83
Machinery electrical	1.10
Transport equipment	1.99
Manufacture of furniture, jewelry, musical instruments, others	1.86

A second unification was necessary to compare economic data of several times and places. For the calculations within the industrial sector, all data were transformed into US$ of 1995.
Table 10 lists the industrial water use intensity (WUI) per industrial branch for Germany 1995. The branch specific WUIs were computed with annual data of the industrial gross domestic product (IGDP) per branch and the water used in firms per branch in Germany (Statistisches Bundesamt, 1998, 1999).

5.2.4 Input of industrial gross domestic product (IGDP)

The availability of data of IGDP in Ceará and Piauí is very different. For all municipalities of Ceará branch specific data from 1993 to 1996 exist in the internal database of IPLANCE. Whereas for Piauí, SEPLAN (1997) published the total gross domestic product (GDP) of Piauí 1996 and SUDENE (1996a, 1996b) published preliminary data of sectoral GDPs for the three main sectors: agriculture, industry and services for 1995. Neither data of the total GDP per municipality nor the IGDP per municipality do not exist for Piauí.

Branch-specific IGDPs for the all municipalities of Piauí were assigned in three steps:

1) Assuming that Piauí and Ceará have the same firm-specific IGDP per industrial branch, for each municipality of Piauí an IGDP was assigned via the number of firms per branch and an IGDP/firm per branch:

$$IGDP_i = \sum_{b=1}^{19} firms_{b,i} * \frac{IGDP}{firm}_b \qquad \text{(F 5.5)}$$

i: *municipality of Piauí*
b: *industrial branch*
IGDP: *industrial gross domestic product [US$1995]*
firms: *number of firms*
IGDP/firm: *industrial gross domestic product per firm per branch [US$1995/firm], mean value of Ceará*

The IGDPs/firm per branch are average values for the state of Ceará 1995. They were calculated from the number of firms per branch and municipality (IPLANCE, 1997) and the IGDP per branch and municipality (internal data of IPLANCE). This procedure was used, because the number of firms per branch and municipality were the only industrial data available for both states (IPLANCE, 1997; FIEPI, 1991).

2) For those municipalities of Piauí which only have an industrial water use IWUWW but no firms, the total IGDP resulted from the quotient of their IWUWW and an average industrial water use intensity of Piauí ($IWUI_{Piauí}$). The $IWUI_{Piauí}$ was calculated from all municipalities of Piauí having both, IGDP and IWUWW; it's value is 5.442 m³/1000 US$1995. For comparison: the average IWUI of Ceará is 4.475 m³/1000US$ and of Germany 15.87 m³/1000US$.

3) Municipalities of Piauí which neither had firms in 1991 nor industrial water from AGESPISA 1998/99 got the IGDP zero.

Finally, for the computation of industrial water use the following IGDP data per branch per municipality were used: for Ceará the given data by IPLANCE, for Piauí the self-produced IGDP data as described above.

5.2.5 Scenarios

The important driving force of the industrial water use scenarios is the industrial gross domestic product (IGDP) while all other factors like industrial mix, water use intensity and the fraction of IGDP on total GDP are held constant for the scenarios. The annual IGDP per municipality is calculated from the total GDP per year and municipality and it's percentage of GDP in 1997. The annual changing population multiplied by the annual increasing GDP per capita (see Table 9) gives the total GDP per municipality. Driving forces set for one scenario region are used for all municipalities within this region. With NoWUM, structural change of industry could be shown if the industrial mix will be varied. To do this in a sophisticated way, macroeconomic knowledge has to be consulted.

6 Tourism water use

6.1 Method and calculation

The tourism withdrawal water use per municipality is calculated as

$$wd_tourism[i][m] = tourists[i][m] * stay[i][m] * tourist_use[i][m] \qquad \text{(F 6.1)}$$

i:	*municipality*
m:	*month*
wd_tourism:	*total tourism withdrawal water use [m³/month] per municipality*
tourists:	*number of tourists [p/month] per municipality*
stay:	*medium stay of tourists [d] per municipality*
tourist_use:	*withdrawal use per tourist [m³/month/p]*

A water use efficiency of 0.2 (USGS, 1998) is used to calculate the tourism consumptive water use out of the tourism withdrawal water use.

6.2 Input data

6.2.1 Present state

The present number of tourists per "touristic" municipality in Piauí was personally given by the co-director of the tourism agency of Piauí PIEMTUR. Touristic municipalities here means touristic municipalities and municipalities with tourism potential classified by EMBRATUR (1997). For the municipalities of Ceará the number of tourists was derived from several regional studies on tourism in Ceará (Table 11).

As medium stay of tourists per municipality the given values of 9 days for the Ibiapaba region (SETUR/CE 1998 c), 8 days for the coastal region (SETUR/CE 1997 a) and 5 days for the Cariri region (SETUR/CE 1998 d) and the rest of Ceará (SETUR/CE 1997 c) are used in the simulations. For Piauí the medium values of Ceará are taken over: 8 days for the coastal municipalities and 5 days for the municipalities of the interior.

The water requirement in hotels varies between 300 and 500 l/d/p (Stephenson, 1998). In NoWUM is used a high touristic water requirement of 500 l/d/p in the coastal municipalities reflecting the better hotel infrastructure (swimming pools, irrigation of gardens) and relating activities of tourists (several baths per day). In all other municipalities a water requirement of 300 l/d/tourist is used.

6.2.2 Scenarios

For the two reference scenarios we made different assumptions for the number of tourists and the touristic water use, while the medium stay of tourists is used as for the present state. For the "coastal boom scenario" (A) the number of tourists increases with factor 5 towards the present state in the municipalities of the coastal region and the metropolitan area of Fortaleza. In the municipalities of the interior it increases only with factor 3. In the "decentralization scenario" (B) the number of tourists is assumed to increase with factor 3 towards the present state in all municipalities. While for the scenario B the touristic water use is used as in the present state, it differs in scenario A. In the coastal boom scenario A the touristic water use for the municipalities of the regions Teresina, metropolitan area of Fortaleza and the coastal region is set to 500 l/p/d; in all other municipalities to 300 l/p/d. For pilgrims NoWUM uses only 100 l/p/d.

Table 11: Assessment of number of tourists in municipalities of Ceará 1997/98

Region	Tourists	Source	Distribution in the municipalities
I Ceará total	5.660.483	*7, 8*	It is obvious that in *7* not all pilgrims were counted, because in the estimation of 720.157 tourists/a only 168.517 pilgrims are included and 1.831.483 pilgrims lacking. Consequently, the same number has to be added to the total number of tourists. It rises from 3.829.000 to 5.660.483 tourists per year.
II Fortaleza and from there to other municipalities of Ceará 1997	970.000	*2, 4, 5*	Persons arriving at Fortaleza with any kind of transport (plane, bus, car, etc.) are assumed to stay 5 d in Fortaleza. Following they visit other municipalities (the percentile quota to single municipalities in: *1*). Source *2* includes the monthly division.
III Ibiapaba 1998	117.196	*6*	The number of tourists is equally divided into all of the seven municipalities of the Ibiapaba region. The monthly division of tourists is taken over from the situation in Fortaleza (*2*).
IV Cariri without pilgrims 1998	551.640	*7*	23,4% of the 720.157 tourists in the Cariri region have a religious motivation for their visit. The tourists, except pilgrims, are monthly divided as in Fortaleza (*2*). Single municipalities get the number of tourists according to their number of beds (from: *3*).
V Cariri-pilgrims 1998	2.000.000	*12, 13*	Estimation of pilgrims per year in newspapers. Pilgrims appear only in the month of February, July, September and November. They are distributed to the three municipalities Juazeiro do Norte, Crato and Barbalha according to their number of beds (from: *3*).
VI Canindé average of 97/98	700.000	*11*	This amount of pilgrims appears during the 10 days procession in October.
VII Sum (II up to VI)	4.338.836		
VIII Rest (VII - I)	1.321.726		The rest of tourists is distributed to the touristic municipalities classified by EMBRATUR except Canindé, the seven municipalities of the Ibiapaba and the six municipalities of the Cariri region. For this, the 21 coastal municipalities were weighted with factor 3 and the interior municipalities with factor 1. In case a municipality still got tourists under point II, these tourists are added.

PI: 767.200 tourists per year without double appearance in several municipalities like at point II.

1 SETUR/CE,1997 a
2 SETUR/CE,1997 b
3 SETUR/CE,1997 c
4 SETUR/CE,1998 a
5 SETUR/CE,1998 b
6 SETUR/CE,1998 c
7 SETUR/CE,1998 d
8 SETUR/CE,1998 e
9 SEBRAE/CE, SETUR,1998
10 SEBRAE/CE,1998
11 O Povo,1998
12 Diário do Nordeste,1998 a
13 Diário do Nordeste,1998 b
14 EMBRATUR,1997
15 Stephenson, D.,1998

7 Model input

Most of the parameters are read from one input file each. The data are read into matrixes of size *number of municipalities* and *number of months* or *number of days*. NoWUM needs several input data files:

1. daily values of precipitation per municipality
2. daily values of evapotranspiration per municipality
3. planting data, growing periods and crop coefficients of irrigated crops
4. irrigated areas per crop of one year per municipality
5. numbers of livestock species per municipality
6. total population of one year per month per municipality
7. supplied population of one year per month per municipality
8. monthly water volume supplied by public water supply system per municipality
9. water use efficiency of public water supply system per municipality
10. best guess of industrial water use per municipality
11. industrial gross domestic product per industrial branch per municipality
12. water use intensity per industrial branch (constant for all municipalities)
13. number of tourists per municipality
14. medium stay of tourists per municipality
15. tourist water use per municipality

Some driving forces of the scenarios are given only per scenario region such as population growth, price rates and growth of gross domestic product per capita. They are read from customized input files.

Appendix 1 gives examples for the input data files. Data of input files 1 to 4 are used to calculate the irrigation water use, data of file 5 for livestock water use, data of files 6 to 9 for domestic water use, data of files 10 to 12 for industrial water use and data of files 13 to 15 for tourism water use calculation. For executing NoWUM, all data file names (input and output) are either read from the desktop or from file *input*.

8 Model output

NoWUM computes monthly sectoral and total withdrawal and consumption water use [m^3/month] for all municipalities of Ceará and Piauí. Examples of some of the output files are given in Appendix 2:

1. Total withdrawal water use of all sectors per month per municipality
2. Total consumptive water use of all sectors per month per municipality
3. Withdrawal water use of irrigation per month per municipality
4. Consumptive water use of irrigation per month per municipality
5. Withdrawal water use of livestock per month per municipality

Consumptive water use of livestock per month per municipality

6. Withdrawal water use of domestic sector per month per municipality
7. Consumptive water use of domestic sector per month per municipality

8. Withdrawal water use of industrial sector option 1 per month per municipality
9. Consumptive water use of industrial sector option 1 per month per municipality
10. Withdrawal water use of industrial sector option 2 per month per municipality
11. Consumptive water use of industrial sector option 2 per month per municipality
12. Withdrawal water use of tourism sector per month per municipality
13. Consumptive water use of tourism sector per month per municipality

Each sectoral procedure has a query for missing input data. If one parameter is missing, the output file gets in the same position the missing value -9999, too. Besides, a list of missing values is written to a protocol file.

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Appendix B

Municipalities of Ceará 1996



Municipalities of Piauí 1996



1) NoWUM output: Annual withdrawal water uses [m3] of present state 1996/98

Muni_nr	Municipality	irrigation	livestock	domestic	industry_1	industry_2	tourism	total_1	total_2
1	Abaiara	0	143,857	170,802	25,538	46,121	0	340,197	360,780
2	Acarape	2,168,710	57,822	283,082	31,383	244,298	0	2,540,997	2,753,912
3	Acarau	37,938	376,608	1,009,700	458	44,381	157,028	1,581,732	1,625,655
4	Acopiara	0	1,276,789	1,298,276	1,282	16,282	2,924	2,579,271	2,594,271
5	Aiuaba	219,605	600,919	247,734	160	290	19,629	1,088,047	1,088,177
6	Alcantaras	0	84,735	164,988	0	0	0	249,723	249,723
7	Altaneira	0	56,448	97,830	540	974	0	154,818	155,252
8	Alto Santo	469,498	624,640	318,723	458	18,425	0	1,413,319	1,431,286
9	Amontada	89,385	393,420	768,436	70	127	157,028	1,408,339	1,408,396
10	Antonina do Norte	0	138,665	207,488	2,564	39	0	348,717	346,192
11	Apuiares	3,512,936	248,042	289,462	611	2,218	0	4,051,051	4,052,658
12	Aquiraz	35,073	482,547	1,036,430	1,091,418	691,761	1,018,816	3,664,284	3,264,627
13	Aracati	1,345,779	265,104	1,741,239	14,593	693,068	640,568	4,007,283	4,685,758
14	Aracoiaba	1,720,107	330,329	533,632	501	904	1,464	2,586,033	2,586,436
15	Ararenda	51,994	226,614	184,032	0	0	0	462,640	462,640
16	Araripe	0	328,824	390,844	3,083	226	19,629	742,380	739,523
17	Aratuba	40,168	106,948	236,714	458	2,898	19,629	403,917	406,357
18	Arneiroz	0	509,458	161,814	1,062	1,918	0	672,334	673,190
19	Assare	934,274	513,222	343,008	519	937	0	1,791,023	1,791,441
20	Aurora	879,076	658,134	592,192	1,007	26,174	19,629	2,150,038	2,175,205
21	Baixio	0	240,012	151,961	120	217	0	392,093	392,190
22	Banabuiu	1,278,062	680,148	504,735	76,190	137,597	19,629	2,558,764	2,620,171
23	Barbalha	193,063	249,319	1,374,160	13,524	559,323	239,476	2,069,542	2,615,341
24	Barreira	4,509	185,621	305,172	39	70	1,464	496,805	496,836
25	Barro	0	434,765	500,380	15,690	28,336	0	950,835	963,481
26	Barroquinha	61,737	129,961	234,126	2,957	5,340	157,028	585,809	588,192
27	Baturite	153,408	230,751	919,930	6,869	77,935	24,015	1,334,973	1,406,039
28	Beberibe	7,498,886	441,546	753,768	5,953	76,180	574,272	9,274,425	9,344,652
29	Bela Cruz	0	535,431	591,259	1,343	1,754	0	1,128,033	1,128,444
30	Boa Viagem	340,308	1,559,740	1,812,524	8,660	15,639	1,464	3,722,696	3,729,675
31	Brejo Santo	1,485,066	686,297	627,084	30,529	55,134	1,464	2,830,440	2,855,045
32	Camocim	2,872,824	335,728	1,798,885	1,464,935	2,645,625	164,824	6,637,196	7,817,886
33	Campos Sales	0	377,390	774,684	2,351	37,365	0	1,154,425	1,189,439
34	Caninde	206,799	1,325,671	2,383,098	65,041	117,461	1,060,238	5,040,847	5,093,267
35	Capistrano	265,909	154,330	359,418	458	145	0	780,115	779,802
36	Caridade	50,872	261,590	307,442	885	73,259	0	620,789	693,163
37	Carire	405,693	542,409	429,518	1,496	4,607	0	1,379,116	1,382,227
38	Caririacu	56,816	378,262	421,254	180	326	19,629	876,141	876,287
39	Carius	53,891	375,926	314,622	308	556	0	744,747	744,995
40	Carnaubal	555,686	127,172	398,456	946	33	45,203	1,127,463	1,126,550
41	Cascavel	4,270,690	379,091	1,200,779	2,259	224,089	227,220	6,080,039	6,301,869
42	Catarina	0	400,917	272,845	811	1,465	0	674,573	675,227
43	Catunda	569,994	320,933	213,588	0	0	0	1,104,515	1,104,515
44	Caucaia	365,712	638,297	4,676,272	117,931	2,298,910	1,244,992	7,043,204	9,224,183
45	Cedro	0	574,550	419,436	17,505	31,614	19,629	1,031,120	1,045,229
46	Chaval	0	99,205	271,172	611	721,470	19,629	390,617	1,111,476
47	Choro	103,728	417,960	206,010	18	32	0	727,716	727,730
48	Chorozinho	399,902	178,052	312,778	135	244	0	890,867	890,976
49	Coreau	0	323,709	555,567	1,191	245	0	880,467	879,521
50	Crateus	2,631,202	1,507,009	2,202,374	3,022	49,022	22,552	6,366,159	6,412,159
51	Crato	3,466,352	415,845	1,719,378	330,311	596,532	342,400	6,274,286	6,540,507
52	Croata	334,405	133,373	382,683	1	2	19,629	870,091	870,092
53	Cruz	382,224	192,449	361,158	1,429	2,581	157,028	1,094,288	1,095,440
54	Deputado Irapuan Pinheiro	307,214	314,121	142,776	0	0	0	764,111	764,111
55	Erere	128,940	265,445	154,444	458	1,663	0	549,287	550,492
56	Eusebio	76,694	64,310	489,708	126,598	228,631	1,464	758,774	860,807
57	Farias Brito	0	345,935	474,268	44	79	0	820,247	820,282
58	Forquilha	13,099	278,019	494,691	7,237	13,069	0	793,046	798,878
59	Fortaleza	17,033	133,075	94,489,352	13,895,401	22,657,712	4,037,028	112,571,889	121,334,200
60	Fortim	310,127	49,565	247,766	4,152	8,597	184,320	795,930	800,375
61	Frecheirinha	0	96,042	264,854	416	751	0	361,312	361,647
62	General Sampaio	1,336,621	124,463	128,590	0	0	0	1,589,674	1,589,674
63	Graca	76,186	155,092	258,642	0	0	0	489,920	489,920
64	Granja	173,874	801,551	1,133,252	4,549	8,216	0	2,113,226	2,116,893
65	Granjeiro	4,106	84,680	104,507	0	0	0	193,293	193,293
66	Groairas	659,499	129,347	277,676	218	394	0	1,066,740	1,066,916
67	Guaiuba	54,269	98,728	437,336	458	24,121	19,629	610,420	634,083
68	Guaraciaba do Norte	2,047,331	233,522	759,598	1,130	1,520	45,203	3,086,784	3,087,174
69	Guaramiranga	140,551	27,987	118,288	107	194	19,629	306,562	306,649
70	Hidrolandia	54,296	472,880	442,094	519	32,585	0	969,789	1,001,855
71	Horizonte	0	218,851	471,254	730,853	326,028	7,312	1,428,270	1,023,445
72	Ibaretama	40,894	418,396	195,426	222	401	0	654,938	655,117
73	Ibiapina	1,303,410	171,659	506,742	3,721	6,721	45,203	2,030,735	2,033,735
74	Ibicuitinga	44,429	269,486	159,768	0	0	0	473,683	473,683
75	Icapui	5,688,722	177,711	709,036	2,281	4,120	184,320	6,762,070	6,763,909
76	Ico	15,105,705	1,149,947	2,028,464	8,249	14,897	19,629	18,311,994	18,318,642
77	Iguatu	2,219,132	1,015,845	4,278,522	251,285	453,812	26,940	7,791,724	7,994,251
78	Independencia	219,300	1,641,552	623,823	2,351	2,295	0	2,487,026	2,486,970
79	Ipaporanga	0	312,433	198,108	0	0	0	510,541	510,541
80	Ipaumirim	0	289,881	285,578	2,778	27,034	0	578,237	602,493
81	Ipu	377,869	368,528	1,521,876	3,376	6,098	19,629	2,291,278	2,294,000
82	Ipueiras	57,676	553,573	836,444	608	1,097	0	1,448,301	1,448,790
83	Iracema	55,218	438,117	462,596	11,112	5,119	0	967,043	961,050
84	Iraucuba	28,081	724,065	452,876	185	335	0	1,205,207	1,205,357

