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THE GOVERNMENT OF THE PEOPLE'S REPUBLIC OF MALAYSIA  
MINISTRY OF LOCAL GOVERNMENT

1988 STUDY

ON

WATER DEMAND PROBLEMS AND WATER MANAGEMENT IN MALAYSIA

BY

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FOR THE PROJECT

VOLUME IV

STUDY ON THE PROBLEMS OF

WATER DEMAND PROBLEMS AND  
WATER MANAGEMENT STUDY

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JAPAN INTERNATIONAL COOPERATION AGENCY

THE FORMER YUGOSLAV REPUBLIC OF MACEDONIA  
MINISTRY OF MACEDONIA

**THE STUDY  
ON  
INTEGRATED WATER RESOURCES DEVELOPMENT AND  
MANAGEMENT MASTER PLAN  
IN  
THE FORMER YUGOSLAV REPUBLIC OF MACEDONIA**

**FINAL REPORT**

**VOLUME IV  
SUPPORTING REPORT 2**

**WATER DEMAND PROJECTION AND  
WATER BALANCE STUDY**

**MAY 1999**

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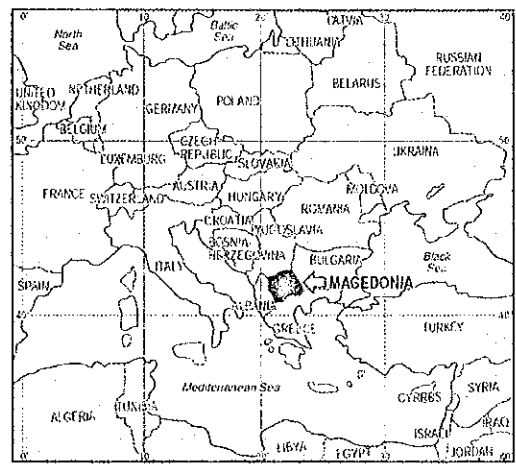
**COMPOSITION OF FINAL REPORT**

- Volume I**      **Executive Summary**
- Volume II**      **Main Report**
- Volume III**      **Supporting Report 1: Sector Study on Current Conditions**  
Appendix    A    Meteorology and Hydrology  
Appendix    B    Groundwater  
Appendix    C    Water Quality  
Appendix    D    River Environment  
Appendix    E    Watershed Management and Flood Control  
Appendix    F    Socioeconomic Conditions  
Appendix    G    Law and Institution  
Appendix    H    PCM Workshop
- Volume IV**      **Supporting Report 2: Water Demand Projection and Water Balance Study**  
Appendix    I    Current Condition of Water Utilization  
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Appendix    L    Outline of Projects Evaluation  
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- Volume VI-1**      **Data Book : Rainfall and Discharge Records**  
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- Volume VI-2**      **Data Book : Results of Water Balance Study**  
Appendix    P    Results of Water Balance Study  
Appendix    Q    Well Inventory  
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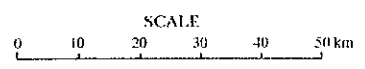
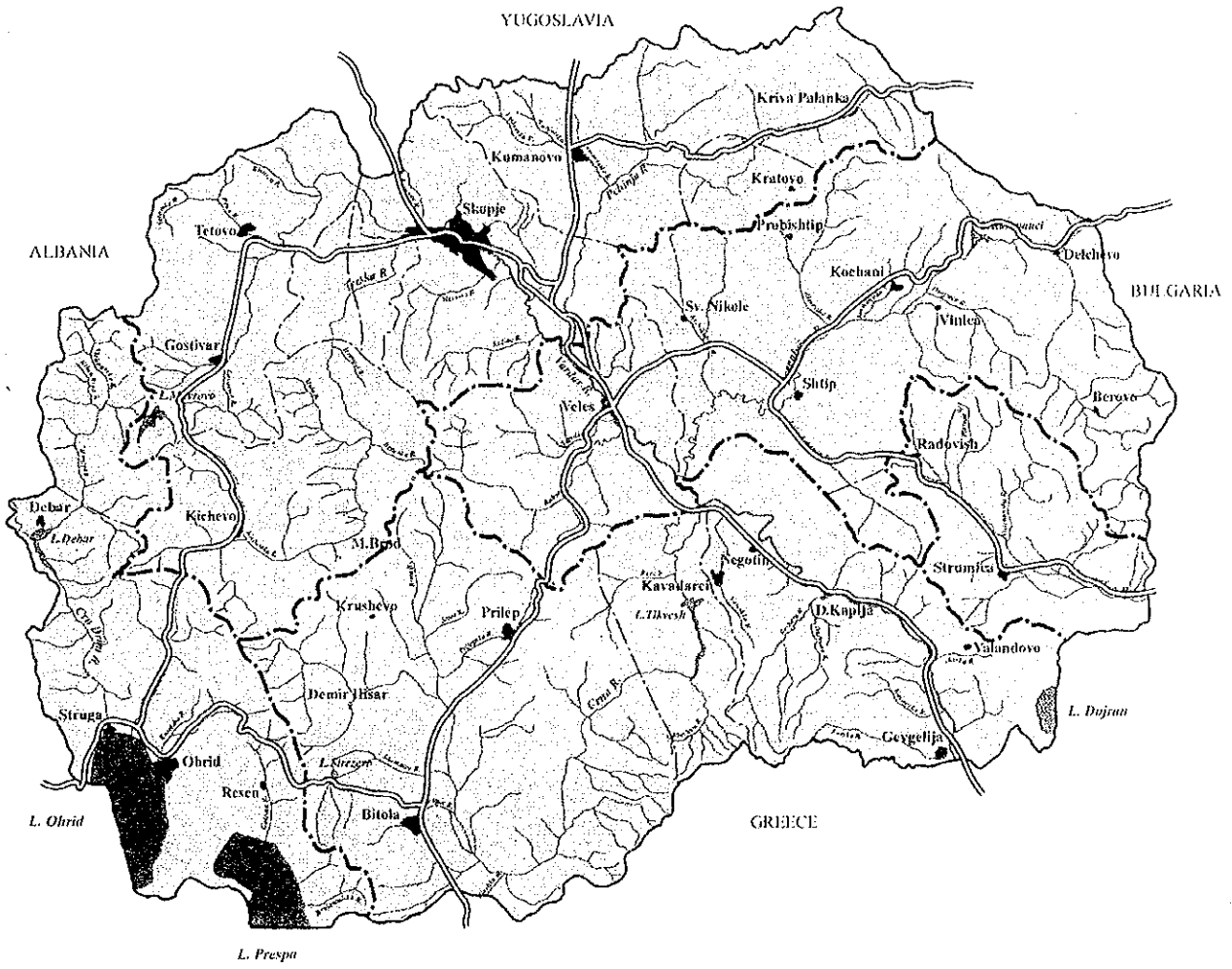
*EXCHANGE RATES*

The exchange rates used in this Study are:	
US Dollar (US\$)1.00	= Macedonian Denar (MKD) 52.00
Deutsche Mark (DM) 1.00	= Macedonian Denar (MKD) 30.98
as of Jan.1999	

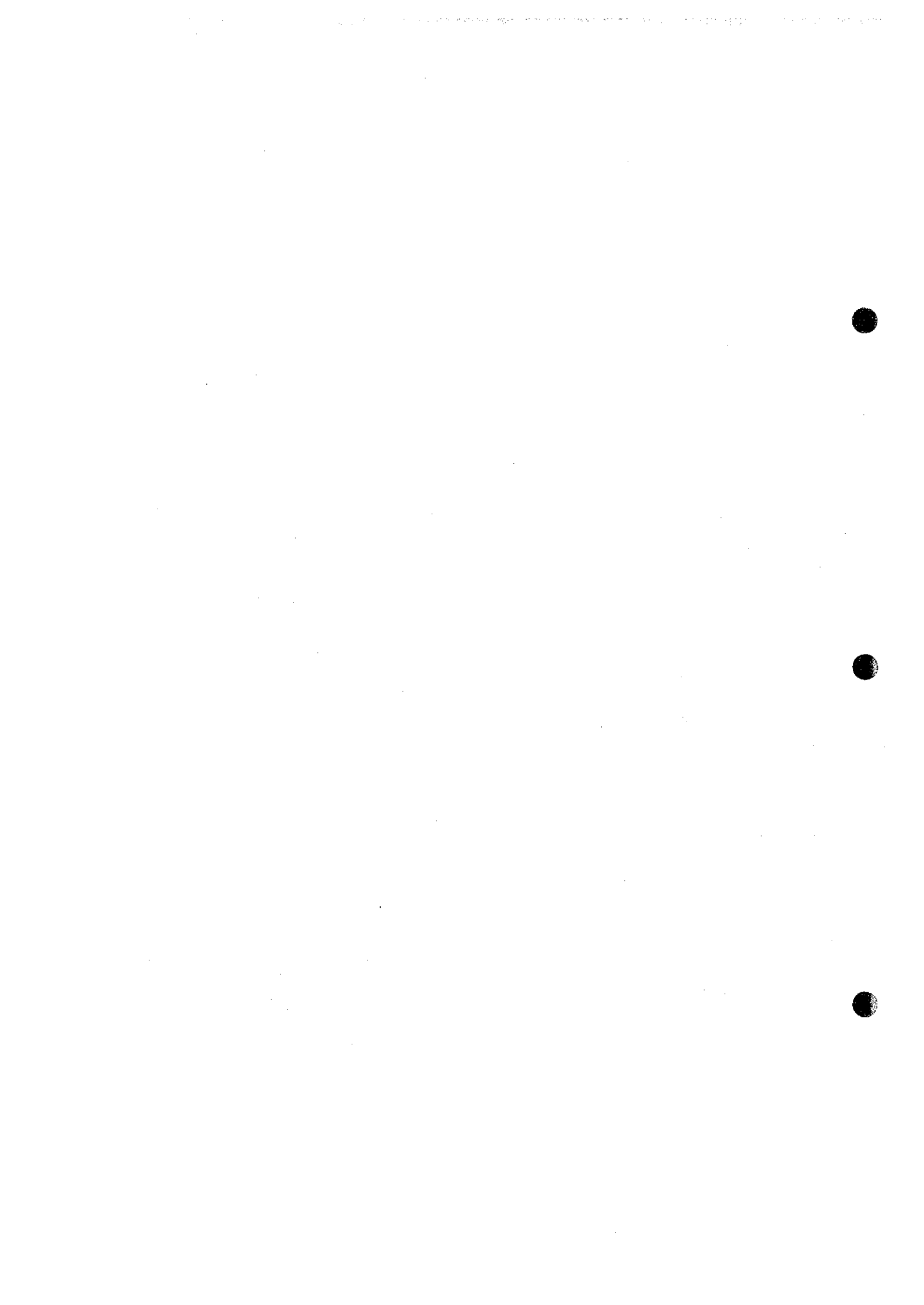




KEY MAP



Location Map



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**FINAL REPORT**

**VOLUME IV  
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**ABBREVIATIONS AND ACRONYMS**

ACU	-	Aid Coordination Unit
a.s.l	-	above sea level
BOD	-	Biological Oxygen Demand
CE(s)	-	Communal Enterprise(s)
DO	-	Dissolved Oxygen
EBRD	-	European Bank for Reconstruction and Development
ECM	-	Electric Power Company of Macedonia
EC	-	European Community
EL	-	Elevation
EU	-	European Union
FRY	-	Federal Republic of Yugoslavia
FYROM	-	The Former Yugoslav Republic of Macedonia
GDP	-	Gross Domestic Product
GEF	-	Global Environment Facility
GNP	-	Gross National Product
GOJ	-	Government of Japan
GOM	-	Government of Macedonia
GTZ	-	Deutsche Gesellschaft für Technische Zusammenarbeit
HMI	-	Republic Hydrometeorological Institute
I/R	-	Interim Report
IEE	-	Initial Environmental Examination
IBRD	-	International Bank for Reconstruction and Development
IDA	-	International Development Association
IMR	-	Infant Mortality Rate
JICA	-	Japan International Cooperation Agency
JUS	-	Jugoslavian Standards
MAFWE	-	Ministry of Agriculture, Forestry and Water Economy