Muni_nr	Municipality	irrigation	livestock	domestic	industry_1	industry_2	tourism	total_1	total_2
85	Itaicaba	10,179	120,768	172,428	458	380	0	303,833	303,755
86	Itaitinga	524,258	130,118	601,714	1,465	3,790	2,342	1,259,897	1,262,222
87	Itapage	195,117	317,595	1,048,730	247,768	447,460	22,552	1,831,762	2,031,454
88	Itapipoca	367,504	752,483	3,285,300	245,652	443,640	164,824	4,815,763	5,013,751
89	Itapiuna	1,145,904	319,577	314,793	474	856	0	1,780,748	1,781,130
90	Itarema	0	346,459	538,046	2,073	3,744	168,728	1,055,306	1,056,977
91	Itatira	307,532	367,769	259,740	104	188	19,629	954,774	954,858
92	Jaguaretama	482,174	1,616,494	444,715	211	381	0	2,543,594	2,543,764
93	Jaguaribara	3,733,986	732,129	215,770	1,801	362	0	4,683,686	4,682,247
94	Jaguaribe	28,434,242	1,672,416	1,625,646	30,942	55,881	2,924	31,766,170	31,791,109
95	Jaguaruana	15,914,661	524,587	670,024	5,404	220,381	0	17,114,676	17,329,653
96	Jardim	21,043	448,887	450,108	1,410	2,547	3,312	924,760	925,897
97	Jati	1,339,471	164,213	186,296	1,404	1,405	0	1,691,384	1,691,385
98	Jijoca de Jericoacoara	0	65,208	207,251	0	0	387,092	659,551	659,551
99	Juazeiro do Norte	4,218,896	214,677	8,237,949	108,712	536,828	3,222,494	16,002,728	16,430,844
100	Jucas	0	461,534	796,568	191,806	346,395	0	1,449,908	1,604,497
101	Lavras da Mangabeira	295,280	801,289	897,534	3,083	6,183	0	1,997,186	2,000,286
102	Limoeiro do Norte	9,303,074	473,580	1,676,956	753,547	1,360,881	26,940	12,234,097	12,841,431
103	Madalena	496,863	563,018	361,464	183	330	0	1,421,528	1,421,675
104	Maracanau	0	70,749	3,546,790	3,117,147	4,206,348	0	6,734,686	7,823,887
105	Maranguape	0	583,608	2,462,652	298,385	744,657	36,084	3,380,729	3,827,001
106	Marco	0	303,872	522,948	5,587	82	0	832,407	826,902
107	Martinopole	0	83,523	170,084	1,313	4,768	1,464	256,384	259,839
108	Massape	207,220	303,232	761,449	5,587	4,868	0	1,277,488	1,276,769
109	Mauriti	764,386	891,087	872,531	153	13,566	0	2,528,157	2,541,570
110	Meruoca	818,414	50,117	212,157	4,829	8,722	19,629	1,105,146	1,109,039
111	Milagres	0	410,937	625,588	1,374	17,946	0	1,037,899	1,054,471
112	Milha	137,709	500,138	338,707	10	18	0	976,564	976,572
113	Miraima	186,986	467,643	190,422	0	0	0	845,051	845,051
114	Missao Velha	65,860	470,791	741,263	1,771	11,684	17,544	1,297,229	1,307,142
115	Mombaca	117,450	1,327,391	836,328	988	1,785	2,924	2,285,081	2,285,878
116	Monsenhor Tabosa	0	472,712	381,592	37	66	0	854,341	854,370
117	Morada Nova	7,706,456	1,610,977	2,549,716	98,018	177,018	19,629	11,984,796	12,063,796
118	Moraujo	0	179,501	192,277	1,496	5,434	0	373,274	377,212
119	Morrinhos	0	203,135	396,268	672	1,549	0	600,075	600,952
120	Mucambo	0	115,228	351,950	0	0	0	467,178	467,178
121	Mulungu	25,842	37,358	147,546	2	4	19,629	230,377	230,379
122	Nova Olinda	0	146,322	352,423	1,343	179,096	19,629	519,717	697,470
123	Nova Russas	109,179	429,005	1,092,161	8,036	14,513	2,924	1,641,305	1,647,782
124	Novo Oriente	64,393	669,496	492,974	20	36	0	1,226,883	1,226,899
125	Ocara	38,935	297,093	365,904	0	0	0	701,932	701,932
126	Oros	2,869,096	425,969	677,490	1,496	14,379	21,092	3,995,143	4,008,026
127	Pacajus	1,549,696	307,680	925,622	1,203,709	369,007	22,552	4,009,259	3,174,557
128	Pacatuba	239,711	113,579	1,063,102	560,531	1,009,726	31,406	2,008,329	2,457,524
129	Pacoti	285,526	95,218	223,257	2,765	4,993	19,629	626,395	628,623
130	Pacuja	137,798	81,625	159,230	1,723	3,111	0	380,376	381,764
131	Palhano	49,624	127,800	187,284	1,038	90,210	0	365,746	454,918
132	Palmacia	0	86,071	222,296	78	141	19,629	328,074	328,137
133	Paracuru	10,208,556	169,564	504,830	488	66,073	254,512	11,137,950	11,203,535
134	Paraipaba	48,290,300	163,486	496,992	488	176	231,116	49,182,382	49,182,070
135	Parambu	170,974	1,215,762	702,772	30	54	0	2,089,538	2,089,562
136	Paramoti	454,078	251,124	272,985	916	59,103	0	979,103	1,037,290
137	Pedra Branca	777,030	859,792	1,106,182	8,817	15,923	0	2,751,821	2,758,927
138	Penaforte	0	109,698	170,358	824	2,175	0	280,880	282,231
139	Pentecoste	8,946,162	508,772	856,890	5,861	8,574	19,629	10,337,314	10,340,027
140	Pereiro	83,867	216,599	358,148	1,068	1,561	19,629	679,311	679,804
141	Pindoretama	0	133,033	244,386	232	419	98,142	475,793	475,980
142	Piquet Carneiro	31,808	346,303	229,770	20	36	0	607,901	607,917
143	Pires Ferreira	362,986	189,033	196,056	0	0	0	748,075	748,075
144	Poranga	319,709	285,003	204,858	80	145	19,629	829,279	829,344
145	Porteiras	0	309,432	345,024	733	18	0	655,189	654,474
146	Potengi	0	188,474	226,436	259	469	0	415,169	415,379
147	Potiretama	24,786	294,917	140,381	0	0	0	460,084	460,084
148	Quiterianopolis	202,604	606,564	396,803	0	0	0	1,205,971	1,205,971
149	Quixada	1,411,174	1,520,924	2,117,684	61,850	32,408	28,402	5,140,034	5,110,592
150	Quixelo	652,950	636,818	371,772	646	1,167	0	1,662,186	1,662,707
151	Quixeramobim	7,144,398	1,879,442	2,558,184	38,221	69,026	22,552	11,642,797	11,673,602
152	Quixere	2,400,351	221,672	397,777	3,572	222	0	3,023,372	3,020,022
153	Redencao	311,760	74,959	512,034	1,557	89,729	21,092	921,402	1,009,574
154	Reriutaba	0	243,268	484,155	733	565	0	728,156	727,988
155	Russas	17,248,616	620,757	1,286,380	12,822	363,291	0	19,168,575	19,519,044
156	Saboeiro	0	629,930	383,394	0	0	0	1,013,324	1,013,324
157	Salitre	29,774	330,391	223,956	0	0	0	584,121	584,121
158	Santana do Acarau	25,812,002	830,204	520,787	1,343	9,253	0	27,164,336	27,172,246
159	Santana do Cariri	875,859	381,064	767,810	5,709	265,679	2,234	2,032,676	2,292,646
160	Santa Quiteria	0	1,753,764	800,514	28,514	54,669	0	2,582,792	2,608,947
161	Sao Benedito	2,566,932	239,422	1,032,196	9,342	4,677	45,203	3,893,095	3,888,430
162	Sao Goncalo do Amarante	4,497,328	331,917	772,468	977	91,956	293,512	5,896,202	5,987,181
163	Sao Joao do Jaguaribe	88,325	222,398	355,887	1,198	2,163	0	667,808	668,773
164	Sao Luis do Curu	2,265,292	91,773	323,286	40	72	0	2,680,391	2,680,423
165	Senador Pompeu	476,322	606,821	750,208	2,717	6,545	4,386	1,840,454	1,844,282
166	Senador Sa	92,357	122,800	159,965	702	2,551	0	375,824	377,673
167	Sobral	716,754	1,289,586	656,014	5,495	1,204,564	34,251	2,702,100	3,901,169
168	Solonopole	51,274	855,504	552,220	617	1,115	0	1,459,615	1,460,113
169	Tabuleiro do Norte	5,132,521	480,548	897,538	13,585	55,647	0	6,524,192	6,566,254
170	Tamboril	0	1,207,719	710,402	580	9,515	0	1,918,701	1,927,636
171	Tarrafas	59,124	162,639	141,840	0	0	0	363,603	363,603

Muni_nr	Municipality	irrigation	livestock	domestic	industry_1	industry_2	tourism	total_1	total_2
172	Taua	0	2,497,134	1,381,618	794	1,560	0	3,879,546	3,880,312
173	Tejucuoca	20,858	290,251	203,148	0	0	0	514,257	514,257
174	Tiangua	3,175,054	416,510	1,499,794	8,945	11,996	45,203	5,145,506	5,148,557
175	Trairi	398,576	322,450	778,216	916	153	168,728	1,668,886	1,668,123
176	Tururu	109,828	104,251	239,106	0	0	0	453,185	453,185
177	Ubajara	20,417,018	258,113	690,886	4,549	4,118	45,203	21,415,769	21,415,338
178	Umari	143,202	326,122	175,320	7	12	0	644,651	644,656
179	Umirim	1,649,713	280,063	382,670	733	1,778	0	2,313,179	2,314,224
180	Uruburetama	73,693	61,854	481,959	2,229	28,890	19,629	639,364	666,025
181	Uruoca	0	249,575	233,166	1,587	579	1,464	485,792	484,784
182	Varjota	4,034,080	108,801	487,105	672	2,440	0	4,630,658	4,632,426
183	Varzea Alegre	50,414	534,784	682,412	26,573	47,990	19,629	1,313,812	1,335,229
184	Vicosa do Ceara	0	541,630	1,042,096	672	1,719	45,203	1,629,601	1,630,648
185	Agricolandia	0	27,640	243,303	38,356	9,925	0	309,299	280,868
186	Agua Branca	124,673	115,571	552,604	2,358	34,056	0	795,206	826,904
187	Alagoinha do Piaui	6,685	219,063	197,090	0	0	0	422,838	422,838
188	Alegrete do Piaui	0	150,931	101,754	0	0	0	252,685	252,685
189	Alto Longa	327,866	918,083	387,786	972	7,774	0	1,634,707	1,641,509
190	Altos	1,047,442	787,261	892,300	3,390	98,455	0	2,730,393	2,825,458
191	Amarante	345,072	323,557	929,338	1,116	11,769	9,000	1,608,083	1,618,736
192	Angical do Piaui	72,382	150,734	244,174	708	3,995	0	467,998	471,285
193	Anisio de Abreu	38,607	331,135	216,084	180	376	0	586,006	586,202
194	Antonio Almeida	571,619	219,320	120,714	228	476	0	911,881	912,129
195	Aroazes	413,031	292,013	222,220	0	0	0	927,264	927,264
196	Arraial	15,445	149,047	195,970	0	0	0	360,462	360,462
197	Avelino Lopes	39,927	497,140	330,256	1,044	2,181	0	868,367	869,504
198	Baixa Grande do Ribeiro	2,643,184	339,778	216,501	0	0	0	3,199,463	3,199,463
199	Barras	1,090,592	951,466	1,356,715	5,575	28,960	7,200	3,411,548	3,434,933
200	Barreiras do Piaui	88,205	247,815	130,204	2,300	5,357	0	468,524	471,581
201	Barro Duro	634,628	88,637	182,120	1,134	51,274	0	906,519	956,659
202	Batalha	135,860	1,067,270	555,167	312	652	5,400	1,764,009	1,764,349
203	Beneditinos	17,215	472,239	279,744	1,458	9,925	0	770,656	779,123
204	Bertolinia	126,061	705,382	407,646	132	276	0	1,239,221	1,239,365
205	Bocaina	168,602	178,803	144,996	0	0	0	492,401	492,401
206	Bom Jesus	1,030,113	846,178	922,992	1,374	21,553	0	2,800,657	2,820,836
207	Bom Principio do Piaui	13,357	190,006	169,920	0	0	1,800	375,083	375,083
208	Bonfim do Piaui	10,027	185,557	87,318	0	0	0	282,902	282,902
209	Brasileira	73,223	325,817	190,688	432	903	0	590,160	590,631
210	Buriti dos Lopes	1,520,448	824,903	718,926	4,777	11,985	0	3,069,054	3,076,262
211	Buriti dos Montes	9,459	378,554	109,836	0	0	0	497,849	497,849
212	Cabeceiras do Piaui	115,579	410,776	175,293	642	1,341	0	702,290	702,989
213	Caldeirao Grande do Piaui	98,462	234,583	98,424	0	0	0	431,469	431,469
214	Campinas do Piaui	31,383	459,392	120,703	0	0	0	611,478	611,478
215	Campo Maior	1,365,240	1,992,082	1,067,400	4,093	90,950	25,200	4,454,015	4,540,872
216	Canavieira	14,591	284,195	149,272	72	150	0	448,130	448,208
217	Canto do Buriti	693,871	1,050,418	950,861	858	45,134	5,400	2,701,408	2,745,684
218	Capitao de Campos	389,875	189,551	212,779	66	138	0	792,271	792,343
219	Caracol	79,901	371,615	417,095	0	0	1,800	870,411	870,411
220	Castelo do Piaui	24,798	860,730	778,454	1,398	10,840	0	1,665,380	1,674,822
221	Cocal	380,353	801,564	567,442	9,125	6,775	0	1,758,484	1,756,134
222	Coivaras	94,350	161,645	141,696	0	0	0	397,691	397,691
223	Colonia do Gurgueia	17,568	100,138	171,503	0	0	0	289,209	289,209
224	Colonia do Piaui	62,903	327,973	162,388	0	0	0	553,264	553,264
225	Conceicao do Canindе	13,572	509,682	272,056	0	0	0	795,310	795,310
226	Coronel Jose Dias	28,644	237,417	69,768	0	0	14,400	350,229	350,229
227	Corrente	602,110	1,523,254	845,062	2,544	63,254	5,400	2,978,370	3,039,080
228	Cristalandia do Piaui	413,970	524,310	170,606	120	3,060	0	1,109,006	1,111,946
229	Cristino Castro	1,619,632	333,635	571,788	10,528	49,032	5,400	2,540,983	2,579,487
230	Curimata	130,294	839,459	323,506	1,920	13,368	0	1,295,179	1,306,627
231	Demerval Lobao	176,437	145,003	616,854	1,218	11,794	0	939,512	950,088
232	Dirceu Arcoverde	0	360,688	151,734	372	777	0	512,794	513,199
233	Dom Expedito Lopes	145,573	76,796	390,564	678	1,417	0	613,611	614,350
234	Domingos Mourao	0	239,774	175,271	792	1,655	0	415,837	416,700
235	Dom Inocencio	13,875	911,994	162,036	0	0	0	1,087,905	1,087,905
236	Elesbao Veloso	30,011	723,528	704,572	2,154	29,263	0	1,460,265	1,487,374
237	Eliseu Martins	21,627	229,916	172,204	108	226	0	423,855	423,973
238	Esperantina	254,824	711,990	1,371,927	27,632	45,042	9,000	2,375,373	2,392,783
239	Fartura do Piaui	0	280,460	131,886	0	0	0	412,346	412,346
240	Flores do Piaui	55,417	182,955	105,552	540	1,128	0	344,464	345,052
241	Floriano	2,107,775	734,839	1,860,040	52,024	189,519	45,000	4,799,678	4,937,173
242	Francinopolis	344,125	92,767	149,792	0	0	0	586,684	586,684
243	Francisco Ayres	21,974	161,367	150,846	0	0	0	334,187	334,187
244	Francisco Santos	30,671	164,926	158,729	0	0	0	354,326	354,326
245	Fronteiras	0	350,834	259,073	1,452	10,844	0	611,359	620,751
246	Gilbues	330,668	501,450	387,118	2,582	10,651	0	1,221,818	1,229,887
247	Guadalupe	117,962	185,942	798,720	3,830	3,308	3,600	1,110,054	1,109,532
248	Hugo Napoleao	19,059	47,849	152,571	972	4,035	0	220,451	223,514
249	Inhuma	389,674	257,497	431,939	2,322	4,682	0	1,081,432	1,083,792
250	Ipiranga do Piaui	205,088	134,066	302,041	60	125	0	641,255	641,320
251	Isaias Coelho	0	400,901	197,925	0	0	0	598,826	598,826
252	Itainopolis	178,034	571,339	334,763	0	0	0	1,084,136	1,084,136
253	Itaueira	259,143	484,576	330,243	38,596	14,607	0	1,112,558	1,088,569
254	Jacobina do Piaui	24,063	560,521	90,216	0	0	0	674,800	674,800
255	Jaicos	45,712	680,534	668,062	624	15,631	0	1,394,932	1,409,939
256	Jardim do Mulato	42,568	103,848	110,986	324	677	0	257,726	258,079
257	Jerumenha	368,934	264,754	158,498	444	12,751	0	792,630	804,937
258	Joaquim Pires	394,146	564,237	322,195	0	0	0	1,280,578	1,280,578

Muni_nr	Municipality	irrigation	livestock	domestic	industry_1	industry_2	tourism	total_1	total_2
259	Jose de Freitas	1,275,315	782,052	1,351,317	4,309	25,635	14,400	3,427,393	3,448,719
260	Lagoa Alegre	75,523	217,771	137,312	0	0	0	430,606	430,606
261	Lagoa do Barro Piaui	18,537	427,217	96,048	0	0	0	541,802	541,802
262	Landri Sales	559,269	235,702	393,760	0	0	0	1,188,731	1,188,731
263	Luis Correia	39,198	567,806	623,616	9,341	26,467	0	1,239,961	1,257,087
264	Luzilandia	272,560	754,222	893,828	26,984	23,013	0	1,947,594	1,943,623
265	Manoel Emidio	43,433	308,603	260,732	684	1,374	0	613,452	614,142
266	Marcolandia	4,644	48,065	104,886	0	0	0	157,595	157,595
267	Marcos Parente	37,140	182,329	230,605	36	75	0	450,110	450,149
268	Matias Olimpio	115,095	163,827	238,343	0	0	0	517,265	517,265
269	Miguel Alves	5,534,678	567,518	512,252	26,402	25,322	0	6,640,850	6,639,770
270	Miguel Leao	2,351,283	56,393	58,724	38,428	9,014	0	2,504,828	2,475,414
271	Monsenhor Gil	233,014	236,957	273,124	1,212	13,233	1,800	746,107	758,128
272	Monsenhor Hipolito	0	190,769	204,791	366	765	0	395,926	396,325
273	Monte Alegre do Piaui	69,275	369,918	318,419	492	1,028	0	758,104	758,640
274	Nazare do Piaui	55,604	341,266	269,758	0	0	0	666,628	666,628
275	Nossa Senhora dos Remedios	10,490	129,828	146,206	0	0	0	286,524	286,524
276	Novo Oriente do Piaui	106,484	234,008	261,778	0	0	0	602,270	602,270
277	Oeiras	1,892,731	1,069,493	2,058,868	1,686	38,510	28,200	5,050,978	5,087,802
278	Padre Marcos	12,755	459,857	289,394	1,044	3,308	0	763,050	765,314
279	Paes Landim	74,245	292,491	129,404	0	0	0	496,140	496,140
280	Palmeira do Piaui	231,058	248,826	129,613	0	0	0	609,497	609,497
281	Palmeirais	1,083,652	392,390	293,622	38,404	5,369	0	1,808,068	1,775,033
282	Parnagua	376,326	1,286,405	296,010	588	3,308	0	1,959,329	1,962,049
283	Parnaiba	1,525,958	472,851	8,966,711	22,835	320,903	1,056,000	12,044,355	12,342,423
284	Passagem Franca do Piaui	202,117	197,925	137,700	0	0	0	537,742	537,742
285	Patos do Piaui	32,145	327,660	139,536	0	0	0	499,341	499,341
286	Paulistana	147,181	1,367,381	725,024	2,106	19,470	5,400	2,247,092	2,264,456
287	Pedro II	648,110	977,039	1,244,404	4,513	29,434	13,800	2,887,866	2,912,787
288	Picos	5,602,346	959,697	4,358,408	26,592	184,047	36,000	10,983,043	11,140,498
289	Pimenteiras	334,622	467,654	337,124	264	552	0	1,139,664	1,139,952
290	Pio IX	5,565	589,631	341,634	720	9,014	0	937,550	945,844
291	Piracuruca	280,662	1,240,237	1,018,424	5,965	62,782	36,000	2,581,288	2,638,105
292	Piripiri	1,831,169	693,587	2,911,652	7,693	106,236	37,500	5,481,601	5,580,144
293	Porto	484,820	279,402	486,431	0	0	0	1,250,653	1,250,653
294	Prata do Piaui	32,139	87,306	134,214	0	0	0	253,659	253,659
295	Queimada Nova	12,729	508,980	140,094	0	0	0	661,803	661,803
296	Redencao do Gurgueia	345,986	335,115	242,973	0	0	0	924,074	924,074
297	Regeneracao	55,980	212,494	778,596	2,568	49,499	0	1,049,638	1,096,569
298	Ribeiro Goncalves	87,024	271,018	301,478	2,300	27,880	0	661,820	687,400
299	Rio Grande do Piaui	32,460	420,046	410,600	38,356	9,925	0	901,462	873,031
300	Santa Cruz do Piaui	31,963	425,040	344,380	744	26,600	0	802,127	827,983
301	Santa Cruz dos Milagres	1,434,080	548,212	178,398	0	0	9,450	2,170,140	2,170,140
302	Santa Filomena	65,808	311,020	131,972	126	263	0	508,926	509,063
303	Santa Luz	25,372	103,184	165,676	1,936	9,014	0	296,168	303,246
304	Santana do Piaui	43,023	52,496	65,808	0	0	0	161,327	161,327
305	Santa Rosa do Piaui	48,474	283,796	272,964	588	1,229	0	605,822	606,463
306	Santo Antonio de Lisboa	21,357	145,320	203,534	36	75	0	370,247	370,286
307	Santo Inacio do Piaui	69,476	329,468	142,136	0	0	0	541,080	541,080
308	Sao Braz do Piaui	13,764	91,242	72,252	0	0	0	177,258	177,258
309	Sao Felix do Piaui	56,347	302,398	307,701	0	0	0	666,446	666,446
310	Sao Francisco do Piaui	40,727	365,774	247,126	456	953	0	654,083	654,580
311	Sao Goncalo do Piaui	42,118	54,295	236,207	636	13,273	0	333,256	345,893
312	Sao Joao da Canabrava	7,614	191,905	170,681	0	0	0	370,200	370,200
313	Sao Joao da Serra	8,261	510,487	197,326	0	0	0	716,074	716,074
314	Sao Joao do Piaui	398,959	1,942,223	1,260,369	1,674	38,203	7,200	3,610,425	3,646,954
315	Sao Jose do Divino	463,902	336,896	133,176	144	301	0	934,118	934,275
316	Sao Jose do Peixe	1,181	495,582	241,266	780	2,669	0	738,809	740,698
317	Sao Jose do Piaui	113,975	103,771	177,632	624	9,054	0	396,002	404,432
318	Sao Juliao	0	172,805	205,994	0	0	0	378,799	378,799
319	Sao Lourenco do Piaui	0	295,615	76,896	0	0	0	372,511	372,511
320	Sao Miguel do Tapuio	421,576	1,020,507	609,683	78	163	0	2,051,844	2,051,929
321	Sao Pedro do Piaui	306,166	173,799	646,112	732	21,837	0	1,126,809	1,147,914
322	Sao Raimundo Nonato	213,375	556,875	868,818	5,772	80,721	29,250	1,674,090	1,749,039
323	Sigefredo Pacheco	41,993	468,103	350,982	0	0	0	861,078	861,078
324	Simoes	57,508	858,388	444,078	906	1,830	0	1,360,880	1,361,804
325	Simplicio Mendes	459,626	810,676	580,634	390	815	0	1,851,326	1,851,751
326	Socorro do Piaui	12,775	193,978	134,578	0	0	0	341,331	341,331
327	Teresina	11,838,604	829,887	52,060,440	334,465	1,858,892	390,000	65,453,396	66,977,823
328	Uniao	61,960,764	656,588	1,071,309	26,552	38,600	0	63,715,213	63,727,261
329	Urucui	212,454	395,835	561,168	3,008	60,345	0	1,172,465	1,229,802
330	Valenca do Piaui	564,019	468,099	639,587	4,626	28,996	7,200	1,683,531	1,707,901
331	Varzea Branca	0	169,671	79,596	0	0	0	249,267	249,267
332	Varzea Grande	25,875	169,933	230,238	0	0	0	426,046	426,046

NoWUM output: Annual withdrawal water uses of present state 1996/98

	irrigation	livestock	domestic	industry_1	industry_2	tourism	total_1	total_2
CE [m³]	323,995,431	81,209,462	225,541,178	25,580,029	46,215,772	16,742,384	673,068,484	693,704,227
PI [m³]	127,452,637	65,127,274	123,574,949	882,097	4,132,062	1,810,800	318,847,757	322,097,722
CE [km³]	324	81	226	26	46	17	673	694
PI [km³]	127	65	124	1	4	2	319	322
total [km³]	451	146	349	26	50	19	992	1,016