MCIC	-	Macedonian Center for International Cooperation
MKS	-	Macedonian Standards
MOD	-	Ministry of Development
MOE	-	Ministry of Economy
MOH	-	Ministry of Health
MUPC	-	Ministry of Urban Planning and Construction
MOEn	-	Ministry of Environment
MOS	-	Ministry of Science
MOFA	-	Ministry of Foreign Affairs
NDS	-	National Development Strategy 1997
NEAP	-	National Environmental Action Plan 1997
NEHAP	-	National Environmental Health Action Plan
NGO(s)	-	Non Governmental Organization(s)



### ABBREVIATIONS AND ACRONYMS (Continued)

ODA	-	Official Development Assistance
O&M	-	Operation and Maintenance
PCM	-	Project Cycle Management
PDM	-	Project Design Matrix
PHARE	-	Pologne et Hongri Aide a Reconstruction Economique (Poland and Hungary Aid for Economic Reconstruction)
PIP	-	Program for Public Sector Investment in the Republic of Macedonia 1998-2000
P/R	-	Progress Report
PWME	-	Public Water Management Enterprise
RIHP	-	Republic Institute for Health Protection
S/W	-	Scope of Work
SS	-	Suspended Substances
SFRY	-	Socialist Federal Republic Yugoslavia
UNDP	-	United Nations Development Program
UNESCO	-	United Nations Educational, Scientific and Cultural Organization
UNICEF	-	United Nations Children's Fund
WHO	-	World Health Organization
WDI	-	Water Development Institute
WMO(s)	-	Water Management Organization(s)
WUA(s)	-	Water Users' Association(s)