2) NoWUM output: Annual consumptive water uses [m3] of present state 1996/98

Muni_nr	Municipality	irrigation	livestock	domestic	industry_1	industry_2	tourism	total_1	total_2
1	Abaiara	0	143,857	34,160	5,108	9,224	0	183,125	187,242
2	Acarape	1,373,881	57,822	56,616	6,277	48,860	0	1,494,596	1,537,179
3	Acarau	23,369	376,608	201,940	92	8,876	31,406	633,414	642,199
4	Acopiara	0	1,276,789	259,655	256	3,256	585	1,537,285	1,540,285
5	Aiuaba	118,177	600,919	49,547	32	58	3,926	772,601	772,627
6	Alcantaras	0	84,735	32,998	0	0	0	117,733	117,733
7	Altaneira	0	56,448	19,566	108	195	0	76,122	76,209
8	Alto Santo	209,541	624,640	63,745	92	3,685	0	898,017	901,610
9	Amontada	54,348	393,420	153,687	14	25	31,406	632,875	632,887
10	Antonina do Norte	0	138,665	41,498	513	8	0	180,675	180,170
11	Apuiares	2,125,879	248,042	57,892	122	444	0	2,431,936	2,432,257
12	Aquiraz	23,767	482,547	207,286	218,284	138,352	203,763	1,135,647	1,055,716
13	Aracati	986,238	265,104	348,248	2,919	138,614	128,114	1,730,622	1,866,317
14	Aracoiaba	1,281,826	330,329	106,726	100	181	293	1,719,274	1,719,355
15	Ararenda	30,818	226,614	36,806	0	0	0	294,239	294,239
16	Araripe	0	328,824	78,169	617	45	3,926	411,536	410,964
17	Aratuba	23,610	106,948	47,343	92	580	3,926	181,918	182,406
18	Arneiroz	0	509,458	32,363	212	384	0	542,033	542,204
19	Assare	438,676	513,222	68,602	104	187	0	1,020,603	1,020,687
20	Aurora	967,810	658,134	118,438	201	5,235	3,926	1,748,510	1,753,544
21	Baixio	0	240,012	30,392	24	43	0	270,428	270,448
22	Banabuiu	875,673	680,148	100,947	15,238	27,519	3,926	1,675,932	1,688,213
23	Barbalha	82,355	249,319	274,832	2,705	111,865	47,895	657,106	766,266
24	Barreira	4,923	185,621	61,034	8	14	293	251,879	251,885
25	Barro	0	434,765	100,076	3,138	5,667	0	537,979	540,508
26	Barroquinha	41,040	129,961	46,825	591	1,068	31,406	249,823	250,300
27	Baturite	93,145	230,751	183,986	1,374	15,587	4,803	514,059	528,272
28	Beberibe	5,056,910	441,546	150,754	1,191	15,236	114,854	5,765,254	5,779,300
29	Bela Cruz	0	535,431	118,252	269	351	0	653,952	654,034
30	Boa Viagem	198,024	1,559,740	362,505	1,732	3,128	293	2,122,294	2,123,690
31	Brejo Santo	632,592	686,297	125,417	6,106	11,027	293	1,450,704	1,455,625
32	Camocim	2,083,078	335,728	359,777	292,987	529,125	32,965	3,104,535	3,340,673
33	Campos Sales	0	377,390	154,937	470	7,473	0	532,797	539,800
34	Caninde	132,785	1,325,671	476,620	13,008	23,492	71,942	2,020,025	2,030,509
35	Capistrano	176,051	154,330	71,884	92	29	0	402,356	402,294
36	Caridade	31,368	261,590	61,488	177	14,652	0	354,623	369,097
37	Carire	306,321	542,409	85,904	299	921	0	934,933	935,555
38	Caririacu	30,340	378,262	84,251	36	65	3,926	496,815	496,844
39	Carius	30,447	375,926	62,924	62	111	0	469,359	469,408
40	Carnaubal	470,623	127,172	79,691	189	7	9,041	686,716	686,534
41	Cascavel	2,677,790	379,091	240,156	452	44,818	45,444	3,342,932	3,387,298
42	Catarina	0	400,917	54,569	162	293	0	455,649	455,779
43	Catunda	371,266	320,933	42,718	0	0	0	734,916	734,916
44	Caucaia	215,076	638,297	935,254	23,586	459,782	248,998	2,061,212	2,497,408
45	Cedro	0	574,550	83,887	3,501	6,323	3,926	665,864	668,686
46	Chaval	0	99,205	54,234	122	144,294	3,926	157,487	301,659
47	Choro	74,455	417,960	41,202	4	6	0	533,621	533,624
48	Chorozinho	293,647	178,052	62,556	27	49	0	534,282	534,304
49	Coreau	0	323,709	111,113	238	49	0	435,060	434,871
50	Crateus	1,753,309	1,507,009	440,475	604	9,804	4,510	3,705,908	3,715,108
51	Crato	1,815,162	415,845	343,876	66,062	119,306	68,480	2,709,426	2,762,670
52	Croata	327,907	133,373	76,537	0	0	3,926	541,743	541,743
53	Cruz	193,948	192,449	72,232	286	516	31,406	490,319	490,550
54	Deputado Irapuan Pinheiro	166,947	314,121	28,555	0	0	0	509,623	509,623
55	Erere	64,770	265,445	30,889	92	333	0	361,195	361,436
56	Eusebio	53,246	64,310	97,942	25,320	45,726	293	241,109	261,516
57	Farias Brito	0	345,935	94,854	9	16	0	440,798	440,805
58	Forquilha	20,284	278,019	98,938	1,447	2,614	0	398,688	399,854
59	Fortaleza	11,484	133,075	18,897,868	2,779,080	4,531,542	807,406	22,628,912	24,381,376
60	Fortim	207,092	49,565	49,553	830	1,719	36,864	343,904	344,793
61	Frecheirinha	0	96,042	52,971	83	150	0	149,096	149,163
62	General Sampaio	913,123	124,463	25,718	0	0	0	1,063,304	1,063,304
63	Graca	56,998	155,092	51,728	0	0	0	263,818	263,818
64	Granja	136,544	801,551	226,650	910	1,643	0	1,165,655	1,166,389
65	Granjeiro	1,904	84,680	20,901	0	0	0	107,485	107,485
66	Groairas	479,727	129,347	55,535	44	79	0	664,653	664,688
67	Guaiuba	34,409	98,728	87,467	92	4,824	3,926	224,621	229,354
68	Guaraciaba do Norte	1,440,273	233,522	151,920	226	304	9,041	1,834,981	1,835,059
69	Guaramiranga	74,621	27,987	23,658	21	39	3,926	130,213	130,230
70	Hidrolandia	34,978	472,880	88,419	104	6,517	0	596,381	602,794
71	Horizonte	0	218,851	94,251	146,171	65,206	1,462	460,735	379,770
72	Ibaretama	37,650	418,396	39,085	44	80	0	495,176	495,212
73	Ibiapina	1,093,814	171,659	101,348	744	1,344	9,041	1,376,605	1,377,205
74	Ibicuitinga	37,976	269,486	31,954	0	0	0	339,416	339,416
75	Icapui	4,074,186	177,711	141,807	456	824	36,864	4,431,024	4,431,392
76	Ico	7,605,972	1,149,947	405,693	1,650	2,979	3,926	9,167,188	9,168,518
77	Iguatu	1,260,042	1,015,845	855,704	50,257	90,762	5,388	3,187,236	3,227,742
78	Independencia	113,083	1,641,552	124,765	470	459	0	1,879,869	1,879,858
79	Ipaporanga	0	312,433	39,622	0	0	0	352,055	352,055
80	Ipaumirim	0	289,881	57,115	556	5,407	0	347,552	352,403
81	Ipu	308,040	368,528	304,375	675	1,220	3,926	985,544	986,088
82	Ipueiras	37,168	553,573	167,289	122	219	0	758,151	758,249
83	Iracema	28,847	438,117	92,519	2,222	1,024	0	561,706	560,507
84	Iraucuba	17,455	724,065	90,575	37	67	0	832,133	832,163

Muni_nr	Municipality	irrigation	livestock	domestic	industry_1	industry_2	tourism	total_1	total_2
85	Itaicaba	7,536	120,768	34,486	92	76	0	162,881	162,866
86	Itaitinga	322,258	130,118	120,343	293	758	468	573,480	573,945
87	Itapage	126,678	317,595	209,746	49,554	89,492	4,510	708,084	748,022
88	Itapipoca	234,730	752,483	657,060	49,130	88,728	32,965	1,726,369	1,765,966
89	Itapiuna	1,005,099	319,577	62,959	95	171	0	1,387,729	1,387,805
90	Itarema	0	346,459	107,609	415	749	33,746	488,229	488,563
91	Itatira	212,528	367,769	51,948	21	38	3,926	636,192	636,209
92	Jaguaretama	317,504	1,616,494	88,943	42	76	0	2,022,983	2,023,017
93	Jaguaribara	2,488,604	732,129	43,154	360	72	0	3,264,248	3,263,960
94	Jaguaribe	19,273,282	1,672,416	325,129	6,188	11,176	585	21,277,600	21,282,588
95	Jaguaruana	13,024,714	524,587	134,005	1,081	44,076	0	13,684,387	13,727,382
96	Jardim	8,685	448,887	90,022	282	509	662	548,538	548,766
97	Jati	686,218	164,213	37,259	281	281	0	887,971	887,971
98	Jijoca de Jericoacoara	0	65,208	41,450	0	0	77,418	184,076	184,076
99	Juazeiro do Norte	2,212,204	214,677	1,647,590	21,742	107,366	292,512	4,388,726	4,474,348
100	Jucas	0	461,534	159,314	38,361	69,279	0	659,208	690,126
101	Lavras da Mangabeira	207,350	801,289	179,507	617	1,237	0	1,188,762	1,189,382
102	Limoeiro do Norte	7,630,443	473,580	335,391	150,709	272,176	5,388	8,595,512	8,716,979
103	Madalena	351,107	563,018	72,293	37	66	0	986,455	986,484
104	Maracanau	0	70,749	709,358	623,429	841,270	0	1,403,537	1,621,377
105	Maranguape	0	583,608	492,530	59,677	148,931	7,217	1,143,032	1,232,287
106	Marco	0	303,872	104,590	1,117	16	0	409,579	408,478
107	Martinopole	0	83,523	34,017	263	954	293	118,095	118,786
108	Massape	235,128	303,232	152,290	1,117	974	0	691,767	691,623
109	Mauriti	326,891	891,087	174,506	31	2,713	0	1,392,515	1,395,197
110	Meruoca	489,614	50,117	42,431	966	1,744	3,926	587,054	587,833
111	Milagres	0	410,937	125,118	275	3,589	0	536,329	539,644
112	Milha	90,324	500,138	67,741	2	4	0	658,206	658,207
113	Miraima	115,879	467,643	38,084	0	0	0	621,606	621,606
114	Missao Velha	32,024	470,791	148,253	354	2,337	3,509	654,931	656,914
115	Mombaca	84,395	1,327,391	167,266	198	357	585	1,579,834	1,579,993
116	Monsenhor Tabosa	0	472,712	76,318	7	13	0	549,038	549,043
117	Morada Nova	6,300,660	1,610,977	509,943	19,604	35,404	3,926	8,445,110	8,460,910
118	Moraujo	0	179,501	38,455	299	1,087	0	218,256	219,043
119	Morrinhos	0	203,135	79,254	134	310	0	282,523	282,698
120	Mucambo	0	115,228	70,390	0	0	0	185,618	185,618
121	Mulungu	14,924	37,358	29,509	0	1	3,926	85,717	85,718
122	Nova Olinda	0	146,322	70,485	269	35,819	3,926	221,001	256,551
123	Nova Russas	79,874	429,005	218,432	1,607	2,903	585	729,504	730,799
124	Novo Oriente	43,794	669,496	98,595	4	7	0	811,889	811,892
125	Ocara	28,791	297,093	73,181	0	0	0	399,065	399,065
126	Oros	1,650,656	425,969	135,498	299	2,876	4,218	2,216,640	2,219,217
127	Pacajus	1,113,602	307,680	185,124	240,742	73,801	4,510	1,851,659	1,684,719
128	Pacatuba	156,214	113,579	212,620	112,106	201,945	6,281	600,800	690,639
129	Pacoti	157,896	95,218	44,651	553	999	3,926	302,244	302,689
130	Pacuja	93,063	81,625	31,846	345	622	0	206,879	207,157
131	Palhano	40,402	127,800	37,457	208	18,042	0	205,866	223,701
132	Palmacia	0	86,071	44,459	16	28	3,926	134,472	134,484
133	Paracuru	7,186,258	169,564	100,966	98	13,215	50,902	7,507,788	7,520,906
134	Paraipaba	34,071,844	163,486	99,399	98	35	46,223	34,381,048	34,380,988
135	Parambu	104,924	1,215,762	140,554	6	11	0	1,461,247	1,461,252
136	Paramoti	298,570	251,124	54,597	183	11,821	0	604,474	616,111
137	Pedra Branca	442,631	859,792	221,236	1,763	3,185	0	1,525,423	1,526,845
138	Penaforte	0	109,698	34,072	165	435	0	143,934	144,205
139	Pentecoste	4,952,106	508,772	171,378	1,172	1,715	3,926	5,637,355	5,637,898
140	Pereiro	43,958	216,599	71,630	214	312	3,926	336,326	336,425
141	Pindoretama	0	133,033	48,877	46	84	19,628	201,585	201,623
142	Piquet Carneiro	22,021	346,303	45,954	4	7	0	414,282	414,285
143	Pires Ferreira	280,513	189,033	39,211	0	0	0	508,757	508,757
144	Poranga	204,219	285,003	40,972	16	29	3,926	534,136	534,148
145	Porteiras	0	309,432	69,005	147	4	0	378,583	378,440
146	Potengi	0	188,474	45,287	52	94	0	233,813	233,854
147	Potiretama	12,542	294,917	28,076	0	0	0	335,535	335,535
148	Quiterianopolis	142,238	606,564	79,361	0	0	0	828,162	828,162
149	Quixada	1,128,938	1,520,924	423,537	12,370	6,482	5,680	3,091,449	3,085,561
150	Quixelo	318,505	636,818	74,354	129	233	0	1,029,807	1,029,911
151	Quixeramobim	5,273,000	1,879,442	511,637	7,644	13,805	4,510	7,676,233	7,682,394
152	Quixere	2,050,175	221,672	79,555	714	44	0	2,352,116	2,351,447
153	Redencao	151,480	74,959	102,407	311	17,946	4,218	333,376	351,010
154	Reriutaba	0	243,268	96,831	147	113	0	340,246	340,212
155	Russas	13,736,007	620,757	257,276	2,564	72,658	0	14,616,604	14,686,698
156	Saboeiro	0	629,930	76,679	0	0	0	706,609	706,609
157	Salitre	14,753	330,391	44,791	0	0	0	389,936	389,936
158	Santana do Acarau	13,796,053	830,204	104,157	269	1,851	0	14,730,683	14,732,265
159	Santana do Cariri	456,470	381,064	153,562	1,142	53,136	447	992,684	1,044,678
160	Santa Quiteria	0	1,753,764	160,103	5,703	10,934	0	1,919,569	1,924,800
161	Sao Benedito	2,296,863	239,422	206,439	1,868	935	9,041	2,753,633	2,752,700
162	Sao Goncalo do Amarante	3,227,489	331,917	154,494	195	18,391	58,702	3,772,797	3,790,993
163	Sao Joao do Jaguaribe	51,188	222,398	71,177	240	433	0	345,003	345,196
164	Sao Luis do Curu	1,797,728	91,773	64,657	8	14	0	1,954,167	1,954,173
165	Senador Pompeu	275,775	606,821	150,042	543	1,309	877	1,034,058	1,034,824
166	Senador Sa	51,732	122,800	31,993	140	510	0	206,666	207,035
167	Sobral	507,103	1,289,586	131,203	1,099	240,913	6,850	1,935,841	2,175,654
168	Solonopole	35,156	855,504	110,444	123	223	0	1,001,228	1,001,328
169	Tabuleiro do Norte	2,974,664	480,548	179,508	2,717	11,129	0	3,637,436	3,645,849
170	Tamboril	0	1,207,719	142,080	116	1,903	0	1,349,916	1,351,703
171	Tarrafas	29,599	162,639	28,368	0	0	0	220,606	220,606

Muni_nr	Municipality	irrigation	livestock	domestic	industry_1	industry_2	tourism	total_1	total_2
172	Taua	0	2,497,134	276,324	159	312	0	2,773,616	2,773,770
173	Tejucuoca	12,252	290,251	40,630	0	0	0	343,133	343,133
174	Tiangua	2,397,235	416,510	299,959	1,789	2,399	9,041	3,124,533	3,125,143
175	Trairi	269,154	322,450	155,643	183	31	33,746	781,176	781,023
176	Tururu	70,532	104,251	47,821	0	0	0	222,604	222,604
177	Ubajara	17,755,048	258,113	138,177	910	824	9,041	18,161,288	18,161,202
178	Umari	91,934	326,122	35,064	1	2	0	453,122	453,123
179	Umirim	1,134,531	280,063	76,534	147	356	0	1,491,275	1,491,484
180	Uruburetama	45,581	61,854	96,392	446	5,778	3,926	208,198	213,531
181	Uruoca	0	249,575	46,633	317	116	293	296,818	296,617
182	Varjota	2,444,680	108,801	97,421	134	488	0	2,651,036	2,651,390
183	Varzea Alegre	30,447	534,784	136,482	5,315	9,598	3,926	710,953	715,237
184	Vicosa do Ceara	0	541,630	208,419	134	344	9,041	759,225	759,434
185	Agricolandia	0	27,640	48,661	7,671	1,985	0	83,971	78,285
186	Agua Branca	62,983	115,571	110,521	472	6,811	0	289,547	295,886
187	Alagoinha do Piaui	5,113	219,063	39,418	0	0	0	263,594	263,594
188	Alegrete do Piaui	0	150,931	20,351	0	0	0	171,282	171,282
189	Alto Longa	178,496	918,083	77,557	194	1,555	0	1,174,331	1,175,691
190	Altos	675,821	787,261	178,460	678	19,691	0	1,642,220	1,661,232
191	Amarante	142,295	323,557	185,867	223	2,354	1,800	653,743	655,874
192	Angical do Piaui	35,557	150,734	48,835	142	799	0	235,267	235,925
193	Anisio de Abreu	15,551	331,135	43,217	36	75	0	389,939	389,978
194	Antonio Almeida	224,181	219,320	24,143	46	95	0	467,689	467,739
195	Aroazes	264,805	292,013	44,444	0	0	0	601,262	601,262
196	Arraial	6,837	149,047	39,194	0	0	0	195,078	195,078
197	Avelino Lopes	17,600	497,140	66,051	209	436	0	581,000	581,227
198	Baixa Grande do Ribeiro	1,322,764	339,778	43,300	0	0	0	1,705,842	1,705,842
199	Barras	647,959	951,466	271,343	1,115	5,792	1,440	1,873,322	1,877,999
200	Barreiras do Piaui	50,132	247,815	26,041	460	1,071	0	324,448	325,059
201	Barro Duro	301,086	88,637	36,424	227	10,255	0	426,374	436,402
202	Batalha	93,940	1,067,270	111,033	62	130	1,080	1,273,386	1,273,454
203	Beneditinos	10,966	472,239	55,949	292	1,985	0	539,445	541,139
204	Bertolinia	75,565	705,382	81,529	26	55	0	862,502	862,531
205	Bocaina	96,857	178,803	28,999	0	0	0	304,659	304,659
206	Bom Jesus	472,169	846,178	184,598	275	4,311	0	1,503,220	1,507,256
207	Bom Principio do Piaui	6,278	190,006	33,984	0	0	360	230,628	230,628
208	Bonfim do Piaui	5,874	185,557	17,464	0	0	0	208,895	208,895
209	Brasileira	46,346	325,817	38,138	86	181	0	410,388	410,482
210	Buriti dos Lopes	827,022	824,903	143,785	955	2,397	0	1,796,666	1,798,107
211	Buriti dos Montes	10,213	378,554	21,967	0	0	0	410,734	410,734
212	Cabeceiras do Piaui	73,254	410,776	35,059	128	268	0	519,217	519,357
213	Caldeirao Grande do Piaui	51,964	234,583	19,685	0	0	0	306,232	306,232
214	Campinas do Piaui	16,344	459,392	24,141	0	0	0	499,876	499,876
215	Campo Maior	952,206	1,992,082	213,480	819	18,190	5,040	3,163,626	3,180,997
216	Canavieira	7,780	284,195	29,854	14	30	0	321,844	321,860
217	Canto do Buriti	292,368	1,050,418	190,172	172	9,027	1,080	1,534,210	1,543,065
218	Capitao de Campos	213,554	189,551	42,556	13	28	0	445,675	445,689
219	Caracol	32,606	371,615	83,419	0	0	360	487,999	487,999
220	Castelo do Piaui	14,019	860,730	155,691	280	2,168	0	1,030,719	1,032,607
221	Cocal	146,303	801,564	113,488	1,825	1,355	0	1,063,180	1,062,710
222	Coivaras	52,626	161,645	28,339	0	0	0	242,610	242,610
223	Colonia do Gurgueia	10,464	100,138	34,301	0	0	0	144,903	144,903
224	Colonia do Piaui	30,096	327,973	32,478	0	0	0	390,546	390,546
225	Conceicao do Canindé	8,423	509,682	54,411	0	0	0	572,516	572,516
226	Coronel Jose Dias	12,557	237,417	13,954	0	0	2,880	266,807	266,807
227	Corrente	294,852	1,523,254	169,012	509	12,651	1,080	1,988,708	2,000,850
228	Cristalandia do Piaui	182,341	524,310	34,121	24	612	0	740,796	741,384
229	Cristino Castro	789,692	333,635	114,358	2,106	9,806	1,080	1,240,870	1,248,571
230	Curimata	60,294	839,459	64,701	384	2,674	0	964,838	967,128
231	Demerval Lobao	97,872	145,003	123,371	244	2,359	0	366,490	368,605
232	Dirceu Arcoverde	0	360,688	30,347	74	155	0	391,109	391,190
233	Dom Expedito Lopes	86,978	76,796	78,113	136	283	0	242,023	242,171
234	Domingos Mourao	0	239,774	35,054	158	331	0	274,987	275,159
235	Dom Inocencio	6,483	911,994	32,407	0	0	0	950,884	950,884
236	Elesbao Veloso	17,143	723,528	140,914	431	5,853	0	882,015	887,437
237	Eliseu Martins	10,211	229,916	34,441	22	45	0	274,589	274,613
238	Esperantina	155,740	711,990	274,385	5,526	9,008	1,800	1,149,442	1,152,924
239	Fartura do Piaui	0	280,460	26,377	0	0	0	306,837	306,837
240	Flores do Piaui	27,262	182,955	21,110	108	226	0	231,435	231,553
241	Floriano	952,549	734,839	372,008	10,405	37,904	9,000	2,078,801	2,106,300
242	Francinopolis	171,192	92,767	29,958	0	0	0	293,917	293,917
243	Francisco Ayres	9,792	161,367	30,169	0	0	0	201,329	201,329
244	Francisco Santos	18,422	164,926	31,746	0	0	0	215,095	215,095
245	Fronteiras	0	350,834	51,815	290	2,169	0	402,939	404,818
246	Gilbues	142,718	501,450	77,424	516	2,130	0	722,107	723,721
247	Guadalupe	56,423	185,942	159,744	766	662	720	403,595	403,490
248	Hugo Napoleao	9,878	47,849	30,514	194	807	0	88,435	89,048
249	Inhuma	221,893	257,497	86,388	464	936	0	566,242	566,714
250	Ipiranga do Piaui	128,717	134,066	60,408	12	25	0	323,204	323,217
251	Isaias Coelho	0	400,901	39,585	0	0	0	440,486	440,486
252	Itainopolis	109,592	571,339	66,953	0	0	0	747,884	747,884
253	Itaueira	234,891	484,576	66,049	7,719	2,921	0	793,235	788,437
254	Jacobina do Piaui	20,991	560,521	18,043	0	0	0	599,555	599,555
255	Jaicos	30,928	680,534	133,612	125	3,126	0	845,199	848,200
256	Jardim do Mulato	18,036	103,848	22,197	65	135	0	144,146	144,217
257	Jerumenha	285,080	264,754	31,699	89	2,550	0	581,623	584,084
258	Joaquim Pires	263,454	564,237	64,439	0	0	0	892,130	892,130