### WEIGHTS AND MEASURES

#### Metric System

mm	-	Millimeter(s)	ha	-	Hectare (100m x 100m)
m	-	Meter(s)	l	-	Liter(s)
m <sup>2</sup>	-	Square meter(s)	lit/sec (l/sec)	-	Liter per second
km <sup>2</sup>	-	Square kilometer(s)	m <sup>3</sup>	-	Cubic meter(s)
lpcd	-	litre/capita/day	m <sup>3</sup> /sec (m <sup>3</sup> /s)	-	Cubic meter(s) per second
			p.e.	-	population equivalent

### CURRENCY

MKD	-	Macedonian Denar	DM	-	Deutsche Mark
USD	-	United States Dollar	JPY	-	Japanese Yen



*Appendix I*

*Current Conditions of Water Utilization*



Appendix I CURRENT CONDITION ON WATER UTILIZATION

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## Appendix I CURRENT CONDITION ON WATER UTILIZATION

### I.1 Present Water Utilization

#### I.1.1 Municipal Water Utilization

The present municipal water utilization was analyzed by three different approaches in order to provide a comprehensive picture of municipal water use in Macedonia. The approaches taken are as follows:

- 1) Analysis of historical water consumption records, obtained from the Statistical Office, for all municipalities in the Republic
- 2) More detailed assessment of the water supply situation in the principal municipal water supply companies (Communal Enterprises)
- 3) Domestic water utilization survey of consumers, by conducting detailed interview surveys with a sample of end-users in the field

#### (1) Municipal Water Demand Model

Historical water consumption records for supplies by municipal water companies, for the period 1990 to 1996, were obtained from the Statistical Office sub-divided into the following six categories:

- 1) Domestic households
- 2) Communal facilities (parks, hospitals, schools etc.)
- 3) Commercial establishments (shops, offices, hotels etc.)
- 4) Potable supplies to industry (excluding water from own sources)
- 5) Supplies to others (unspecified)
- 6) System losses (network leakage and treatment plant usage)

These data, together with population data from the Statistical Office, were input into a water demand model which was used to determine actual per-capita water consumption rates for each municipality.

This model was applied to produce municipal water demand projections up to the year 2025, using projected population figures, projected network coverage and per-capita consumption, projected tourist expansion and predicted future leakage rates, etc.

#### (2) Information from Municipal Water Companies

Information was also obtained from the municipal water supply companies (Communal Enterprises) in Macedonia covering the following criteria:

- 1) Available water resources (groundwater and surface water)
- 2) Existing water demands (municipal and industrial)
- 3) Identified water shortages
- 4) Un-accounted-for water (un-metered water and leakage losses)
- 5) Current water tariffs
- 6) Billing collection rates

This information, from 14 principal water companies, was used to validate the water consumption and loss data supplied by the Statistical Office was also used to calibrate the water demand model. The information on tariffs and billing collection rates will be used to assist in assessing willingness-to-pay for water and the identified water shortages was used to estimate any suppressed demand. All these criteria are useful for deriving the future water demand projections.

### (3) Municipal Water Utilization Survey

A municipal water utilization survey was carried out from a sample of 1,200 domestic households selected across all municipalities in Macedonia. The survey covered the following principal issues:

- 1) Source of water (public network, rural supply or own source)
- 2) Present water consumption per household
- 3) Sufficiency of supplies (water shortages)
- 4) Water acceptability (water quality)
- 5) Current tariff levels
- 6) Willingness-to-pay for improved service
- 7) Wastewater treatment

The results of this survey were used to calibrate the water demand model by assessing network coverage, verifying per-capita consumption, identifying suppressed demand and estimating willingness-to-pay for water. All of which were used by the model in deriving future municipal water demands.

### I.1.2 Agricultural Water Utilization

Existing data and information with regard to the agricultural water utilization are as follows:

- (1) Integrated Development of the Vardar/Axios River Basin Master Plan (1978)  
Integrated Development of the Vardar/Axios River Basin Master Plan, 1978 that



had been prepared by United Nations was used to estimate the present irrigation water utilization.

(2) Land Reclamation Systems (1988)

Land Reclamation Systems, 1988, National Commission on Irrigation and Drainage from Macedonia was used to estimate the present irrigation water utilization.

(3) Irrigation Rehabilitation and Restructuring Project (1997)

Chapter 2 and Annex A of the World Bank Staff Appraisal Report Irrigation Rehabilitation and Restructuring Project, 1997 was used to grasp the present irrigation water utilization.