Muni_nr	Municipality	irrigation	livestock	domestic	industry_1	industry_2	tourism	total_1	total_2
259	Jose de Freitas	633,010	782,052	270,263	862	5,127	2,880	1,689,067	1,693,332
260	Lagoa Alegre	40,986	217,771	27,462	0	0	0	286,219	286,219
261	Lagoa do Barro Piaui	8,683	427,217	19,210	0	0	0	455,109	455,109
262	Landri Sales	226,441	235,702	78,752	0	0	0	540,895	540,895
263	Luis Correia	21,735	567,806	124,723	1,868	5,293	105,600	821,732	825,158
264	Luzilandia	141,236	754,222	178,766	5,397	4,603	0	1,079,620	1,078,826
265	Manoel Emidio	19,317	308,603	52,146	137	275	0	380,203	380,340
266	Marcolandia	2,482	48,065	20,977	0	0	0	71,524	71,524
267	Marcos Parente	14,005	182,329	46,121	7	15	0	242,462	242,470
268	Matias Olimpio	47,052	163,827	47,669	0	0	0	258,548	258,548
269	Miguel Alves	2,413,390	567,518	102,450	5,280	5,064	0	3,088,640	3,088,424
270	Miguel Leao	1,330,323	56,393	11,745	7,686	1,803	0	1,406,147	1,400,264
271	Monsenhor Gil	109,274	236,957	54,625	242	2,647	360	401,458	403,862
272	Monsenhor Hipolito	0	190,769	40,958	73	153	0	231,800	231,880
273	Monte Alegre do Piaui	30,488	369,918	63,684	98	206	0	464,187	464,295
274	Nazare do Piaui	25,792	341,266	53,952	0	0	0	421,010	421,010
275	Nossa Senhora dos Remedios	4,288	129,828	29,241	0	0	0	163,357	163,357
276	Novo Oriente do Piaui	89,275	234,008	52,356	0	0	0	375,639	375,639
277	Oeiras	1,143,074	1,069,493	411,774	337	7,702	5,640	2,630,318	2,637,683
278	Padre Marcos	8,814	459,857	57,879	209	662	0	526,759	527,212
279	Paes Landim	37,909	292,491	25,881	0	0	0	356,281	356,281
280	Palmeira do Piaui	115,673	248,826	25,923	0	0	0	390,422	390,422
281	Palmeirais	446,351	392,390	58,724	7,681	1,074	0	905,146	898,539
282	Parnagua	168,934	1,286,405	59,202	118	662	0	1,514,659	1,515,203
283	Parnaiba	879,555	472,851	1,793,342	4,567	64,181	105,600	3,255,915	3,315,529
284	Passagem Franca do Piaui	107,306	197,925	27,540	0	0	0	332,771	332,771
285	Patos do Piaui	15,917	327,660	27,907	0	0	0	371,484	371,484
286	Paulistana	96,003	1,367,381	145,005	421	3,894	1,080	1,609,890	1,613,363
287	Pedro II	489,528	977,039	248,881	903	5,887	2,760	1,719,111	1,724,095
288	Picos	3,559,270	959,697	871,682	5,318	36,809	7,200	5,403,166	5,434,658
289	Pimenteiras	222,669	467,654	67,425	53	110	0	757,801	757,859
290	Pio IX	2,845	589,631	68,327	144	1,803	0	660,947	662,606
291	Piracuruca	164,968	1,240,237	203,685	1,193	12,556	7,200	1,617,284	1,628,647
292	Piripiri	1,135,592	693,587	582,330	1,539	21,247	7,500	2,420,548	2,440,257
293	Porto	201,309	279,402	97,286	0	0	0	577,997	577,997
294	Prata do Piaui	17,351	87,306	26,843	0	0	0	131,500	131,500
295	Queimada Nova	9,570	508,980	28,019	0	0	0	546,569	546,569
296	Redencao do Gurgueia	128,169	335,115	48,595	0	0	0	511,879	511,879
297	Regeneracao	34,510	212,494	155,719	514	9,900	0	403,237	412,623
298	Ribeiro Goncalves	48,040	271,018	60,296	460	5,576	0	379,814	384,930
299	Rio Grande do Piaui	12,950	420,046	82,120	7,671	1,985	0	522,787	517,101
300	Santa Cruz do Piaui	16,731	425,040	68,876	149	5,320	0	510,795	515,967
301	Santa Cruz dos Milagres	833,945	548,212	35,680	0	0	1,890	1,419,727	1,419,727
302	Santa Filomena	35,366	311,020	26,395	25	53	0	372,805	372,833
303	Santa Luz	11,997	103,184	33,135	387	1,803	0	148,703	150,119
304	Santana do Piaui	19,017	52,496	13,162	0	0	0	84,675	84,675
305	Santa Rosa do Piaui	25,997	283,796	54,593	118	246	0	364,504	364,632
306	Santo Antonio de Lisboa	11,815	145,320	40,707	7	15	0	197,849	197,857
307	Santo Inacio do Piaui	35,718	329,468	28,427	0	0	0	393,613	393,613
308	Sao Braz do Piaui	5,057	91,242	14,450	0	0	0	110,749	110,749
309	Sao Felix do Piaui	28,736	302,398	61,540	0	0	0	392,674	392,674
310	Sao Francisco do Piaui	18,814	365,774	49,425	91	191	0	434,105	434,204
311	Sao Goncalo do Piaui	24,266	54,295	47,241	127	2,655	0	125,929	128,457
312	Sao Joao da Canabrava	7,020	191,905	34,136	0	0	0	233,062	233,062
313	Sao Joao da Serra	6,567	510,487	39,465	0	0	0	556,520	556,520
314	Sao Joao do Piaui	199,201	1,942,223	252,074	335	7,641	1,440	2,395,273	2,402,578
315	Sao Jose do Divino	251,172	336,896	26,635	29	60	0	614,732	614,764
316	Sao Jose do Peixe	1,296	495,582	48,253	156	534	0	545,287	545,665
317	Sao Jose do Piaui	75,113	103,771	35,526	125	1,811	0	214,535	216,221
318	Sao Juliao	0	172,805	41,199	0	0	0	214,004	214,004
319	Sao Lourenco do Piaui	0	295,615	15,379	0	0	0	310,994	310,994
320	Sao Miguel do Tapuio	270,444	1,020,507	121,937	16	33	0	1,412,903	1,412,920
321	Sao Pedro do Piaui	144,746	173,799	129,222	146	4,367	0	447,913	452,134
322	Sao Raimundo Nonato	75,712	556,875	173,764	1,154	16,144	5,850	813,355	828,345
323	Sigefredo Pacheco	30,008	468,103	70,196	0	0	0	568,307	568,307
324	Simoes	37,998	858,388	88,816	181	366	0	985,383	985,568
325	Simplicio Mendes	253,039	810,676	116,127	78	163	0	1,179,920	1,180,005
326	Socorro do Piaui	6,149	193,978	26,916	0	0	0	227,042	227,042
327	Teresina	6,960,376	829,887	10,412,088	66,893	371,778	130,000	18,399,244	18,704,130
328	Uniao	35,955,340	656,588	214,262	5,310	7,720	0	36,831,500	36,833,908
329	Urucui	82,204	395,835	112,234	602	12,069	0	590,874	602,341
330	Valenca do Piaui	380,631	468,099	127,917	925	5,799	1,440	979,012	983,886
331	Varzea Branca	0	169,671	15,919	0	0	0	185,590	185,590
332	Varzea Grande	11,517	169,933	46,048	0	0	0	227,498	227,498

NoWUM output: Annual consumptive water uses of present state 1996/98

	irrigation	livestock	domestic	industry_1	industry_2	tourism	total_1	total_2
CE [m³]	223,285,775	81,209,462	45,108,235	5,116,008	9,243,155	2,856,391	357,575,859	361,703,016
PI [m³]	71,934,474	65,127,274	24,714,992	176,419	826,414	414,160	162,367,315	163,017,311
CE [km³]	223	81	45	5	9	3	358	362
PI [km³]	72	65	25	0	1	0	162	163
total [km³]	295	146	70	5	10	3	520	525

3) NoWUM output: Annual withdrawal water uses [m3] of 2025 *Coastal Boom and Cash Crops* scenario (RSA)

Muni_nr	Municipality	irrigation	livestock	domestic	industry_1	industry_2	tourism	total_1	total_2
1	Abaiara	6,048,178	147,074	200,226	55,189	99,669	0	6,450,667	6,495,147
2	Acarape	4,365,486	98,529	541,572	112,771	877,855	0	5,118,358	5,883,442
3	Acarau	16,837,336	641,784	2,843,334	1,652	160,081	785,140	21,109,246	21,267,675
4	Acopiara	500,146	929,412	907,848	1,885	23,947	8,770	2,348,061	2,370,123
5	Aiuaba	967,055	437,437	266,856	230	416	58,887	1,730,465	1,730,651
6	Alcantaras	556,791	61,695	177,708	0	0	0	796,194	796,194
7	Altaneira	4,896,798	57,705	164,118	1,153	2,081	0	5,119,774	5,120,702
8	Alto Santo	9,794,656	638,585	379,818	984	39,569	0	10,814,043	10,852,628
9	Amontada	2,507,999	670,423	1,558,776	249	451	785,140	5,522,587	5,522,789
10	Antonina do Norte	5,677,410	141,742	164,448	5,491	84	0	5,989,091	5,983,684
11	Apuiares	2,933,236	180,559	201,486	879	3,189	0	3,316,160	3,318,470
12	Aquiraz	3,603,397	767,414	2,749,620	3,691,880	2,339,982	5,094,080	15,906,391	14,554,493
13	Aracati	3,104,782	451,778	2,944,260	52,646	2,500,326	3,202,840	9,756,306	12,203,986
14	Aracoiaba	3,145,463	562,916	1,297,812	1,787	3,227	12,200	5,020,178	5,021,618
15	Ararenda	728,716	164,948	198,228	0	0	0	1,091,892	1,091,892
16	Araripe	5,840,426	336,174	470,634	6,614	484	58,887	6,712,735	6,706,605
17	Aratuba	2,598,107	182,240	492,228	1,627	10,295	163,575	3,437,777	3,446,445
18	Arneiroz	596,285	370,848	125,478	1,536	2,774	0	1,094,147	1,095,385
19	Assare	8,325,732	524,664	575,466	1,107	1,998	0	9,426,969	9,427,860
20	Aurora	5,054,858	672,818	706,500	2,149	55,857	58,887	6,495,212	6,548,920
21	Baixio	5,532,582	245,366	154,842	256	463	0	5,933,046	5,933,253
22	Banabuiu	7,677,790	695,339	525,510	163,528	295,327	58,887	9,121,054	9,252,853
23	Barbalha	10,102,176	254,873	1,304,568	29,258	1,210,047	718,430	12,409,305	13,590,094
24	Barreira	957,864	316,324	921,312	139	247	12,200	2,207,839	2,207,947
25	Barro	5,037,913	444,480	588,078	33,656	60,783	0	6,104,127	6,131,254
26	Barroquinha	2,727,785	221,431	706,818	10,526	19,008	785,140	4,451,700	4,460,182
27	Baturite	2,332,527	393,216	1,442,472	24,618	279,312	200,125	4,392,958	4,647,652
28	Beberibe	7,368,386	752,448	2,027,472	21,275	272,254	2,871,360	13,040,941	13,291,920
29	Bela Cruz	32,070,318	912,413	1,360,554	4,816	6,292	0	34,348,101	34,349,577
30	Boa Viagem	889,478	1,135,419	1,189,506	12,447	22,478	4,392	3,231,242	3,241,273
31	Brejo Santo	21,635,310	701,600	1,052,082	65,558	118,395	4,392	23,458,942	23,511,779
32	Camocim	4,661,630	572,116	2,853,612	5,246,760	9,475,479	824,120	14,158,238	18,386,957
33	Campos Sales	696,924	274,715	484,452	3,388	53,844	0	1,459,479	1,509,935
34	Caninde	837,365	965,004	1,303,332	93,808	169,413	729,136	3,928,645	4,004,250
35	Capistrano	2,674,268	262,976	732,492	1,625	515	0	3,671,361	3,670,251
36	Caridade	656,407	190,405	231,324	1,272	105,289	0	1,079,408	1,183,425
37	Carire	862,730	394,852	370,650	2,139	6,589	0	1,630,371	1,634,821
38	Caririacu	5,890,579	386,743	706,752	383	693	58,887	7,043,344	7,043,654
39	Carius	8,243,970	384,316	527,838	657	1,186	0	9,156,781	9,157,310
40	Carnaubal	6,853,362	130,024	375,102	2,033	71	135,610	7,496,131	7,494,169
41	Cascavel	5,428,551	646,001	4,183,374	8,143	807,763	1,136,100	11,402,169	12,201,789
42	Catarina	560,812	291,850	198,264	1,176	2,124	0	1,052,102	1,053,050
43	Catunda	1,143,845	233,638	153,888	0	0	0	1,531,371	1,531,371
44	Caucaia	2,970,173	1,015,106	11,935,740	401,741	7,831,422	6,224,960	22,547,720	29,977,401
45	Cedro	5,031,075	587,403	703,704	37,335	67,428	58,887	6,418,404	6,448,497
46	Chaval	1,975,592	169,037	551,874	2,206	2,604,285	163,575	2,862,284	5,464,363
47	Choro	974,915	304,227	221,898	26	46	0	1,501,066	1,501,086
48	Chorozinho	2,298,262	303,443	674,244	482	872	0	3,276,431	3,276,821
49	Coreau	508,670	235,638	424,236	1,711	351	0	1,170,255	1,168,895
50	Crateus	34,648,568	1,097,021	1,213,680	4,359	70,705	67,658	37,031,286	37,097,632
51	Crato	8,832,847	425,144	2,884,674	710,856	1,283,784	1,027,202	13,880,723	14,453,651
52	Croata	5,385,258	136,345	447,360	2	3	58,887	6,027,852	6,027,853
53	Cruz	2,885,522	327,976	1,999,548	5,087	9,190	785,140	6,003,273	6,007,376
54	Deputado Irapuan Pinheiro	742,848	228,664	153,804	0	0	0	1,125,316	1,125,316
55	Erere	8,339,296	271,381	167,736	980	3,558	0	8,779,393	8,781,971
56	Eusebio	2,570,775	102,277	1,581,600	424,278	766,228	12,200	4,691,130	5,033,080
57	Farias Brito	4,949,062	353,661	576,954	94	169	0	5,879,771	5,879,846
58	Forquilha	335,879	202,381	288,228	10,401	18,782	0	836,889	845,270
59	Fortaleza	3,450,178	211,635	120,216,280	47,145,436	76,874,896	20,185,140	191,208,669	220,938,129
60	Fortim	1,851,124	84,481	479,142	14,979	31,014	921,600	3,351,326	3,367,361
61	Frecheirinha	572,690	69,926	199,404	600	1,083	0	842,620	843,103
62	General Sampaio	1,526,491	90,592	86,844	0	0	0	1,703,927	1,703,927
63	Graca	879,305	112,882	278,604	0	0	0	1,270,791	1,270,791
64	Granja	3,309,964	1,365,936	2,246,562	16,087	29,055	0	6,938,549	6,951,517
65	Granjeiro	3,156,500	86,581	125,118	0	0	0	3,368,199	3,368,199
66	Groairas	1,117,200	94,152	148,764	315	569	0	1,360,431	1,360,685
67	Guaiuba	2,129,528	157,010	788,586	1,544	81,311	163,575	3,240,243	3,320,010
68	Guaraciaba do Norte	8,462,590	238,719	888,348	2,434	3,274	135,610	9,727,701	9,728,541
69	Guaramiranga	2,864,752	47,686	236,694	383	694	163,575	3,313,090	3,313,401
70	Hidrolandia	888,459	344,244	353,208	747	46,869	0	1,586,658	1,632,780
71	Horizonte	1,700,615	372,956	1,421,712	2,659,606	1,186,429	60,938	6,215,827	4,742,650
72	Ibaretama	3,966,675	427,721	327,870	475	857	0	4,722,741	4,723,123
73	Ibiapina	7,095,694	175,501	523,758	8,019	14,484	135,610	7,938,582	7,945,047
74	Ibicuitinga	4,339,064	275,497	268,044	0	0	0	4,882,605	4,882,605
75	Icapui	6,730,544	302,817	1,567,470	8,174	14,763	921,600	9,530,605	9,537,194
76	Ico	21,194,198	1,175,620	2,024,352	17,601	31,785	58,887	24,470,658	24,484,842
77	Iguatu	31,060,434	1,038,536	3,139,764	538,923	973,277	80,820	35,858,477	36,292,831
78	Independencia	901,961	1,194,958	445,584	3,379	3,298	0	2,545,882	2,545,801
79	Ipaporanga	478,243	227,441	213,408	0	0	0	919,092	919,092
80	Ipaumirim	4,783,804	296,345	301,536	5,943	57,831	0	5,387,628	5,439,516
81	Ipu	6,539,738	376,748	1,436,202	7,193	12,992	58,887	8,418,768	8,424,567
82	Ipueiras	652,221	402,986	603,036	871	1,572	0	1,659,114	1,659,815
83	Iracema	6,525,523	447,890	405,330	23,742	10,937	0	7,402,485	7,389,680
84	Iraucuba	903,008	527,104	339,708	266	481	0	1,770,086	1,770,301

Muni_nr	Municipality	irrigation	livestock	domestic	industry_1	industry_2	tourism	total_1	total_2
85	Itaicaba	3,246,036	123,475	175,470	983	815	0	3,545,964	3,545,796
86	Itaitinga	3,246,126	206,926	1,239,102	4,968	12,852	19,520	4,716,642	4,724,526
87	Itapage	2,615,313	541,230	1,670,586	887,341	1,602,507	187,938	5,902,408	6,617,574
88	Itapipoca	2,322,397	1,282,291	5,835,792	878,869	1,587,211	824,120	11,143,469	11,851,811
89	Itapiuna	1,309,069	232,627	248,310	682	1,231	0	1,790,688	1,791,237
90	Itarema	1,757,798	590,377	1,292,424	7,450	13,457	843,640	4,491,689	4,497,696
91	Itatira	1,017,108	267,712	279,780	149	270	58,887	1,623,636	1,623,757
92	Jaguaretama	64,316,648	1,652,609	526,170	452	815	0	66,495,879	66,496,242
93	Jaguaribara	8,494,518	748,480	208,422	3,872	779	0	9,455,292	9,452,199
94	Jaguaribe	26,006,464	1,709,778	1,322,946	66,409	119,933	8,770	29,114,367	29,167,891
95	Jaguaruana	18,322,720	536,329	832,944	11,593	472,784	0	19,703,586	20,164,777
96	Jardim	9,798,901	458,914	755,154	3,002	5,424	9,936	11,025,907	11,028,329
97	Jati	6,384,894	167,885	180,618	3,009	3,013	0	6,736,406	6,736,410
98	Jijoca de Jericoacoara	1,958,960	111,102	725,868	0	0	1,935,460	4,731,390	4,731,390
99	Juazeiro do Norte	9,970,486	219,478	5,463,576	236,173	1,166,238	3,450,109	19,339,822	20,269,887
100	Jucas	462,357	335,961	536,532	276,403	499,175	0	1,611,253	1,834,025
101	Lavras da Mangabeira	7,444,454	819,177	993,228	6,579	13,196	0	9,263,438	9,270,055
102	Limoeiro do Norte	60,968,328	484,145	1,554,114	1,619,932	2,925,543	80,820	64,707,339	66,012,950
103	Madalena	959,248	409,821	257,910	263	473	0	1,627,242	1,627,452
104	Maracanau	2,033,642	112,528	7,943,094	11,058,594	14,922,712	0	21,147,858	25,011,976
105	Maranguape	1,991,494	928,140	4,780,848	1,007,582	2,514,546	300,700	9,008,764	10,515,728
106	Marco	31,208,042	517,821	926,172	20,168	297	0	32,672,203	32,652,332
107	Martinopole	2,018,842	142,326	349,530	4,647	16,877	12,200	2,527,545	2,539,775
108	Massape	680,074	220,729	473,700	8,028	6,995	0	1,382,531	1,381,498
109	Mauriti	15,431,585	910,979	1,083,768	327	28,993	0	17,426,659	17,455,325
110	Meruoca	1,277,890	36,471	317,442	6,953	12,558	58,887	1,697,643	1,703,248
111	Milagres	5,602,704	420,106	694,146	2,957	38,620	0	6,719,913	6,755,576
112	Milha	556,299	364,071	228,408	14	26	0	1,148,792	1,148,804
113	Miraima	560,403	340,425	205,116	0	0	0	1,105,944	1,105,944
114	Missao Velha	3,722,370	481,305	824,154	3,782	24,950	52,632	5,084,243	5,105,411
115	Mombaca	671,144	966,239	753,150	1,422	2,570	8,770	2,400,725	2,401,873
116	Monsenhor Tabosa	563,002	344,096	301,404	53	95	0	1,208,555	1,208,597
117	Morada Nova	34,059,640	1,646,980	2,503,686	210,014	379,279	58,887	38,479,207	38,648,472
118	Moraujo	541,454	130,669	124,104	2,153	7,821	0	798,380	804,048
119	Morrinhos	1,836,395	346,165	787,884	2,398	5,527	0	2,972,842	2,975,971
120	Mucambo	474,949	83,881	243,288	0	0	0	802,118	802,118
121	Mulungu	2,488,193	63,651	445,440	7	15	163,575	3,160,866	3,160,874
122	Nova Olinda	4,722,944	149,601	392,838	2,903	387,152	58,887	5,327,173	5,711,422
123	Nova Russas	817,598	312,278	563,370	11,583	20,918	8,770	1,713,599	1,722,934
124	Novo Oriente	762,508	487,332	484,254	29	52	0	1,734,123	1,734,146
125	Ocara	2,774,343	506,253	1,104,660	0	0	0	4,385,256	4,385,256
126	Oros	7,720,451	435,468	680,970	3,212	30,873	63,274	8,903,375	8,931,036
127	Pacajus	3,735,922	524,312	1,991,628	4,390,300	1,345,881	187,938	10,830,100	7,785,681
128	Pacatuba	3,585,204	180,615	2,347,932	1,924,231	3,466,260	261,720	8,299,702	9,841,731
129	Pacoti	2,684,981	162,253	488,946	9,861	17,806	163,575	3,509,616	3,517,561
130	Pacuja	809,350	59,424	104,688	2,491	4,498	0	975,953	977,960
131	Palhano	2,107,139	217,785	363,402	3,730	324,181	0	2,692,056	3,012,507
132	Palmacia	1,812,092	146,664	432,234	279	506	163,575	2,554,844	2,555,071
133	Paracuru	9,183,146	288,982	1,234,062	1,766	239,159	1,272,560	11,980,516	12,217,909
134	Paraipaba	68,502,112	278,606	936,024	1,772	638	1,155,580	70,874,094	70,872,960
135	Parambu	1,021,510	885,017	560,814	43	78	0	2,467,384	2,467,419
136	Paramoti	919,807	182,790	195,168	1,317	84,962	0	1,299,082	1,382,727
137	Pedra Branca	1,379,949	625,853	805,494	12,673	22,888	0	2,823,969	2,834,184
138	Penaforte	5,293,952	112,137	160,572	1,774	4,682	0	5,568,435	5,571,343
139	Pentecoste	7,328,868	370,383	519,042	8,412	12,306	58,887	8,285,592	8,289,486
140	Pereiro	6,520,352	221,426	368,538	2,285	3,340	58,887	7,171,488	7,172,543
141	Pindoretama	1,792,423	226,708	737,778	827	1,495	490,712	3,248,448	3,249,116
142	Piquet Carneiro	874,960	252,104	247,488	29	52	0	1,374,581	1,374,604
143	Pires Ferreira	838,502	137,594	390,750	0	0	0	1,366,846	1,366,846
144	Poranga	848,544	207,471	220,668	115	208	58,887	1,335,685	1,335,778
145	Porteiras	5,587,712	316,360	395,742	1,571	39	0	6,301,385	6,299,853
146	Potengi	5,679,128	192,676	224,898	557	1,007	0	6,097,259	6,097,709
147	Potiretama	6,735,966	301,521	149,478	0	0	0	7,186,965	7,186,965
148	Quiterianopolis	1,070,089	441,553	328,704	0	0	0	1,840,346	1,840,346
149	Quixada	7,692,524	1,554,891	1,809,300	132,739	69,551	85,208	11,274,662	11,211,474
150	Quixelo	4,599,089	651,036	454,392	1,375	2,483	0	5,705,892	5,707,000
151	Quixeramobim	11,163,872	1,921,409	2,551,548	81,833	147,788	67,658	15,786,320	15,852,275
152	Quixere	6,637,889	226,631	445,098	7,664	477	0	7,317,282	7,310,095
153	Redencao	3,305,015	127,722	1,195,674	5,583	321,733	175,762	4,809,756	5,125,906
154	Reriutaba	487,694	177,093	388,818	1,054	813	0	1,054,659	1,054,418
155	Russas	44,797,020	634,613	1,206,000	27,684	784,371	0	46,665,317	47,422,004
156	Saboeiro	497,548	458,550	282,222	0	0	0	1,238,320	1,238,320
157	Salitre	790,369	240,501	241,242	0	0	0	1,272,112	1,272,112
158	Santana do Acarau	20,413,984	1,414,758	898,374	7,492	51,620	0	22,734,608	22,778,736
159	Santana do Cariri	7,462,623	389,554	1,143,630	4,974	231,490	6,700	9,007,481	9,233,997
160	Santa Quiteria	540,340	1,276,618	552,858	63,532	121,808	0	2,433,348	2,491,624
161	Sao Benedito	7,495,658	244,770	1,050,156	20,082	10,053	135,610	8,946,276	8,936,247
162	Sao Goncalo do Amarante	5,453,694	527,832	2,369,766	3,269	307,646	1,467,560	9,822,121	10,126,498
163	Sao Joao do Jaguaribe	4,442,746	227,367	416,760	2,560	4,622	0	5,089,433	5,091,495
164	Sao Luis do Curu	4,129,773	156,396	539,256	144	260	0	4,825,569	4,825,685
165	Senador Pompeu	1,081,520	441,723	473,418	3,902	9,401	13,158	2,013,721	2,019,220
166	Senador Sa	929,702	89,408	118,470	1,008	3,663	0	1,138,588	1,141,243
167	Sobral	1,204,643	938,748	1,815,612	7,946	1,741,758	102,753	4,069,702	5,803,514
168	Solonopole	8,728,827	874,593	589,026	1,322	2,389	0	10,193,768	10,194,835
169	Tabuleiro do Norte	11,055,034	491,284	834,372	29,220	119,690	0	12,409,910	12,500,380
170	Tamboril	579,395	879,147	644,634	834	13,682	0	2,104,010	2,116,858
171	Tarrafas	4,781,754	166,276	237,972	0	0	0	5,186,002	5,186,002

Muni_nr	Municipality	irrigation	livestock	domestic	industry_1	industry_2	tourism	total_1	total_2
172	Taua	626,523	1,817,744	929,682	1,145	2,251	0	3,375,094	3,376,200
173	Tejucuoca	487,584	211,277	218,820	0	0	0	917,681	917,681
174	Tiangua	9,160,705	425,838	1,298,982	19,365	25,970	135,610	11,040,500	11,047,105
175	Trairi	2,493,524	549,500	1,994,118	3,282	547	843,640	5,884,064	5,881,329
176	Tururu	2,620,039	177,646	430,710	0	0	0	3,228,395	3,228,395
177	Ubajara	19,931,596	263,864	695,370	9,781	8,854	135,610	21,036,221	21,035,294
178	Umari	7,818,830	333,433	188,112	15	25	0	8,340,390	8,340,400
179	Umirim	3,289,007	477,245	685,386	2,609	6,331	0	4,454,247	4,457,969
180	Uruburetama	2,404,304	105,391	794,058	7,969	103,293	163,575	3,475,297	3,570,621
181	Uruoca	503,278	181,677	179,694	2,279	831	4,392	871,320	869,872
182	Varjota	13,898,396	79,217	250,374	974	3,537	0	14,228,961	14,231,524
183	Varzea Alegre	8,054,520	546,717	864,324	56,989	102,922	58,887	9,581,437	9,627,370
184	Vicosa do Ceará	5,107,638	553,743	1,243,434	1,435	3,671	135,610	7,041,860	7,044,096
185	Agricolandia	2,181,005	28,246	195,684	82,484	21,344	0	2,487,419	2,426,279
186	Agua Branca	2,472,017	118,140	453,822	5,085	73,448	0	3,049,064	3,117,427
187	Alagoinha do Piauí	51,142	159,459	136,218	0	0	0	346,819	346,819
188	Alegrete do Piauí	65,282	109,876	61,458	0	0	0	236,616	236,616
189	Alto Longa	2,954,304	938,570	419,916	2,121	16,961	0	4,314,911	4,329,751
190	Altos	3,072,506	804,870	859,182	7,327	212,811	0	4,743,885	4,949,369
191	Amarante	2,826,393	330,807	769,404	2,411	25,426	27,000	3,956,015	3,979,030
192	Angical do Piauí	2,693,014	154,097	189,630	1,541	8,693	0	3,038,282	3,045,434
193	Anisio de Abreu	103,299	241,063	151,524	261	546	0	496,147	496,432
194	Antonio Almeida	4,003,067	224,202	132,546	492	1,028	0	4,360,307	4,360,843
195	Aroazes	3,760,232	298,531	248,046	0	0	0	4,306,809	4,306,809
196	Arraial	2,820,440	152,369	234,162	0	0	0	3,206,971	3,206,971
197	Avelino Lopes	2,102,105	505,812	339,186	2,262	4,727	0	2,949,365	2,951,830
198	Baixa Grande do Ribeiro	5,019,870	345,693	222,900	0	0	0	5,588,463	5,588,463
199	Barras	3,699,246	972,704	1,417,638	12,076	62,732	21,600	6,123,264	6,173,920
200	Barreiras do Piauí	1,661,506	252,142	135,102	4,983	11,607	0	2,053,733	2,060,357
201	Barro Duro	3,223,742	90,625	154,008	2,463	111,357	0	3,470,838	3,579,732
202	Batalha	2,418,711	1,091,092	561,564	676	1,412	16,200	4,088,243	4,088,979
203	Beneditinos	2,178,298	482,765	273,372	3,147	21,421	0	2,937,582	2,955,856
204	Bertolinia	1,549,739	717,708	398,046	281	587	0	2,665,774	2,666,080
205	Bocaina	2,814,330	182,794	165,006	0	0	0	3,162,130	3,162,130
206	Bom Jesus	2,804,236	860,951	794,526	2,965	46,511	0	4,462,678	4,506,224
207	Bom Principio do Piauí	2,266,486	194,236	154,410	0	0	5,400	2,620,532	2,620,532
208	Bonfim do Piauí	61,133	135,093	88,608	0	0	0	284,834	284,834
209	Brasileira	2,594,880	333,090	201,420	930	1,943	0	3,130,320	3,131,333
210	Buriti dos Lopes	3,879,192	843,313	848,400	10,360	25,993	0	5,581,265	5,596,898
211	Buriti dos Montes	1,250,129	387,025	199,134	0	0	0	1,836,288	1,836,288
212	Cabeceiras do Piauí	2,466,511	419,954	208,974	1,391	2,906	0	3,096,830	3,098,345
213	Caldeirao Grande do Piauí	141,157	170,793	99,882	0	0	0	411,832	411,832
214	Campinas do Piauí	3,482,433	469,657	138,246	0	0	0	4,090,336	4,090,336
215	Campo Maior	3,509,490	2,036,550	1,935,210	8,804	195,631	75,600	7,565,654	7,752,481
216	Canavieira	1,702,393	289,144	171,672	153	321	0	2,163,362	2,163,530
217	Canto do Buriti	3,233,843	1,068,766	1,422,126	1,832	96,349	16,200	5,742,767	5,837,284
218	Capitao de Campos	3,223,488	193,768	204,222	143	299	0	3,621,621	3,621,777
219	Caracol	137,041	270,515	303,570	0	0	5,400	716,526	716,526
220	Castelo do Piauí	2,329,183	879,953	776,310	3,039	23,566	0	3,988,485	4,009,012
221	Cocal	3,353,319	819,460	559,878	19,853	14,740	0	4,752,510	4,747,397
222	Coivaras	2,686,904	165,260	106,734	0	0	0	2,958,898	2,958,898
223	Colonia do Gurgueia	1,326,858	101,875	126,696	0	0	0	1,555,429	1,555,429
224	Colonia do Piauí	2,775,076	335,296	168,084	0	0	0	3,278,456	3,278,456
225	Conceicao do Canindé	89,208	371,030	182,790	0	0	0	643,028	643,028
226	Coronel Jose Dias	115,117	172,834	70,800	0	0	43,200	401,951	401,951
227	Corrente	2,634,356	1,549,851	778,314	5,522	137,301	16,200	4,984,243	5,116,022
228	Cristalandia do Piauí	2,737,779	533,465	175,878	259	6,609	0	3,447,381	3,453,731
229	Cristino Castro	34,241,836	339,462	496,056	22,732	105,870	16,200	35,116,286	35,199,424
230	Curimata	2,346,926	854,109	336,666	4,132	28,772	0	3,541,833	3,566,473
231	Demerval Lobao	2,017,454	148,258	479,130	2,647	25,636	0	2,647,489	2,670,478
232	Dirceu Arcoverde	72,360	262,570	100,026	547	1,144	0	435,503	436,100
233	Dom Expedito Lopes	3,373,564	78,520	247,530	1,478	3,087	0	3,701,092	3,702,701
234	Domingos Mourao	1,693,772	245,114	216,924	832	1,738	0	2,156,642	2,157,548
235	Dom Inocencio	106,947	663,862	164,454	0	0	0	935,263	935,263
236	Elesbao Veloso	2,195,718	739,672	567,588	4,643	63,081	0	3,507,621	3,566,059
237	Eliseu Martins	2,294,329	233,948	134,712	230	481	0	2,663,219	2,663,470
238	Esperantina	2,620,040	727,902	1,210,620	59,991	97,789	27,000	4,645,553	4,683,351
239	Fartura do Piauí	65,487	204,153	73,794	0	0	0	343,434	343,434
240	Flores do Piauí	2,089,756	186,136	102,072	1,154	2,412	0	2,379,118	2,380,376
241	Floriano	4,305,362	751,256	1,380,624	112,249	408,913	135,000	6,684,491	6,981,155
242	Francinopolis	3,212,662	94,828	136,272	0	0	0	3,443,762	3,443,762
243	Francisco Ayres	3,008,796	164,969	148,692	0	0	0	3,322,457	3,322,457
244	Francisco Santos	3,470,851	168,598	146,118	0	0	0	3,785,567	3,785,567
245	Fronteiras	67,723	255,395	146,466	2,106	15,730	0	471,690	485,314
246	Gilbues	2,507,255	510,198	400,746	5,756	23,747	0	3,423,955	3,441,946
247	Guadalupe	72,973,904	190,084	486,906	8,294	7,164	10,800	73,669,988	73,668,858
248	Hugo Napoleao	2,419,282	48,940	110,442	2,087	8,662	0	2,580,751	2,587,326
249	Inhuma	3,134,366	263,251	410,568	5,049	10,181	0	3,813,234	3,818,366
250	Ipiranga do Piauí	3,075,548	137,090	251,316	131	273	0	3,464,085	3,464,227
251	Isaias Coelho	2,552,516	409,854	272,196	0	0	0	3,234,566	3,234,566
252	Itainopolis	2,429,872	584,085	432,774	0	0	0	3,446,731	3,446,731
253	Itaueira	1,406,267	493,046	308,130	83,112	31,454	0	2,290,555	2,238,897
254	Jacobina do Piauí	82,308	408,012	91,548	0	0	0	581,868	581,868
255	Jaicos	109,505	495,382	446,538	914	22,902	0	1,052,339	1,074,327
256	Jardim do Mulato	3,078,624	106,163	131,244	699	1,462	0	3,316,730	3,317,493
257	Jerumenha	2,252,149	270,638	139,824	974	27,959	0	2,663,585	2,690,570
258	Joaquim Pires	2,266,928	576,822	349,350	0	0	0	3,193,100	3,193,100

Muni_nr	Municipality	irrigation	livestock	domestic	industry_1	industry_2	tourism	total_1	total_2
259	Jose de Freitas	3,350,389	799,510	1,210,152	9,301	55,333	43,200	5,412,552	5,458,584
260	Lagoa Alegre	2,064,030	222,629	160,980	0	0	0	2,447,639	2,447,639
261	Lagoa do Barro Piauí	106,469	310,986	97,476	0	0	0	514,931	514,931
262	Landri Sales	2,002,142	239,816	241,458	0	0	0	2,483,416	2,483,416
263	Luis Correia	1,698,278	967,581	1,056,090	33,538	95,027	2,640,000	6,395,487	6,456,976
264	Luzilandia	39,630,244	771,053	911,850	58,187	49,625	0	41,371,334	41,362,772
265	Manoel Emidio	2,486,301	313,996	251,676	1,454	2,921	0	3,053,427	3,054,894
266	Marcolandia	82,759	35,005	106,446	0	0	0	224,210	224,210
267	Marcos Parente	2,193,793	185,530	173,232	77	161	0	2,552,632	2,552,716
268	Matias Olimpio	2,909,613	167,500	232,866	0	0	0	3,309,979	3,309,979
269	Miguel Alves	9,993,124	580,200	519,954	57,055	54,721	0	11,150,333	11,147,999
270	Miguel Leao	4,125,396	57,635	51,336	83,973	19,697	0	4,318,340	4,254,064
271	Monsenhor Gil	2,679,698	242,256	270,744	2,650	28,933	5,400	3,200,748	3,227,031
272	Monsenhor Hipolito	62,895	138,841	116,856	539	1,126	0	319,131	319,718
273	Monte Alegre do Piauí	2,251,730	376,382	402,168	1,053	2,200	0	3,031,333	3,032,480
274	Nazare do Piauí	1,978,368	347,227	274,746	0	0	0	2,600,341	2,600,341
275	Nossa Senhora dos Remedios	1,824,240	132,711	138,330	0	0	0	2,095,281	2,095,281
276	Novo Oriente do Piauí	2,061,977	239,243	264,690	0	0	0	2,565,910	2,565,910
277	Oeiras	3,913,979	1,093,362	1,792,230	3,655	83,474	84,600	6,887,826	6,967,645
278	Padre Marcos	64,496	334,737	206,586	1,523	4,828	0	607,342	610,647
279	Paes Landim	3,679,424	299,029	126,096	0	0	0	4,104,549	4,104,549
280	Palmeira do Piauí	2,263,168	253,168	156,240	0	0	0	2,672,576	2,672,576
281	Palmeirais	3,801,119	401,134	303,234	83,639	11,692	0	4,589,126	4,517,179
282	Parnagua	2,592,137	1,308,841	306,516	1,278	7,191	0	4,208,772	4,214,685
283	Parnaiba	3,434,960	805,770	10,163,160	82,327	1,156,948	2,640,000	17,126,217	18,200,838
284	Passagem Franca do Piauí	2,345,180	202,330	138,036	0	0	0	2,685,546	2,685,546
285	Patos do Piauí	3,165,910	334,973	150,144	0	0	0	3,651,027	3,651,027
286	Paulistana	226,230	995,363	477,546	3,075	28,424	16,200	1,718,414	1,743,763
287	Pedro II	3,040,053	998,835	1,352,550	9,794	63,876	41,400	5,442,632	5,496,714
288	Picos	7,217,974	981,137	3,489,174	57,491	397,902	108,000	11,853,776	12,194,187
289	Pimenteiras	2,678,937	478,116	372,378	575	1,202	0	3,530,006	3,530,633
290	Pio IX	96,748	429,217	225,354	1,059	13,256	0	752,378	764,575
291	Piracuruca	2,441,970	1,267,932	895,644	12,959	136,395	108,000	4,726,505	4,849,941
292	Piripiri	4,789,702	709,064	2,179,794	16,595	229,170	112,500	7,807,655	8,020,230
293	Porto	2,125,045	285,659	475,356	0	0	0	2,886,060	2,886,060
294	Prata do Piauí	2,391,232	89,248	100,812	0	0	0	2,581,292	2,581,292
295	Queimada Nova	67,644	370,506	142,194	0	0	0	580,344	580,344
296	Redencao do Gurgueia	2,907,507	340,965	199,890	0	0	0	3,448,362	3,448,362
297	Regeneracao	1,719,518	217,254	579,942	5,557	107,107	0	2,522,271	2,623,821
298	Ribeiro Goncalves	1,773,105	275,753	254,868	4,957	60,084	0	2,308,683	2,363,810
299	Rio Grande do Piauí	2,613,095	427,390	441,060	83,001	21,477	0	3,564,546	3,503,022
300	Santa Cruz do Piauí	4,258,691	434,538	361,518	1,615	57,759	0	5,056,362	5,112,506
301	Santa Cruz dos Milagres	4,936,666	560,450	110,448	0	0	28,350	5,635,914	5,635,914
302	Santa Filomena	1,845,492	316,456	121,374	276	577	0	2,283,598	2,283,899
303	Santa Luz	1,911,254	104,991	145,968	4,165	19,392	0	2,166,378	2,181,605
304	Santana do Piauí	3,114,275	53,666	119,304	0	0	0	3,287,245	3,287,245
305	Santa Rosa do Piauí	3,421,947	290,155	228,186	2,820	5,893	0	3,943,108	3,946,181
306	Santo Antonio de Lisboa	3,199,663	148,580	166,686	78	163	0	3,515,007	3,515,092
307	Santo Inacio do Piauí	3,702,348	336,810	152,484	0	0	0	4,191,642	4,191,642
308	Sao Braz do Piauí	95,836	66,451	73,338	0	0	0	235,625	235,625
309	Sao Felix do Piauí	3,056,165	309,166	182,682	0	0	0	3,548,013	3,548,013
310	Sao Francisco do Piauí	2,745,906	373,930	256,416	988	2,064	0	3,377,240	3,378,316
311	Sao Goncalo do Piauí	1,963,756	55,516	215,778	1,368	28,550	0	2,236,418	2,263,600
312	Sao Joao da Canabrava	1,836,485	196,178	229,050	0	0	0	2,261,713	2,261,713
313	Sao Joao da Serra	1,703,417	521,878	212,904	0	0	0	2,438,199	2,438,199
314	Sao Joao do Piauí	3,297,648	1,985,597	1,502,496	3,621	82,627	21,600	6,810,962	6,889,968
315	Sao Jose do Divino	3,148,878	344,410	134,172	313	654	0	3,627,773	3,628,114
316	Sao Jose do Peixe	903,753	504,235	212,940	1,683	5,761	0	1,622,611	1,626,689
317	Sao Jose do Piauí	3,255,838	106,090	207,744	1,338	19,415	0	3,571,010	3,589,087
318	Sao Juliao	63,877	125,795	96,396	0	0	0	286,068	286,068
319	Sao Lourenco do Piauí	72,211	215,191	78,054	0	0	0	365,456	365,456
320	Sao Miguel do Tapuio	3,407,580	1,043,294	611,424	169	353	0	5,062,467	5,062,651
321	Sao Pedro do Piauí	2,799,904	177,682	522,942	1,583	47,227	0	3,502,111	3,547,755
322	Sao Raimundo Nonato	241,298	405,374	432,672	8,425	117,819	87,750	1,175,519	1,284,913
323	Sigefredo Pacheco	2,228,065	478,563	443,574	0	0	0	3,150,202	3,150,202
324	Simoes	113,388	624,846	322,158	1,322	2,670	0	1,061,714	1,063,062
325	Simplicio Mendes	3,710,967	828,784	553,626	846	1,768	0	5,094,223	5,095,145
326	Socorro do Piauí	3,783,133	198,328	166,458	0	0	0	4,147,919	4,147,919
327	Teresina	30,712,226	1,212,922	61,820,124	981,958	5,457,534	1,950,000	96,677,230	101,152,806
328	Uniao	38,924,148	671,238	1,099,842	57,601	83,738	0	40,752,829	40,778,966
329	Urucui	2,216,574	402,732	453,162	6,481	130,025	0	3,078,949	3,202,493
330	Valenca do Piauí	3,190,496	478,534	553,452	10,106	63,346	21,600	4,254,188	4,307,428
331	Varzea Branca	64,683	123,493	80,778	0	0	0	268,954	268,954
332	Varzea Grande	3,428,146	173,708	258,750	0	0	0	3,860,604	3,860,604

NoWUM output: Annual withdrawal water uses of 2025 *Coastal Boom and Cash Crops* scenario (RSA)

	irrigation	livestock	domestic	industry_1	industry_2	tourism	total_1	total_2
CE [m³]	1,158,550,830	81,762,239	296,797,402	84,952,613	147,624,259	64,661,772	1,686,724,856	1,749,396,502
PI [m³]	550,147,860	64,313,226	130,290,378	2,204,686	10,774,831	8,324,400	755,280,550	763,850,695
CE [km³]	1,159	82	297	85	148	65	1,687	1,749
PI [km³]	550	64	130	2	11	8	755	764
total [km³]	1,709	146	427	87	158	73	2,442	2,513

4) NoWUM output: Annual withdrawal water uses [m3] of 2025 *Decentralization* scenario (RSB)

Muni_nr	Municipality	irrigation	livestock	domestic	industry_1	industry_2	tourism	total_1	total_2
1	Abaiara	342,021	174,419	228,588	60,133	108,599	0	805,161	853,627
2	Acarape	2,286,926	75,333	354,540	74,776	582,087	0	2,791,575	3,298,886
3	Acarau	4,315,970	490,557	1,787,256	1,096	106,172	471,084	7,065,963	7,171,039
4	Acopiara	318,078	1,327,748	1,253,760	2,472	31,400	8,770	2,910,828	2,939,756
5	Aiuaba	791,148	624,893	368,196	301	545	58,887	1,843,425	1,843,669
6	Alcantaras	354,148	88,132	245,214	0	0	0	687,494	687,494
7	Altaneira	277,061	68,438	186,882	1,254	2,263	0	533,635	534,644
8	Alto Santo	1,211,189	757,271	433,050	1,070	43,054	0	2,402,580	2,444,564
9	Amontada	606,959	512,463	998,280	165	299	471,084	2,588,951	2,589,085
10	Antonina do Norte	321,134	168,094	187,488	5,966	92	0	682,682	676,808
11	Apuiares	4,490,169	257,938	278,550	1,151	4,176	0	5,027,808	5,030,833
12	Aquiraz	758,448	663,359	2,178,348	2,772,463	1,757,239	3,056,448	9,429,066	8,413,842
13	Aracati	1,681,916	345,306	1,912,326	34,913	1,658,122	1,921,704	5,896,165	7,519,374
14	Aracoiaba	2,189,195	430,265	834,246	1,186	2,140	4,392	3,459,284	3,460,238
15	Ararenda	502,036	235,683	273,510	0	0	0	1,011,229	1,011,229
16	Araripe	330,242	398,645	537,204	7,206	527	58,887	1,332,184	1,325,505
17	Aratuba	594,050	139,313	331,818	1,078	6,818	58,887	1,125,146	1,130,886
18	Arneiroz	379,255	529,787	173,574	2,011	3,631	0	1,084,627	1,086,247
19	Assare	1,122,776	622,221	655,278	1,204	2,174	0	2,401,479	2,402,449
20	Aurora	1,484,342	797,900	805,152	2,339	60,794	58,887	3,148,620	3,207,075
21	Baixio	312,908	290,981	176,874	278	503	0	781,041	781,266
22	Banabuiu	1,393,466	824,576	596,940	177,936	321,347	58,887	3,051,805	3,195,216
23	Barbalha	694,900	302,251	1,485,738	31,879	1,318,452	718,430	3,233,198	4,519,771
24	Barreira	224,917	241,796	592,134	92	164	4,392	1,063,331	1,063,403
25	Barro	284,862	527,098	669,654	36,549	66,006	0	1,518,163	1,547,620
26	Barroquinha	640,693	169,291	454,272	6,982	12,609	471,084	1,742,322	1,747,949
27	Baturite	619,616	300,561	946,212	16,315	185,103	72,045	1,954,749	2,123,537
28	Beberibe	7,241,779	575,138	1,308,582	14,101	180,450	1,722,816	10,862,416	11,028,765
29	Bela Cruz	7,947,948	697,427	893,004	3,190	4,167	0	9,541,569	9,542,546
30	Boa Viagem	870,407	1,622,008	1,632,426	16,331	29,491	4,392	4,145,564	4,158,724
31	Brejo Santo	4,262,632	832,023	1,197,960	71,300	128,765	4,392	6,368,307	6,425,772
32	Camocim	3,186,119	437,325	1,827,876	3,487,355	6,298,052	494,472	9,433,147	12,243,844
33	Campos Sales	443,244	392,449	667,818	4,449	70,713	0	1,507,960	1,574,224
34	Caninde	684,563	1,378,575	1,797,402	123,075	222,268	729,136	4,712,751	4,811,944
35	Capistrano	760,204	201,039	483,546	1,078	342	0	1,445,867	1,445,131
36	Caridade	450,677	272,028	320,424	1,668	138,099	0	1,044,797	1,181,228
37	Carire	904,653	564,051	510,846	2,798	8,618	0	1,982,348	1,988,168
38	Caririacu	382,671	458,574	804,756	418	756	58,887	1,705,306	1,705,644
39	Carius	500,943	455,771	601,050	716	1,292	0	1,558,480	1,559,056
40	Carnaubal	785,784	154,177	428,664	2,213	77	135,610	1,506,448	1,504,312
41	Cascavel	4,557,127	493,787	2,521,776	5,394	535,105	681,660	8,259,744	8,789,455
42	Catarina	356,688	416,938	275,136	1,541	2,784	0	1,050,303	1,051,546
43	Catunda	1,137,176	333,732	213,018	0	0	0	1,683,926	1,683,926
44	Caucaia	1,019,034	877,457	9,448,170	301,691	5,881,076	3,734,976	15,381,328	20,960,713
45	Cedro	284,446	696,556	801,276	40,734	73,565	58,887	1,881,899	1,914,730
46	Chaval	430,328	129,224	362,256	1,462	1,725,793	58,887	982,157	2,706,488
47	Choro	697,199	434,637	306,180	34	60	0	1,438,050	1,438,076
48	Chorozinho	789,315	231,939	456,306	320	578	0	1,477,880	1,478,138
49	Coreau	323,541	336,619	583,506	2,247	461	0	1,245,913	1,244,127
50	Crateus	14,718,196	1,567,160	1,676,316	5,718	92,764	67,658	18,035,048	18,122,094
51	Crato	2,922,964	504,147	3,284,634	774,093	1,397,988	1,027,202	8,513,040	9,136,935
52	Croata	557,210	161,693	510,114	2	4	58,887	1,287,906	1,287,908
53	Cruz	908,975	250,667	1,165,440	3,375	6,096	471,084	2,799,541	2,802,262
54	Deputado Irapuan Pinheiro	827,222	326,657	212,208	0	0	0	1,366,087	1,366,087
55	Erere	563,910	321,808	191,352	1,068	3,878	0	1,078,138	1,080,948
56	Eusebio	606,527	88,415	1,251,444	318,262	574,768	4,392	2,269,040	2,525,546
57	Farias Brito	280,012	419,389	657,186	102	184	0	1,356,689	1,356,771
58	Forquilha	255,452	289,107	398,814	13,663	24,673	0	957,036	968,046
59	Fortaleza	705,948	182,936	95,083,880	35,350,820	57,642,704	12,111,084	143,434,668	165,726,552
60	Fortim	676,640	64,559	322,026	9,925	20,551	552,960	1,626,110	1,636,736
61	Frecheirinha	364,243	99,858	275,550	785	1,418	0	740,436	741,069
62	General Sampaio	2,110,282	129,407	120,078	0	0	0	2,359,767	2,359,767
63	Graca	617,405	161,284	384,402	0	0	0	1,163,091	1,163,091
64	Granja	834,167	1,044,073	1,461,066	10,667	19,266	0	3,349,973	3,358,572
65	Granjeiro	188,428	102,641	142,950	0	0	0	434,019	434,019
66	Groairas	1,229,789	134,526	205,716	413	746	0	1,570,444	1,570,777
67	Guaiuba	501,171	135,695	625,722	1,159	61,018	58,887	1,322,634	1,382,493
68	Guaraciaba do Norte	2,013,465	283,116	1,013,274	2,642	3,553	135,610	3,448,107	3,449,018
69	Guaramiranga	722,090	36,456	159,282	253	459	58,887	976,968	977,174
70	Hidrolandia	601,673	491,771	486,492	978	61,417	0	1,580,914	1,641,353
71	Horizonte	370,438	285,091	911,136	1,764,635	787,189	21,938	3,353,238	2,375,792
72	Ibaretama	267,164	507,222	373,338	516	932	0	1,148,240	1,148,656
73	Ibiapina	1,324,851	208,139	598,728	8,736	15,778	135,610	2,276,064	2,283,106
74	Ibicuitinga	287,376	326,711	305,220	0	0	0	919,307	919,307
75	Icapui	5,486,773	231,483	924,756	5,413	9,777	552,960	7,201,385	7,205,749
76	Ico	19,173,628	1,394,121	2,299,500	19,205	34,682	58,887	22,945,341	22,960,818
77	Iguatu	9,088,479	1,231,546	3,558,762	587,329	1,060,696	80,820	14,546,936	15,020,303
78	Independencia	747,105	1,707,064	615,090	4,444	4,338	0	3,073,703	3,073,597
79	Ipaporanga	304,191	324,911	294,438	0	0	0	923,540	923,540
80	Ipaumirim	270,517	351,429	343,944	6,487	63,129	0	972,377	1,029,019
81	Ipu	636,453	446,805	1,627,572	7,826	14,136	58,887	2,777,543	2,783,853
82	Ipueiras	458,596	575,665	835,050	1,144	2,064	0	1,870,455	1,871,375
83	Iracema	415,661	531,158	461,562	25,932	11,945	0	1,434,313	1,420,326
84	Iraucuba	598,951	752,957	468,390	349	631	0	1,820,647	1,820,929

Muni_nr	Municipality	irrigation	livestock	domestic	industry_1	industry_2	tourism	total_1	total_2
85	Itaicaba	201,679	146,411	200,106	1,072	890	0	549,268	549,086
86	Itaitinga	1,237,766	178,871	982,962	3,717	9,615	7,027	2,410,343	2,416,241
87	Itapage	701,606	413,682	1,116,870	589,196	1,064,068	67,658	2,889,012	3,363,884
88	Itapipoca	779,309	980,150	3,580,428	582,062	1,051,186	494,472	6,416,421	6,885,545
89	Itapiuna	1,731,217	332,334	343,476	893	1,612	0	2,407,920	2,408,639
90	Itarema	382,890	451,277	844,656	4,941	8,924	506,184	2,189,948	2,193,931
91	Itatira	870,769	382,455	386,040	195	354	58,887	1,698,346	1,698,505
92	Jaguaretama	14,737,168	1,959,759	599,076	492	887	0	17,296,495	17,296,890
93	Jaguaribara	3,741,538	887,612	237,972	4,209	847	0	4,871,331	4,867,969
94	Jaguaribe	22,036,580	2,027,566	1,499,394	72,430	130,808	8,770	25,644,740	25,703,118
95	Jaguaruana	16,371,284	635,990	948,966	12,657	516,171	0	17,968,897	18,472,411
96	Jardim	569,179	544,192	859,866	3,266	5,899	9,936	1,986,439	1,989,072
97	Jati	1,618,443	199,089	206,142	3,276	3,279	0	2,026,950	2,026,953
98	Jijoca de Jericoacoara	426,703	84,946	444,030	0	0	1,161,276	2,116,955	2,116,955
99	Juazeiro do Norte	3,308,162	260,257	6,227,628	257,236	1,270,252	3,450,109	13,503,392	14,516,408
100	Jucas	294,043	479,962	735,780	361,785	653,373	0	1,871,570	2,163,158
101	Lavras da Mangabeira	630,915	971,455	1,129,710	7,178	14,396	0	2,739,258	2,746,476
102	Limoeiro do Norte	23,641,240	574,140	1,765,560	1,764,813	3,187,194	80,820	27,826,573	29,248,954
103	Madalena	1,096,385	585,502	356,280	345	621	0	2,038,512	2,038,788
104	Maracanau	406,900	97,262	6,300,630	8,299,898	11,200,069	0	15,104,690	18,004,861
105	Maranguape	398,463	802,287	3,783,216	754,974	1,884,131	108,252	5,847,192	6,976,349
106	Marco	7,734,268	395,825	605,928	13,413	197	0	8,749,434	8,736,218
107	Martinopole	439,744	108,796	230,172	3,087	11,211	4,392	786,191	794,315
108	Massape	823,162	315,310	654,360	10,495	9,144	0	1,803,327	1,801,976
109	Mauriti	2,930,902	1,080,301	1,235,652	357	31,617	0	5,247,212	5,278,472
110	Meruoca	1,433,008	52,101	434,370	9,129	16,487	58,887	1,987,495	1,994,853
111	Milagres	316,834	498,223	791,196	3,215	41,995	0	1,609,468	1,648,248
112	Milha	510,987	520,101	315,366	19	34	0	1,346,473	1,346,488
113	Miraima	607,671	486,303	283,020	0	0	0	1,376,994	1,376,994
114	Missao Velha	324,791	570,762	939,858	4,124	27,204	52,632	1,892,167	1,915,247
115	Mombaca	520,509	1,380,392	1,039,554	1,862	3,364	8,770	2,951,087	2,952,589
116	Monsenhor Tabosa	358,081	491,578	415,824	70	125	0	1,265,553	1,265,608
117	Morada Nova	18,407,442	1,953,088	2,836,596	229,229	413,983	58,887	23,485,242	23,669,996
118	Moraujo	344,393	186,654	171,426	2,822	10,249	0	705,295	712,722
119	Morrinhos	400,010	264,587	514,398	1,589	3,663	0	1,180,584	1,182,658
120	Mucambo	302,098	119,818	335,652	0	0	0	757,568	757,568
121	Mulungu	559,235	48,671	286,278	5	10	58,887	953,076	953,081
122	Nova Olinda	267,209	177,412	446,268	3,160	421,430	58,887	952,936	1,371,206
123	Nova Russas	595,645	446,137	777,564	15,192	27,437	8,770	1,843,308	1,855,553
124	Novo Oriente	534,486	696,233	668,502	38	68	0	1,899,259	1,899,289
125	Ocara	633,432	386,957	709,950	0	0	0	1,730,339	1,730,339
126	Oros	4,565,829	516,424	774,708	3,504	33,675	63,274	5,923,739	5,953,910
127	Pacajus	2,312,266	400,788	1,286,880	2,913,596	893,186	67,658	6,981,188	4,960,778
128	Pacatuba	966,952	156,150	1,859,946	1,442,559	2,598,589	94,219	4,519,826	5,675,856
129	Pacoti	796,317	124,026	326,640	6,530	11,792	58,887	1,312,400	1,317,662
130	Pacuja	618,788	84,890	144,444	3,263	5,892	0	851,385	854,014
131	Palhano	495,374	166,468	240,306	2,471	214,781	0	904,619	1,116,929
132	Palmacia	394,724	112,093	289,824	185	336	58,887	855,713	855,864
133	Paracuru	9,632,847	220,873	796,656	1,171	158,609	763,536	11,415,083	11,572,521
134	Paraipaba	47,894,948	212,954	626,136	1,177	424	693,348	49,428,563	49,427,810
135	Parambu	777,462	1,264,266	775,128	57	102	0	2,816,913	2,816,958
136	Paramoti	960,582	261,164	270,084	1,729	111,568	0	1,493,559	1,603,398
137	Pedra Branca	1,442,091	894,099	1,108,980	16,609	29,996	0	3,461,779	3,475,166
138	Penaforte	299,312	132,984	183,444	1,934	5,106	0	617,674	620,846
139	Pentecoste	12,432,753	529,057	717,408	11,023	16,125	58,887	13,749,128	13,754,230
140	Pereiro	430,889	262,626	420,696	2,489	3,638	58,887	1,175,587	1,176,736
141	Pindoretama	390,436	173,282	474,192	549	992	294,428	1,332,887	1,333,330
142	Piquet Carneiro	580,185	360,131	341,484	38	69	0	1,281,838	1,281,869
143	Pires Ferreira	838,502	196,564	532,830	0	0	0	1,567,896	1,567,896
144	Poranga	785,179	296,376	304,476	151	273	58,887	1,445,069	1,445,191
145	Porteiras	315,976	375,144	451,962	1,711	42	0	1,144,793	1,143,124
146	Potengi	321,224	228,487	256,680	605	1,095	0	806,996	807,486
147	Potiretama	401,847	357,556	170,754	0	0	0	930,157	930,157
148	Quiterianopolis	813,914	630,768	454,032	0	0	0	1,898,714	1,898,714
149	Quixada	1,404,154	1,843,882	2,063,040	144,580	75,756	85,208	5,540,864	5,472,040
150	Quixelo	1,034,512	772,021	517,434	1,501	2,711	0	2,325,468	2,326,678
151	Quixeramobim	6,604,287	2,278,563	2,887,710	88,911	160,570	67,658	11,927,129	11,998,788
152	Quixere	2,197,909	268,745	507,210	8,353	520	0	2,982,217	2,974,384
153	Redencao	939,563	97,656	768,642	3,691	212,739	63,274	1,872,826	2,081,874
154	Reriutaba	310,200	252,985	536,538	1,378	1,063	0	1,101,101	1,100,786
155	Russas	28,652,328	752,596	1,381,056	30,159	854,497	0	30,816,139	31,640,477
156	Saboeiro	316,420	655,070	390,576	0	0	0	1,362,066	1,362,066
157	Salitre	523,014	343,559	332,862	0	0	0	1,199,435	1,199,435
158	Santana do Acarau	23,481,182	1,081,370	633,702	4,969	34,234	0	25,201,223	25,230,488
159	Santana do Cariri	1,041,681	461,994	1,288,518	5,407	251,612	6,700	2,804,300	3,050,505
160	Santa Quiteria	343,671	1,823,770	769,956	83,422	159,943	0	3,020,819	3,097,340
161	Sao Benedito	2,339,131	290,267	1,197,918	21,926	10,976	135,610	3,984,852	3,973,902
162	Sao Goncalo do Amarante	7,287,636	456,289	1,871,358	2,450	230,636	880,536	10,498,269	10,726,455
163	Sao Joao do Jaguaribe	558,638	269,642	471,084	2,788	5,033	0	1,302,152	1,304,397
164	Sao Luis do Curu	3,943,254	119,539	354,024	95	173	0	4,416,912	4,416,990
165	Senador Pompeu	1,522,062	631,035	653,676	5,121	12,337	13,158	2,825,052	2,832,268
166	Senador Sa	653,132	127,709	163,098	1,322	4,804	0	945,261	948,743
167	Sobral	1,306,044	1,341,027	2,593,710	10,403	2,280,378	102,753	5,353,937	7,623,912
168	Solonopole	784,079	1,037,175	668,586	1,440	2,601	0	2,491,280	2,492,441
169	Tabuleiro do Norte	8,301,097	582,604	949,500	31,767	130,125	0	9,864,968	9,963,326
170	Tamboril	368,509	1,255,933	885,576	1,092	17,915	0	2,511,110	2,527,933
171	Tarrafas	323,366	197,184	270,960	0	0	0	791,510	791,510

Muni_nr	Municipality	irrigation	livestock	domestic	industry_1	industry_2	tourism	total_1	total_2
172	Taua	398,480	2,596,796	1,284,366	1,504	2,956	0	4,281,146	4,282,598
173	Tejucuoca	331,214	301,845	301,920	0	0	0	934,979	934,979
174	Tiangua	2,726,196	504,949	1,483,338	21,026	28,197	135,610	4,871,119	4,878,290
175	Trairi	821,172	420,012	1,300,398	2,171	362	506,184	3,049,937	3,048,128
176	Tururu	643,138	135,787	294,210	0	0	0	1,073,135	1,073,135
177	Ubajara	15,326,086	312,914	793,866	10,662	9,652	135,610	16,579,138	16,578,128
178	Umari	537,686	395,363	215,058	16	28	0	1,148,123	1,148,135
179	Umirim	1,922,680	364,794	457,392	1,727	4,191	0	2,746,593	2,749,057
180	Uruburetama	573,810	80,576	515,292	5,285	68,499	58,887	1,233,850	1,297,064
181	Uruoca	320,111	259,535	248,466	2,988	1,090	4,392	835,492	833,594
182	Varjota	9,673,615	113,164	346,356	1,276	4,631	0	10,134,411	10,137,766
183	Varzea Alegre	489,451	648,346	986,910	61,901	111,792	58,887	2,245,495	2,295,386
184	Vicosa do Ceara	288,770	656,664	1,417,170	1,562	3,995	135,610	2,499,776	2,502,209
185	Agricolandia	370,308	33,497	222,024	89,744	23,222	0	715,573	649,051
186	Agua Branca	549,170	140,125	517,032	5,537	79,970	0	1,211,864	1,286,297
187	Alagoinha do Piaui	51,142	227,797	188,946	0	0	0	467,885	467,885
188	Alegrete do Piaui	32,604	156,949	86,052	0	0	0	275,605	275,605
189	Alto Longa	787,941	1,113,042	478,422	2,312	18,490	0	2,381,717	2,397,895
190	Altos	1,426,515	954,426	982,200	7,981	231,798	0	3,371,122	3,594,939
191	Amarante	839,548	392,254	869,658	2,622	27,648	27,000	2,131,082	2,156,108
192	Angical do Piaui	556,726	182,759	215,844	1,680	9,478	0	957,009	964,807
193	Anisio de Abreu	98,381	344,330	211,662	342	715	0	654,715	655,088
194	Antonio Almeida	1,479,354	265,875	150,426	534	1,116	0	1,896,189	1,896,771
195	Aroazes	1,003,094	354,036	280,716	0	0	0	1,637,846	1,637,846
196	Arraial	493,582	180,690	264,654	0	0	0	938,926	938,926
197	Avelino Lopes	1,138,004	0	384,768	2,372	4,956	0	1,525,144	1,527,728
198	Baixa Grande do Ribeiro	12,155,918	0	251,886	0	0	0	12,407,804	12,407,804
199	Barras	2,034,114	1,153,520	1,609,842	13,154	68,329	21,600	4,832,230	4,887,405
200	Barreiras do Piaui	1,050,162	0	152,352	5,228	12,176	0	1,207,742	1,214,690
201	Barro Duro	1,119,865	107,468	176,070	2,684	121,354	0	1,406,087	1,524,757
202	Batalha	574,777	1,293,899	640,800	738	1,541	16,200	2,526,414	2,527,217
203	Beneditinos	388,052	572,526	311,766	3,424	23,307	0	1,275,768	1,295,651
204	Bertolinia	1,128,875	0	444,258	295	616	0	1,573,428	1,573,749
205	Bocaina	669,758	216,766	186,720	0	0	0	1,073,244	1,073,244
206	Bom Jesus	4,058,639	0	889,194	3,112	48,821	0	4,950,945	4,996,654
207	Bom Principio do Piaui	399,329	230,342	175,284	0	0	5,400	810,355	810,355
208	Bonfim do Piaui	60,179	192,967	122,982	0	0	0	376,128	376,128
209	Brasileira	512,231	394,993	229,782	1,013	2,116	0	1,138,019	1,139,122
210	Buriti dos Lopes	3,861,386	1,000,072	965,076	11,254	28,237	0	5,837,788	5,854,771
211	Buriti dos Montes	238,876	458,937	226,038	0	0	0	923,851	923,851
212	Cabeceiras do Piaui	538,526	498,010	238,380	1,515	3,165	0	1,276,431	1,278,081
213	Caldeirao Grande do Piaui	178,695	243,953	138,618	0	0	0	561,266	561,266
214	Campinas do Piaui	620,675	556,943	157,410	0	0	0	1,335,028	1,335,028
215	Campo Maior	1,803,594	2,415,083	2,196,684	9,578	212,836	75,600	6,500,539	6,703,797
216	Canavieira	886,535	0	192,108	161	337	0	1,078,804	1,078,980
217	Canto do Buriti	2,963,901	0	1,584,282	1,922	101,080	16,200	4,566,305	4,665,463
218	Capitao de Campos	897,801	229,801	234,102	156	326	0	1,361,860	1,362,030
219	Caracol	171,380	386,431	418,260	0	0	5,400	981,471	981,471
220	Castelo do Piaui	423,526	1,043,511	880,860	3,310	25,665	0	2,351,207	2,373,562
221	Cocal	907,307	971,777	642,072	21,591	16,030	0	2,542,747	2,537,186
222	Coivaras	561,250	195,972	121,224	0	0	0	878,446	878,446
223	Colonia do Gurgueia	734,994	0	143,460	0	0	0	878,454	878,454
224	Colonia do Piaui	536,859	397,635	191,898	0	0	0	1,126,392	1,126,392
225	Conceicao do Caninde	63,719	530,009	252,450	0	0	0	846,178	846,178
226	Coronel Jose Dias	90,918	246,896	98,262	0	0	43,200	479,276	479,276
227	Corrente	2,472,933	0	878,082	5,780	143,707	16,200	3,372,995	3,510,922
228	Cristalandia do Piaui	2,126,810	0	199,026	271	6,919	0	2,326,107	2,332,755
229	Cristino Castro	17,602,956	0	554,838	23,803	110,856	16,200	18,197,797	18,284,850
230	Curimata	1,419,755	0	382,326	4,330	30,150	0	1,806,411	1,832,231
231	Demerval Lobao	538,704	175,785	543,228	2,881	27,895	0	1,260,598	1,285,612
232	Dirceu Arcoverde	36,307	375,073	139,566	720	1,504	0	551,666	552,450
233	Dom Expedito Lopes	699,221	93,129	279,972	1,608	3,361	0	1,073,930	1,075,683
234	Domingos Mourao	287,568	290,690	244,968	907	1,895	0	824,133	825,121
235	Dom Inocencio	69,905	948,397	228,204	0	0	0	1,246,506	1,246,506
236	Elesbao Veloso	406,432	877,172	642,978	5,055	68,669	0	1,931,637	1,995,251
237	Eliseu Martins	1,194,574	0	152,118	242	505	0	1,346,934	1,347,197
238	Esperantina	700,411	863,178	1,374,498	65,339	106,506	27,000	3,030,426	3,071,593
239	Fartura do Piaui	32,814	291,652	102,630	0	0	0	427,096	427,096
240	Flores do Piaui	1,148,584	0	116,376	1,208	2,525	0	1,266,168	1,267,485
241	Floriano	2,739,926	890,891	1,572,876	122,316	445,586	135,000	5,461,009	5,784,279
242	Francinopolis	853,057	112,452	155,214	0	0	0	1,120,723	1,120,723
243	Francisco Ayres	531,433	195,632	169,086	0	0	0	896,151	896,151
244	Francisco Santos	618,555	199,956	166,986	0	0	0	985,497	985,497
245	Fronteiras	33,845	364,837	204,456	2,766	20,655	0	605,904	623,793
246	Gilbues	1,860,151	0	451,056	6,031	24,879	0	2,317,238	2,336,086
247	Guadalupe	18,359,250	225,448	550,164	9,033	7,803	10,800	19,154,695	19,153,465
248	Hugo Napoleao	431,100	58,030	125,508	2,277	9,450	0	616,915	624,088
249	Inhuma	904,999	312,175	466,776	5,500	11,090	0	1,689,450	1,695,040
250	Ipiranga do Piaui	705,071	162,533	285,582	142	296	0	1,153,328	1,153,482
251	Isaias Coelho	433,417	486,028	308,460	0	0	0	1,227,905	1,227,905
252	Itainopolis	647,621	692,683	491,202	0	0	0	1,831,506	1,831,506
253	Itaueira	1,658,134	0	347,934	86,982	32,919	0	2,093,050	2,038,987
254	Jacobina do Piaui	98,500	582,913	127,056	0	0	0	808,469	808,469
255	Jaicos	146,999	707,694	619,926	1,199	30,033	0	1,475,818	1,504,652
256	Jardim do Mulato	558,808	125,895	149,100	761	1,589	0	834,564	835,392
257	Jerumenha	1,255,021	320,966	158,814	1,061	30,460	0	1,735,862	1,765,261
258	Joaquim Pires	906,520	684,051	399,264	0	0	0	1,989,835	1,989,835

Muni_nr	Municipality	irrigation	livestock	domestic	industry_1	industry_2	tourism	total_1	total_2
259	Jose de Freitas	1,798,481	948,142	1,369,476	10,151	60,391	43,200	4,169,450	4,219,690
260	Lagoa Alegre	439,015	264,042	183,570	0	0	0	886,627	886,627
261	Lagoa do Barro Piaui	75,303	444,268	135,282	0	0	0	654,853	654,853
262	Landri Sales	2,220,004	0	270,120	0	0	0	2,490,124	2,490,124
263	Luis Correia	418,403	739,588	739,284	22,301	63,189	1,584,000	3,503,576	3,544,464
264	Luzilandia	10,308,240	914,375	1,039,860	63,422	54,089	0	12,325,897	12,316,564
265	Manoel Emidio	1,337,401	0	281,766	1,526	3,064	0	1,620,693	1,622,231
266	Marcolandia	46,988	49,984	147,744	0	0	0	244,716	244,716
267	Marcos Parente	1,170,180	0	194,628	80	168	0	1,364,888	1,364,976
268	Matias Olimpio	596,894	198,613	273,300	0	0	0	1,068,807	1,068,807
269	Miguel Alves	13,131,122	688,027	616,176	62,098	59,559	0	14,497,423	14,494,884
270	Miguel Leao	2,668,609	68,381	58,284	91,342	21,426	0	2,886,616	2,816,700
271	Monsenhor Gil	693,957	287,287	309,336	2,886	31,514	5,400	1,298,866	1,327,494
272	Monsenhor Hipolito	31,397	198,369	162,378	707	1,478	0	392,851	393,622
273	Monte Alegre do Piaui	1,265,655	0	450,084	1,106	2,310	0	1,716,845	1,718,049
274	Nazare do Piaui	1,095,312	0	309,660	0	0	0	1,404,972	1,404,972
275	Nossa Senhora dos Remedios	324,689	157,385	162,030	0	0	0	644,104	644,104
276	Novo Oriente do Piaui	485,004	283,710	299,778	0	0	0	1,068,492	1,068,492
277	Oeiras	2,490,254	1,296,596	2,024,706	3,975	90,797	84,600	5,900,131	5,986,953
278	Padre Marcos	77,540	478,226	288,798	1,994	6,319	0	846,558	850,883
279	Paes Landim	688,954	354,609	143,742	0	0	0	1,187,305	1,187,305
280	Palmeira do Piaui	1,539,334	0	176,208	0	0	0	1,715,542	1,715,542
281	Palmeirais	1,744,812	475,732	345,924	90,878	12,704	0	2,657,346	2,579,172
282	Parnagua	1,975,445	0	350,016	1,341	7,546	0	2,326,802	2,333,007
283	Parnaiba	2,075,313	615,910	6,191,118	54,679	768,408	1,584,000	10,521,020	11,234,749
284	Passagem Franca do Piaui	646,746	239,968	156,726	0	0	0	1,043,440	1,043,440
285	Patos do Piaui	571,533	397,243	170,964	0	0	0	1,139,740	1,139,740
286	Paulistana	376,953	1,421,939	663,732	4,031	37,269	16,200	2,482,855	2,516,093
287	Pedro II	1,093,980	1,184,516	1,537,644	10,669	69,581	41,400	3,868,209	3,927,121
288	Picos	7,348,964	1,163,484	3,943,332	62,578	433,114	108,000	12,626,358	12,996,894
289	Pimenteiras	830,054	566,976	422,034	627	1,309	0	1,819,691	1,820,373
290	Pio IX	56,661	613,157	315,486	1,387	17,369	0	986,691	1,002,673
291	Piracuruca	697,217	1,503,597	1,017,438	14,150	148,929	108,000	3,340,402	3,475,181
292	Piripiri	4,124,962	840,875	2,470,602	18,094	249,866	112,500	7,567,033	7,798,805
293	Porto	1,335,318	338,727	540,048	0	0	0	2,214,093	2,214,093
294	Prata do Piaui	437,317	105,865	114,414	0	0	0	657,596	657,596
295	Queimada Nova	65,387	529,289	197,310	0	0	0	791,986	791,986
296	Redencao do Gurgueia	2,074,930	0	226,560	0	0	0	2,301,490	2,301,490
297	Regeneracao	385,632	257,599	657,720	6,042	116,462	0	1,306,993	1,417,413
298	Ribeiro Goncalves	1,037,774	0	285,240	5,199	63,022	0	1,328,213	1,386,036
299	Rio Grande do Piaui	1,370,035	0	493,218	87,045	22,524	0	1,950,298	1,885,777
300	Santa Cruz do Piaui	752,414	515,314	409,824	1,763	63,045	0	1,679,315	1,740,597
301	Santa Cruz dos Milagres	1,953,579	664,647	125,388	0	0	28,350	2,771,964	2,771,964
302	Santa Filomena	1,050,041	0	138,972	290	605	0	1,189,303	1,189,618
303	Santa Luz	1,042,309	0	164,442	4,372	20,356	0	1,211,123	1,227,107
304	Santana do Piaui	569,575	63,646	135,426	0	0	0	768,647	768,647
305	Santa Rosa do Piaui	622,148	344,065	259,662	3,070	6,414	0	1,228,945	1,232,289
306	Santo Antonio de Lisboa	563,604	176,177	189,234	85	178	0	929,100	929,193
307	Santo Inacio do Piaui	685,996	399,422	173,628	0	0	0	1,259,046	1,259,046
308	Sao Braz do Piaui	67,069	94,887	101,760	0	0	0	263,716	263,716
309	Sao Felix do Piaui	566,829	366,596	207,012	0	0	0	1,140,437	1,140,437
310	Sao Francisco do Piaui	509,679	443,458	290,244	1,075	2,246	0	1,244,456	1,245,627
311	Sao Goncalo do Piaui	390,072	65,836	244,188	1,490	31,091	0	701,586	731,187
312	Sao Joao da Canabrava	326,508	232,677	259,962	0	0	0	819,147	819,147
313	Sao Joao da Serra	301,232	618,901	242,082	0	0	0	1,162,215	1,162,215
314	Sao Joao do Piaui	983,000	2,354,647	1,698,432	3,937	89,844	21,600	5,061,616	5,147,523
315	Sao Jose do Divino	951,117	408,440	152,790	341	713	0	1,512,688	1,513,060
316	Sao Jose do Peixe	462,657	0	239,118	1,767	6,049	0	703,542	707,824
317	Sao Jose do Piaui	653,853	125,802	235,680	1,459	21,168	0	1,016,794	1,036,503
318	Sao Juliao	31,887	179,704	133,956	0	0	0	345,547	345,547
319	Sao Lourenco do Piaui	36,220	307,414	108,300	0	0	0	451,934	451,934
320	Sao Miguel do Tapuio	957,459	1,237,219	697,944	183	383	0	2,892,805	2,893,005
321	Sao Pedro do Piaui	823,482	210,725	591,354	1,725	51,449	0	1,627,286	1,677,010
322	Sao Raimundo Nonato	343,758	579,085	601,380	11,036	154,342	87,750	1,623,009	1,766,315
323	Sigefredo Pacheco	425,717	567,487	500,322	0	0	0	1,493,526	1,493,526
324	Simoes	152,036	892,657	449,184	1,737	3,508	0	1,495,614	1,497,385
325	Simplicio Mendes	1,039,769	982,838	626,514	921	1,925	0	2,650,042	2,651,046
326	Socorro do Piaui	653,703	235,174	188,784	0	0	0	1,077,661	1,077,661
327	Teresina	11,518,259	1,093,144	52,542,032	812,901	4,517,947	1,950,000	67,916,336	71,621,382
328	Uniao	53,150,800	796,049	1,250,556	62,754	91,229	0	55,260,159	55,288,634
329	Urucui	1,493,021	0	513,018	6,797	136,353	0	2,012,836	2,142,392
330	Valenca do Piaui	1,098,666	567,500	630,876	11,001	68,954	21,600	2,329,643	2,387,596
331	Varzea Branca	32,412	176,434	112,098	0	0	0	320,944	320,944
332	Varzea Grande	605,181	206,015	293,724	0	0	0	1,104,920	1,104,920

NoWUM output: Annual withdrawal water uses of 2025 *Decentralization* scenario (RSB)

	irrigation	livestock	domestic	industry_1	industry_2	tourism	total_1	total_2
CE [m³]	488,163,676	93,888,438	260,482,382	64,243,556	114,286,712	41,558,214	948,336,266	998,379,422
PI [m³]	265,903,412	60,252,990	125,556,416	2,089,483	9,792,787	6,212,400	460,014,701	467,718,005
CE [km³]	488	94	260	64	114	42	948	998
PI [km³]	266	60	126	2	10	6	460	468
total [km³]	754	154	386	66	124	48	1,408	1,466

5) NoWUM output: Annual withdrawal water uses [m3] of 2025 *Coastal Boom and Cash Crops* intervention scenario (ISA)

Muni_nr	Municipality	irrigation	livestock	domestic	industry_1	industry_2	tourism	total_1	total_2
1	Abaiara	6,048,178	147,074	226,152	55,189	99,669	0	6,476,593	6,521,073
2	Acarape	4,365,486	98,529	609,054	112,771	877,855	0	5,185,840	5,950,924
3	Acarau	16,837,336	641,784	3,317,706	1,652	160,081	785,140	21,583,618	21,742,047
4	Acopiara	500,146	929,412	1,057,176	1,885	23,947	8,770	2,497,389	2,519,451
5	Aiuaba	967,055	437,437	314,490	230	416	58,887	1,778,099	1,778,285
6	Alcantaras	556,791	61,695	209,430	0	0	0	827,916	827,916
7	Altaneira	4,896,798	57,705	191,190	1,153	2,081	0	5,146,846	5,147,774
8	Alto Santo	9,794,656	638,585	435,606	984	39,569	0	10,869,831	10,908,416
9	Amontada	2,507,999	670,423	1,788,978	249	451	785,140	5,752,789	5,752,991
10	Antonina do Norte	5,677,410	141,742	188,976	5,491	84	0	6,013,619	6,008,212
11	Apuiares	2,933,236	180,559	231,306	879	3,189	0	3,345,980	3,348,290
12	Aquiraz	3,603,397	767,414	3,031,452	3,691,880	2,339,982	5,094,080	16,188,223	14,836,325
13	Aracati	3,104,782	451,778	3,335,820	52,646	2,500,326	3,202,840	10,147,866	12,595,546
14	Aracoiaba	3,145,463	562,916	1,484,454	1,787	3,227	12,200	5,206,820	5,208,260
15	Ararenda	728,716	164,948	233,604	0	0	0	1,127,268	1,127,268
16	Araripe	5,840,426	336,174	531,828	6,614	484	58,887	6,773,929	6,767,799
17	Aratuba	2,598,107	182,240	538,104	1,627	10,295	163,575	3,483,653	3,492,321
18	Arneiroz	596,285	370,848	143,028	1,536	2,774	0	1,111,697	1,112,935
19	Assare	8,325,732	524,664	670,344	1,107	1,998	0	9,521,847	9,522,738
20	Aurora	5,054,858	672,818	814,218	2,149	55,857	58,887	6,602,930	6,656,638
21	Baixio	5,532,582	245,366	173,418	256	463	0	5,951,622	5,951,829
22	Banabuiu	7,677,790	695,339	629,940	163,528	295,327	58,887	9,225,484	9,357,283
23	Barbalha	10,102,176	254,873	1,516,098	29,258	1,210,047	718,430	12,620,835	13,801,624
24	Barreira	957,864	316,324	1,053,978	139	247	12,200	2,340,505	2,340,613
25	Barro	5,037,913	444,480	684,606	33,656	60,783	0	6,200,655	6,227,782
26	Barroquinha	2,727,785	221,431	808,602	10,526	19,008	785,140	4,553,484	4,561,966
27	Baturite	2,332,527	393,216	1,619,208	24,618	279,312	200,125	4,569,694	4,824,388
28	Beberibe	7,368,386	752,448	2,310,510	21,275	272,254	2,871,360	13,323,979	13,574,958
29	Bela Cruz	32,070,318	912,413	1,526,442	4,816	6,292	0	34,513,989	34,515,465
30	Boa Viagem	889,478	1,135,419	1,499,904	12,447	22,478	4,392	3,541,640	3,551,671
31	Brejo Santo	21,635,310	701,600	1,225,530	65,558	118,395	4,392	23,632,390	23,685,227
32	Camocim	4,661,630	572,116	3,274,464	5,246,760	9,475,479	824,120	14,579,090	18,807,809
33	Campos Sales	696,924	274,715	577,908	3,388	53,844	0	1,552,935	1,603,391
34	Caninde	837,365	965,004	1,546,062	93,808	169,413	729,136	4,171,375	4,246,980
35	Capistrano	2,674,268	262,976	817,272	1,625	515	0	3,756,141	3,755,031
36	Caridade	656,407	190,405	258,996	1,272	105,289	0	1,107,080	1,211,097
37	Carire	862,730	394,852	443,274	2,139	6,589	0	1,702,995	1,707,445
38	Caririacu	5,890,579	386,743	823,272	383	693	58,887	7,159,864	7,160,174
39	Carius	8,243,970	384,316	614,856	657	1,186	0	9,243,799	9,244,328
40	Carnaubal	6,853,362	130,024	417,678	2,033	71	135,610	7,538,707	7,536,745
41	Cascavel	5,428,551	646,001	5,055,606	8,143	807,763	1,136,100	12,274,401	13,074,021
42	Catarina	560,812	291,850	216,210	1,176	2,124	0	1,070,048	1,070,996
43	Catunda	1,143,845	233,638	173,850	0	0	0	1,551,333	1,551,333
44	Caucaia	2,970,173	1,015,106	13,265,596	401,741	7,831,422	6,224,960	23,877,576	31,307,257
45	Cedro	5,031,075	587,403	819,714	37,335	67,428	58,887	6,534,414	6,564,507
46	Chaval	1,975,592	169,037	619,098	2,206	2,604,285	163,575	2,929,508	5,531,587
47	Choro	974,915	304,227	261,510	26	46	0	1,540,678	1,540,698
48	Chorozinho	2,298,262	303,443	734,208	482	872	0	3,336,395	3,336,785
49	Coreau	508,670	235,638	520,572	1,711	351	0	1,266,591	1,265,231
50	Crateus	34,648,568	1,097,021	1,411,122	4,359	70,705	67,658	37,228,728	37,295,074
51	Crato	8,832,847	425,144	3,360,240	710,856	1,283,784	1,027,202	14,356,289	14,929,217
52	Croata	5,385,258	136,345	512,202	2	3	58,887	6,092,694	6,092,695
53	Cruz	2,885,522	327,976	2,481,000	5,087	9,190	785,140	6,484,725	6,488,828
54	Deputado Irapuan Pinheiro	742,848	228,664	181,242	0	0	0	1,152,754	1,152,754
55	Erere	8,339,296	271,381	190,896	980	3,558	0	8,802,553	8,805,131
56	Eusebio	2,570,775	102,277	1,764,990	424,278	766,228	12,200	4,874,520	5,216,470
57	Farias Brito	4,949,062	353,661	669,306	94	169	0	5,972,123	5,972,198
58	Forquilha	335,879	202,381	326,880	10,401	18,782	0	875,541	883,922
59	Fortaleza	3,450,178	211,635	134,680,016	47,145,436	76,874,896	20,185,140	205,672,405	235,401,865
60	Fortim	1,851,124	84,481	525,342	14,979	31,014	921,600	3,397,526	3,413,561
61	Frecheirinha	572,690	69,926	230,550	600	1,083	0	873,766	874,249
62	General Sampaio	1,526,491	90,592	99,528	0	0	0	1,716,611	1,716,611
63	Graca	879,305	112,882	328,344	0	0	0	1,320,531	1,320,531
64	Granja	3,309,964	1,365,936	2,542,242	16,087	29,055	0	7,234,229	7,247,197
65	Granjeiro	3,156,500	86,581	139,950	0	0	0	3,383,031	3,383,031
66	Groairas	1,117,200	94,152	170,142	315	569	0	1,381,809	1,382,063
67	Guaiuba	2,129,528	157,010	856,062	1,544	81,311	163,575	3,307,719	3,387,486
68	Guaraciaba do Norte	8,462,590	238,719	1,013,208	2,434	3,274	135,610	9,852,561	9,853,401
69	Guaramiranga	2,864,752	47,686	259,212	383	694	163,575	3,335,608	3,335,919
70	Hidrolandia	888,459	344,244	425,640	747	46,869	0	1,659,090	1,705,212
71	Horizonte	1,700,615	372,956	1,630,668	2,659,606	1,186,429	60,938	6,424,783	4,951,606
72	Ibaretama	3,966,675	427,721	381,924	475	857	0	4,776,795	4,777,177
73	Ibiapina	7,095,694	175,501	581,382	8,019	14,484	135,610	7,996,206	8,002,671
74	Ibicuitinga	4,339,064	275,497	312,246	0	0	0	4,926,807	4,926,807
75	Icapui	6,730,544	302,817	1,926,828	8,174	14,763	921,600	9,889,963	9,896,552
76	Ico	21,194,198	1,175,620	2,425,776	17,601	31,785	58,887	24,872,082	24,886,266
77	Iguatu	31,060,434	1,038,536	3,857,322	538,923	973,277	80,820	36,576,035	37,010,389
78	Independencia	901,961	1,194,958	521,754	3,379	3,298	0	2,622,052	2,621,971
79	Ipaporanga	478,243	227,441	251,478	0	0	0	957,162	957,162
80	Ipaumirim	4,783,804	296,345	343,806	5,943	57,831	0	5,429,898	5,481,786
81	Ipu	6,539,738	376,748	1,768,236	7,193	12,992	58,887	8,750,802	8,756,601
82	Ipueiras	652,221	402,986	677,466	871	1,572	0	1,733,544	1,734,245
83	Iracema	6,525,523	447,890	471,624	23,742	10,937	0	7,468,779	7,455,974
84	Iraucuba	903,008	527,104	403,980	266	481	0	1,834,358	1,834,573

Muni_nr	Municipality	irrigation	livestock	domestic	industry_1	industry_2	tourism	total_1	total_2
85	Itaicaba	3,246,036	123,475	200,616	983	815	0	3,571,110	3,570,942
86	Itaitinga	3,246,126	206,926	1,348,044	4,968	12,852	19,520	4,825,584	4,833,468
87	Itapage	2,615,313	541,230	1,841,304	887,341	1,602,507	187,938	6,073,126	6,788,292
88	Itapipoca	2,322,397	1,282,291	6,951,402	878,869	1,587,211	824,120	12,259,079	12,967,421
89	Itapiuna	1,309,069	232,627	283,002	682	1,231	0	1,825,380	1,825,929
90	Itarema	1,757,798	590,377	1,455,894	7,450	13,457	843,640	4,655,159	4,661,166
91	Itatira	1,017,108	267,712	329,712	149	270	58,887	1,673,568	1,673,689
92	Jaguaretama	64,316,648	1,652,609	613,716	452	815	0	66,583,425	66,583,788
93	Jaguaribara	8,494,518	748,480	234,834	3,872	779	0	9,481,704	9,478,611
94	Jaguaribe	26,006,464	1,709,778	1,626,678	66,409	119,933	8,770	29,418,099	29,471,623
95	Jaguaruana	18,322,720	536,329	963,834	11,593	472,784	0	19,834,476	20,295,667
96	Jardim	9,798,901	458,914	879,654	3,002	5,424	9,936	11,150,407	11,152,829
97	Jati	6,384,894	167,885	204,390	3,009	3,013	0	6,760,178	6,760,182
98	Jijoca de Jericoacoara	1,958,960	111,102	866,730	0	0	1,935,460	4,872,252	4,872,252
99	Juazeiro do Norte	9,970,486	219,478	6,284,496	236,173	1,166,238	3,450,109	20,160,742	21,090,807
100	Jucas	462,357	335,961	682,410	276,403	499,175	0	1,757,131	1,979,903
101	Lavras da Mangabeira	7,444,454	819,177	1,172,070	6,579	13,196	0	9,442,280	9,448,897
102	Limoeiro do Norte	60,968,328	484,145	1,859,820	1,619,932	2,925,543	80,820	65,013,045	66,318,656
103	Madalena	959,248	409,821	299,280	263	473	0	1,668,612	1,668,822
104	Maracanau	2,033,642	112,528	8,649,312	11,058,594	14,922,712	0	21,854,076	25,718,194
105	Maranguape	1,991,494	928,140	5,330,388	1,007,582	2,514,546	300,700	9,558,304	11,065,268
106	Marco	31,208,042	517,821	1,042,284	20,168	297	0	32,788,315	32,768,444
107	Martinopole	2,018,842	142,326	390,924	4,647	16,877	12,200	2,568,939	2,581,169
108	Massape	680,074	220,729	550,008	8,028	6,995	0	1,458,839	1,457,806
109	Mauriti	15,431,585	910,979	1,242,690	327	28,993	0	17,585,581	17,614,247
110	Meruoca	1,277,890	36,471	414,534	6,953	12,558	58,887	1,794,735	1,800,340
111	Milagres	5,602,704	420,106	798,540	2,957	38,620	0	6,824,307	6,859,970
112	Milha	556,299	364,071	266,808	14	26	0	1,187,192	1,187,204
113	Miraima	560,403	340,425	241,728	0	0	0	1,142,556	1,142,556
114	Missao Velha	3,722,370	481,305	942,438	3,782	24,950	52,632	5,202,527	5,223,695
115	Mombaca	671,144	966,239	883,554	1,422	2,570	8,770	2,531,129	2,532,277
116	Monsenhor Tabosa	563,002	344,096	355,878	53	95	0	1,263,029	1,263,071
117	Morada Nova	34,059,640	1,646,980	3,091,008	210,014	379,279	58,887	39,066,529	39,235,794
118	Moraujo	541,454	130,669	144,180	2,153	7,821	0	818,456	824,124
119	Morrinhos	1,836,395	346,165	888,342	2,398	5,527	0	3,073,300	3,076,429
120	Mucambo	474,949	83,881	287,106	0	0	0	845,936	845,936
121	Mulungu	2,488,193	63,651	509,568	7	15	163,575	3,224,994	3,225,002
122	Nova Olinda	4,722,944	149,601	470,334	2,903	387,152	58,887	5,404,669	5,788,918
123	Nova Russas	817,598	312,278	661,320	11,583	20,918	8,770	1,811,549	1,820,884
124	Novo Oriente	762,508	487,332	566,784	29	52	0	1,816,653	1,816,676
125	Ocara	2,774,343	506,253	1,263,738	0	0	0	4,544,334	4,544,334
126	Oros	7,720,451	435,468	801,798	3,212	30,873	63,274	9,024,203	9,051,864
127	Pacajus	3,735,922	524,312	2,267,316	4,390,300	1,345,881	187,938	11,105,788	8,061,369
128	Pacatuba	3,585,204	180,615	2,590,836	1,924,231	3,466,260	261,720	8,542,606	10,084,635
129	Pacoti	2,684,981	162,253	539,328	9,861	17,806	163,575	3,559,998	3,567,943
130	Pacuja	809,350	59,424	123,492	2,491	4,498	0	994,757	996,764
131	Palhano	2,107,139	217,785	404,844	3,730	324,181	0	2,733,498	3,053,949
132	Palmacia	1,812,092	146,664	475,002	279	506	163,575	2,597,612	2,597,839
133	Paracuru	9,183,146	288,982	1,406,076	1,766	239,159	1,272,560	12,152,530	12,389,923
134	Paraipaba	68,502,112	278,606	1,031,082	1,772	638	1,155,580	70,969,152	70,968,018
135	Parambu	1,021,510	885,017	646,170	43	78	0	2,552,740	2,552,775
136	Paramoti	919,807	182,790	221,148	1,317	84,962	0	1,325,062	1,408,707
137	Pedra Branca	1,379,949	625,853	976,080	12,673	22,888	0	2,994,555	3,004,770
138	Penaforte	5,293,952	112,137	179,634	1,774	4,682	0	5,587,497	5,590,405
139	Pentecoste	7,328,868	370,383	597,912	8,412	12,306	58,887	8,364,462	8,368,356
140	Pereiro	6,520,352	221,426	416,358	2,285	3,340	58,887	7,219,308	7,220,363
141	Pindoretama	1,792,423	226,708	844,032	827	1,495	490,712	3,354,702	3,355,370
142	Piquet Carneiro	874,960	252,104	291,684	29	52	0	1,418,777	1,418,800
143	Pires Ferreira	838,502	137,594	530,424	0	0	0	1,506,520	1,506,520
144	Poranga	848,544	207,471	260,064	115	208	58,887	1,375,081	1,375,174
145	Porteiras	5,587,712	316,360	444,672	1,571	39	0	6,350,315	6,348,783
146	Potengi	5,679,128	192,676	254,964	557	1,007	0	6,127,325	6,127,775
147	Potiretama	6,735,966	301,521	167,394	0	0	0	7,204,881	7,204,881
148	Quiterianopolis	1,070,089	441,553	381,906	0	0	0	1,893,548	1,893,548
149	Quixada	7,692,524	1,554,891	2,072,166	132,739	69,551	85,208	11,537,528	11,474,340
150	Quixelo	4,599,089	651,036	529,140	1,375	2,483	0	5,780,640	5,781,748
151	Quixeramobim	11,163,872	1,921,409	3,188,028	81,833	147,788	67,658	16,422,800	16,488,755
152	Quixere	6,637,889	226,631	513,882	7,664	477	0	7,386,066	7,378,879
153	Redencao	3,305,015	127,722	1,367,538	5,583	321,733	175,762	4,981,620	5,297,770
154	Reriutaba	487,694	177,093	457,782	1,054	813	0	1,123,623	1,123,382
155	Russas	44,797,020	634,613	1,308,912	27,684	784,371	0	46,768,229	47,524,916
156	Saboeiro	497,548	458,550	319,704	0	0	0	1,275,802	1,275,802
157	Salitre	790,369	240,501	284,304	0	0	0	1,315,174	1,315,174
158	Santana do Acarau	20,413,984	1,414,758	936,666	7,492	51,620	0	22,772,900	22,817,028
159	Santana do Cariri	7,462,623	389,554	1,499,664	4,974	231,490	6,700	9,363,515	9,590,031
160	Santa Quiteria	540,340	1,276,618	572,412	63,532	121,808	0	2,452,902	2,511,178
161	Sao Benedito	7,495,658	244,770	1,196,904	20,082	10,053	135,610	9,093,024	9,082,995
162	Sao Goncalo do Amarante	5,453,694	527,832	2,695,980	3,269	307,646	1,467,560	10,148,335	10,452,712
163	Sao Joao do Jaguaribe	4,442,746	227,367	527,688	2,560	4,622	0	5,200,361	5,202,423
164	Sao Luis do Curu	4,129,773	156,396	604,878	144	260	0	4,891,191	4,891,307
165	Senador Pompeu	1,081,520	441,723	552,516	3,902	9,401	13,158	2,092,819	2,098,318
166	Senador Sa	929,702	89,408	143,778	1,008	3,663	0	1,163,896	1,166,551
167	Sobral	1,204,643	938,748	1,815,618	7,946	1,741,758	102,753	4,069,708	5,803,520
168	Solonopole	8,728,827	874,593	711,786	1,322	2,389	0	10,316,528	10,317,595
169	Tabuleiro do Norte	11,055,034	491,284	978,594	29,220	119,690	0	12,554,132	12,644,602
170	Tamboril	579,395	879,147	802,746	834	13,682	0	2,262,122	2,274,970
171	Tarrafas	4,781,754	166,276	277,194	0	0	0	5,225,224	5,225,224

Muni_nr	Municipality	irrigation	livestock	domestic	industry_1	industry_2	tourism	total_1	total_2
172	Taua	626,523	1,817,744	1,077,672	1,145	2,251	0	3,523,084	3,524,190
173	Tejucuoca	487,584	211,277	257,874	0	0	0	956,735	956,735
174	Tiangua	9,160,705	425,838	1,461,138	19,365	25,970	135,610	11,202,656	11,209,261
175	Trairi	2,493,524	549,500	2,250,942	3,282	547	843,640	6,140,888	6,138,153
176	Tururu	2,620,039	177,646	464,628	0	0	0	3,262,313	3,262,313
177	Ubajara	19,931,596	263,864	784,602	9,781	8,854	135,610	21,125,453	21,124,526
178	Umari	7,818,830	333,433	208,554	15	25	0	8,360,832	8,360,842
179	Umirim	3,289,007	477,245	756,762	2,609	6,331	0	4,525,623	4,529,345
180	Uruburetama	2,404,304	105,391	900,390	7,969	103,293	163,575	3,581,629	3,676,953
181	Uruoca	503,278	181,677	205,632	2,279	831	4,392	897,258	895,810
182	Varjota	13,898,396	79,217	284,850	974	3,537	0	14,263,437	14,266,000
183	Varzea Alegre	8,054,520	546,717	973,080	56,989	102,922	58,887	9,690,193	9,736,126
184	Vicosa do Ceara	5,107,638	553,743	1,431,924	1,435	3,671	135,610	7,230,350	7,232,586
185	Agricolandia	2,181,005	28,246	214,416	82,484	21,344	0	2,506,151	2,445,011
186	Agua Branca	2,472,017	118,140	482,586	5,085	73,448	0	3,077,828	3,146,191
187	Alagoinha do Piaui	51,142	159,459	158,004	0	0	0	368,605	368,605
188	Alegrete do Piaui	65,282	109,876	63,558	0	0	0	238,716	238,716
189	Alto Longa	2,954,304	938,570	446,394	2,121	16,961	0	4,341,389	4,356,229
190	Altos	3,072,506	804,870	890,868	7,327	212,811	0	4,775,571	4,981,055
191	Amarante	2,826,393	330,807	864,876	2,411	25,426	27,000	4,051,487	4,074,502
192	Angical do Piaui	2,693,014	154,097	202,836	1,541	8,693	0	3,051,488	3,058,640
193	Anisio de Abreu	103,299	241,063	161,772	261	546	0	506,395	506,680
194	Antonio Almeida	4,003,067	224,202	145,002	492	1,028	0	4,372,763	4,373,299
195	Aroazes	3,760,232	298,531	276,552	0	0	0	4,335,315	4,335,315
196	Arraial	2,820,440	152,369	263,466	0	0	0	3,236,275	3,236,275
197	Avelino Lopes	2,102,105	505,812	357,168	2,262	4,727	0	2,967,347	2,969,812
198	Baixa Grande do Ribeiro	5,019,870	345,693	237,606	0	0	0	5,603,169	5,603,169
199	Barras	3,699,246	972,704	1,543,074	12,076	62,732	21,600	6,248,700	6,299,356
200	Barreiras do Piaui	1,661,506	252,142	145,032	4,983	11,607	0	2,063,663	2,070,287
201	Barro Duro	3,223,742	90,625	159,606	2,463	111,357	0	3,476,436	3,585,330
202	Batalha	2,418,711	1,091,092	590,220	676	1,412	16,200	4,116,899	4,117,635
203	Beneditinos	2,178,298	482,765	288,516	3,147	21,421	0	2,952,726	2,971,000
204	Bertolinia	1,549,739	717,708	441,072	281	587	0	2,708,800	2,709,106
205	Bocaina	2,814,330	182,794	183,996	0	0	0	3,181,120	3,181,120
206	Bom Jesus	2,804,236	860,951	873,252	2,965	46,511	0	4,541,404	4,584,950
207	Bom Principio do Piaui	2,266,486	194,236	168,516	0	0	5,400	2,634,638	2,634,638
208	Bonfim do Piaui	61,133	135,093	102,210	0	0	0	298,436	298,436
209	Brasileira	2,594,880	333,090	212,136	930	1,943	0	3,141,036	3,142,049
210	Buriti dos Lopes	3,879,192	843,313	912,192	10,360	25,993	0	5,645,057	5,660,690
211	Buriti dos Montes	1,250,129	387,025	217,350	0	0	0	1,854,504	1,854,504
212	Cabeceiras do Piaui	2,466,511	419,954	220,176	1,391	2,906	0	3,108,032	3,109,547
213	Caldeirao Grande do Piaui	141,157	170,793	115,224	0	0	0	427,174	427,174
214	Campinas do Piaui	3,482,433	469,657	147,528	0	0	0	4,099,618	4,099,618
215	Campo Maior	3,509,490	2,036,550	2,112,384	8,804	195,631	75,600	7,742,828	7,929,655
216	Canavieira	1,702,393	289,144	188,730	153	321	0	2,180,420	2,180,588
217	Canto do Buriti	3,233,843	1,068,766	1,585,026	1,832	96,349	16,200	5,905,667	6,000,184
218	Capitao de Campos	3,223,488	193,768	207,396	143	299	0	3,624,795	3,624,951
219	Caracol	137,041	270,515	378,516	0	0	5,400	791,472	791,472
220	Castelo do Piaui	2,329,183	879,953	849,732	3,039	23,566	0	4,061,907	4,082,434
221	Cocal	3,353,319	819,460	566,976	19,853	14,740	0	4,759,608	4,754,495
222	Coivaras	2,686,904	165,260	116,274	0	0	0	2,968,438	2,968,438
223	Colonia do Gurgueia	1,326,858	101,875	134,172	0	0	0	1,562,905	1,562,905
224	Colonia do Piaui	2,775,076	335,296	176,118	0	0	0	3,286,490	3,286,490
225	Conceicao do Canindе	89,208	371,030	222,240	0	0	0	682,478	682,478
226	Coronel Jose Dias	115,117	172,834	81,654	0	0	43,200	412,805	412,805
227	Corrente	2,634,356	1,549,851	834,012	5,522	137,301	16,200	5,039,941	5,171,720
228	Cristalandia do Piaui	2,737,779	533,465	186,636	259	6,609	0	3,458,139	3,464,489
229	Cristino Castro	34,241,836	339,462	546,108	22,732	105,870	16,200	35,166,338	35,249,476
230	Curimata	2,346,926	854,109	353,196	4,132	28,772	0	3,558,363	3,583,003
231	Demerval Lobao	2,017,454	148,258	527,340	2,647	25,636	0	2,695,699	2,718,688
232	Dirceu Arcoverde	72,360	262,570	108,414	547	1,144	0	443,891	444,488
233	Dom Expedito Lopes	3,373,564	78,520	276,942	1,478	3,087	0	3,730,504	3,732,113
234	Domingos Mourao	1,693,772	245,114	245,358	832	1,738	0	2,185,076	2,185,982
235	Dom Inocencio	106,947	663,862	189,678	0	0	0	960,487	960,487
236	Elesbao Veloso	2,195,718	739,672	628,374	4,643	63,081	0	3,568,407	3,626,845
237	Eliseu Martins	2,294,329	233,948	144,000	230	481	0	2,672,507	2,672,758
238	Esperantina	2,620,040	727,902	1,319,412	59,991	97,789	27,000	4,754,345	4,792,143
239	Fartura do Piaui	65,487	204,153	83,058	0	0	0	352,698	352,698
240	Flores do Piaui	2,089,756	186,136	105,720	1,154	2,412	0	2,382,766	2,384,024
241	Floriano	4,305,362	751,256	1,468,326	112,249	408,913	135,000	6,772,193	7,068,857
242	Francinopolis	3,212,662	94,828	145,266	0	0	0	3,452,756	3,452,756
243	Francisco Ayres	3,008,796	164,969	160,212	0	0	0	3,333,977	3,333,977
244	Francisco Santos	3,470,851	168,598	151,746	0	0	0	3,791,195	3,791,195
245	Fronteiras	67,723	255,395	157,656	2,106	15,730	0	482,880	496,504
246	Gilbues	2,507,255	510,198	432,618	5,756	23,747	0	3,455,827	3,473,818
247	Guadalupe	72,973,904	190,084	548,790	8,294	7,164	10,800	73,731,872	73,730,742
248	Hugo Napoleao	2,419,282	48,940	119,730	2,087	8,662	0	2,590,039	2,596,614
249	Inhuma	3,134,366	263,251	443,334	5,049	10,181	0	3,846,000	3,851,132
250	Ipiranga do Piaui	3,075,548	137,090	272,316	131	273	0	3,485,085	3,485,227
251	Isaias Coelho	2,552,516	409,854	300,702	0	0	0	3,263,072	3,263,072
252	Itainopolis	2,429,872	584,085	472,734	0	0	0	3,486,691	3,486,691
253	Itaueira	1,406,267	493,046	329,196	83,112	31,454	0	2,311,621	2,259,963
254	Jacobina do Piaui	82,308	408,012	105,600	0	0	0	595,920	595,920
255	Jaicos	109,505	495,382	512,658	914	22,902	0	1,118,459	1,140,447
256	Jardim do Mulato	3,078,624	106,163	142,494	699	1,462	0	3,327,980	3,328,743
257	Jerumenha	2,252,149	270,638	151,776	974	27,959	0	2,675,537	2,702,522
258	Joaquim Pires	2,266,928	576,822	363,000	0	0	0	3,206,750	3,206,750

Muni_nr	Municipality	irrigation	livestock	domestic	industry_1	industry_2	tourism	total_1	total_2
259	Jose de Freitas	3,350,389	799,510	1,349,448	9,301	55,333	43,200	5,551,848	5,597,880
260	Lagoa Alegre	2,064,030	222,629	169,962	0	0	0	2,456,621	2,456,621
261	Lagoa do Barro Piaui	106,469	310,986	112,440	0	0	0	529,895	529,895
262	Landri Sales	2,002,142	239,816	265,710	0	0	0	2,507,668	2,507,668
263	Luis Correia	1,698,278	967,581	1,110,258	33,538	95,027	2,640,000	6,449,655	6,511,144
264	Luzilandia	39,630,244	771,053	962,742	58,187	49,625	0	41,422,226	41,413,664
265	Manoel Emidio	2,486,301	313,996	276,240	1,454	2,921	0	3,077,991	3,079,458
266	Marcolandia	82,759	35,005	122,778	0	0	0	240,542	240,542
267	Marcos Parente	2,193,793	185,530	188,136	77	161	0	2,567,536	2,567,620
268	Matias Olimpio	2,909,613	167,500	233,340	0	0	0	3,310,453	3,310,453
269	Miguel Alves	9,993,124	580,200	520,026	57,055	54,721	0	11,150,405	11,148,071
270	Miguel Leao	4,125,396	57,635	56,022	83,973	19,697	0	4,323,026	4,258,750
271	Monsenhor Gil	2,679,698	242,256	281,874	2,650	28,933	5,400	3,211,878	3,238,161
272	Monsenhor Hipolito	62,895	138,841	132,606	539	1,126	0	334,881	335,468
273	Monte Alegre do Piaui	2,251,730	376,382	441,918	1,053	2,200	0	3,071,083	3,072,230
274	Nazare do Piaui	1,978,368	347,227	295,380	0	0	0	2,620,975	2,620,975
275	Nossa Senhora dos Remedios	1,824,240	132,711	138,672	0	0	0	2,095,623	2,095,623
276	Novo Oriente do Piaui	2,061,977	239,243	293,574	0	0	0	2,594,794	2,594,794
277	Oeiras	3,913,979	1,093,362	2,022,066	3,655	83,474	84,600	7,117,662	7,197,481
278	Padre Marcos	64,496	334,737	218,334	1,523	4,828	0	619,090	622,395
279	Paes Landim	3,679,424	299,029	133,392	0	0	0	4,111,845	4,111,845
280	Palmeira do Piaui	2,263,168	253,168	167,562	0	0	0	2,683,898	2,683,898
281	Palmeirais	3,801,119	401,134	319,212	83,639	11,692	0	4,605,104	4,533,157
282	Parnagua	2,592,137	1,308,841	315,786	1,278	7,191	0	4,218,042	4,223,955
283	Parnaiba	3,434,960	805,770	12,177,552	82,327	1,156,948	2,640,000	19,140,609	20,215,230
284	Passagem Franca do Piaui	2,345,180	202,330	150,378	0	0	0	2,697,888	2,697,888
285	Patos do Piaui	3,165,910	334,973	160,206	0	0	0	3,661,089	3,661,089
286	Paulistana	226,230	995,363	541,266	3,075	28,424	16,200	1,782,134	1,807,483
287	Pedro II	3,040,053	998,835	1,460,478	9,794	63,876	41,400	5,550,560	5,604,642
288	Picos	7,217,974	981,137	3,925,890	57,491	397,902	108,000	12,290,492	12,630,903
289	Pimenteiras	2,678,937	478,116	410,916	575	1,202	0	3,568,544	3,569,171
290	Pio IX	96,748	429,217	234,234	1,059	13,256	0	761,258	773,455
291	Piracuruca	2,441,970	1,267,932	972,204	12,959	136,395	108,000	4,803,065	4,926,501
292	Piripiri	4,789,702	709,064	2,404,620	16,595	229,170	112,500	8,032,481	8,245,056
293	Porto	2,125,045	285,659	515,760	0	0	0	2,926,464	2,926,464
294	Prata do Piaui	2,391,232	89,248	110,316	0	0	0	2,590,796	2,590,796
295	Queimada Nova	67,644	370,506	164,022	0	0	0	602,172	602,172
296	Redencao do Gurgueia	2,907,507	340,965	211,032	0	0	0	3,459,504	3,459,504
297	Regeneracao	1,719,518	217,254	636,954	5,557	107,107	0	2,579,283	2,680,833
298	Ribeiro Goncalves	1,773,105	275,753	280,098	4,957	60,084	0	2,333,913	2,389,040
299	Rio Grande do Piaui	2,613,095	427,390	485,988	83,001	21,477	0	3,609,474	3,547,950
300	Santa Cruz do Piaui	4,258,691	434,538	398,178	1,615	57,759	0	5,093,022	5,149,166
301	Santa Cruz dos Milagres	4,936,666	560,450	120,456	0	0	28,350	5,645,922	5,645,922
302	Santa Filomena	1,845,492	316,456	123,810	276	577	0	2,286,034	2,286,335
303	Santa Luz	1,911,254	104,991	157,092	4,165	19,392	0	2,177,502	2,192,729
304	Santana do Piaui	3,114,275	53,666	130,236	0	0	0	3,298,177	3,298,177
305	Santa Rosa do Piaui	3,421,947	290,155	244,590	2,820	5,893	0	3,959,512	3,962,585
306	Santo Antonio de Lisboa	3,199,663	148,580	181,932	78	163	0	3,530,253	3,530,338
307	Santo Inacio do Piaui	3,702,348	336,810	162,570	0	0	0	4,201,728	4,201,728
308	Sao Braz do Piaui	95,836	66,451	84,576	0	0	0	246,863	246,863
309	Sao Felix do Piaui	3,056,165	309,166	201,714	0	0	0	3,567,045	3,567,045
310	Sao Francisco do Piaui	2,745,906	373,930	285,396	988	2,064	0	3,406,220	3,407,296
311	Sao Goncalo do Piaui	1,963,756	55,516	240,612	1,368	28,550	0	2,261,252	2,288,434
312	Sao Joao da Canabrava	1,836,485	196,178	250,260	0	0	0	2,282,923	2,282,923
313	Sao Joao da Serra	1,703,417	521,878	229,860	0	0	0	2,455,155	2,455,155
314	Sao Joao do Piaui	3,297,648	1,985,597	1,688,094	3,621	82,627	21,600	6,996,560	7,075,566
315	Sao Jose do Divino	3,148,878	344,410	142,968	313	654	0	3,636,569	3,636,910
316	Sao Jose do Peixe	903,753	504,235	231,570	1,683	5,761	0	1,641,241	1,645,319
317	Sao Jose do Piaui	3,255,838	106,090	227,718	1,338	19,415	0	3,590,984	3,609,061
318	Sao Juliao	63,877	125,795	109,488	0	0	0	299,160	299,160
319	Sao Lourenco do Piaui	72,211	215,191	90,024	0	0	0	377,426	377,426
320	Sao Miguel do Tapuio	3,407,580	1,043,294	640,950	169	353	0	5,091,993	5,092,177
321	Sao Pedro do Piaui	2,799,904	177,682	585,888	1,583	47,227	0	3,565,057	3,610,701
322	Sao Raimundo Nonato	241,298	405,374	490,164	8,425	117,819	87,750	1,233,011	1,342,405
323	Sigefredo Pacheco	2,228,065	478,563	505,800	0	0	0	3,212,428	3,212,428
324	Simoes	113,388	624,846	351,822	1,322	2,670	0	1,091,378	1,092,726
325	Simplicio Mendes	3,710,967	828,784	617,352	846	1,768	0	5,157,949	5,158,871
326	Socorro do Piaui	3,783,133	198,328	182,916	0	0	0	4,164,377	4,164,377
327	Teresina	30,712,226	1,212,922	62,266,768	981,958	5,457,534	1,950,000	97,123,874	101,599,450
328	Uniao	38,924,148	671,238	1,186,254	57,601	83,738	0	40,839,241	40,865,378
329	Urucui	2,216,574	402,732	480,210	6,481	130,025	0	3,105,997	3,229,541
330	Valenca do Piaui	3,190,496	478,534	586,116	10,106	63,346	21,600	4,286,852	4,340,092
331	Varzea Branca	64,683	123,493	93,186	0	0	0	281,362	281,362
332	Varzea Grande	3,428,146	173,708	282,282	0	0	0	3,884,136	3,884,136

NoWUM output: Annual withdrawal water uses of 2025 *Coastal Boom and Cash Crops* intervention scenario (ISA)

	irrigation	livestock	domestic	industry_1	industry_2	tourism	total_1	total_2
CE [m³]	1,158,550,830	81,762,239	337,921,398	84,952,613	147,624,259	64,661,772	1,727,848,852	1,790,520,498
PI [m³]	550,147,860	64,313,226	138,071,068	2,204,686	10,774,831	8,324,400	763,061,240	771,631,385
CE [km³]	1,159	82	338	85	148	65	1,728	1,791
PI [km³]	550	64	138	2	11	8	763	772
total [km³]	1,709	146	476	87	158	73	2,491	2,562