(4) Irrigation Rehabilitation and Restructuring Project Environmental Statement (1997)

Annexes A, B and C of the Irrigation Rehabilitation and Restructuring Project, 1997, that had been prepared by the Project Management Team (PMT) under the MAFWE, was used to grasp the present irrigation water utilization.

(5) ICID Paper, Regional and Local Water Management Systems (1988)

The part of The Water Shortage - Essential Condition for Water Requirement Satisfaction in the SR of Macedonia in the International Commission on Irrigation and Drainage (ICID) Proceedings Volume 4 Regional and Local Water Management Systems, 1988 was used to grasp the present irrigation water utilization.

(6) Professional Paper, (1996)

The part of Situation of Polluted Waters and Soil in the Republic of Macedonia and Protective Measures in Terms of Irrigation of Professional Paper, published in 1996 was used to grasp the present irrigation water utilization.

(7) National Environmental Action Plan (1997)

National Environmental Action Plan, 1997, that had been prepared by the former MUPCE, was referred to grasp the present irrigation water utilization.

(8) Agricultural Water Utilization Survey

An agricultural water utilization survey was carried out from a sample of 200 farmers selected across all municipalities in Macedonia. The survey covered the following principal issues:

- 1) Source of water
- 2) Present water consumption
- 3) Sufficiency of supplies (water shortages)
- 4) Water acceptability (water quality)
- 5) Current tariff levels
- 6) Willingness-to-pay for improved service

### I.1.3 Industrial Water Utilization

The present industrial water utilization is also assessed by three different approaches in order to provide a comprehensive picture of water use by industry and mining across Macedonia. The approaches taken are as follows:

- 1) Analysis of historical water consumption records, obtained from the Statistical Office, for each type of industrial activity
- 2) More detailed assessment of the water supply situation of selected principal industries
- 3) Industrial water utilization survey of industrial consumers, by conducting detailed on-site interview surveys with selected factories

#### (1) Industrial Water Demand Model

Historical water consumption records for supplies to industry and mining covering the whole of Macedonia, for the period 1990 to 1996, were obtained from the Statistical Office sub-divided by type of activity and separated into the following two categories:

- a) Water used for production (including re-cycled water)
- b) Water supplied to industry and mining

These data were also input into a water demand model which had been used to identify recent trends in industrial water usage. The water supplied to the industry and mining comprises both process water, usually from their own sources, and potable water supplied by the water companies.

This model was used for the study to project future industrial water demands for each type of activity, using industrial production projections, and hence to produce an overall industrial water demand projection up to the year 2025.

#### (2) Information from Selected Industries

The information was also obtained from selected principal industries from eight municipalities covering the following criteria:

- 1) Source of supply (public network or own source);
- 2) Process water used for production;
- 3) Cooling water;
- 4) Potable water (drinking and sanitation);
- 5) Wastewater.

### (3) Industrial Water Utilization Survey

An industrial water utilization survey was carried out from a sample of 100 industries selected across 25 municipalities. The survey covered the following principal issues:

- 1) Source of water (river intake, groundwater or public network);
- 2) Sufficiency of supplies (water shortages);
- 3) Water acceptability (water quality);
- 4) Expenditure on water;
- 5) Water resource management;
- 6) Willingness-to-pay for improved service.

The results of this survey was used to assist in calibration of the industrial water demand model.

#### I.1.4 Hydropower Water Utilization

The information on water utilization by hydropower plants in Macedonia was obtained from two sources:

- 1) Electric Power Company of Macedonia (ECM);
- 2) Statistical Office.

The data from ECM are more detailed and cover all hydropower plants and were therefore used in preference to that from the Statistical Office. Monthly discharges from major hydropower plants were provided directly by ECM, but discharges from small hydro plants needed to be estimated from energy generation records and power plant characteristics.

#### I.2 Current Water Requirement

The current water requirement, which was set for the year 1996, consists of that of municipal, agricultural, and industrial sectors. The biological minimum will be added from the ecological standpoint.

## I.2.1 Municipal Water Utilization

### (1) Composition of Municipal Water and Water Consumption Records

The current municipal water requirement is calculated as the sum of historical water consumption records broken down into 1) to 7) in the following table, and also referring to the municipal water utilization survey of consumers which was carried out from February to March in 1998 during the first fieldwork.

**Breakdown of Municipal Water and Water Consumption Records**

Breakdown	Period of Water Consumption Records
1) Domestic households	1960 - 1996
2) Communal facilities (parks, hospitals, schools, etc.)	1960 - 1996
3) Commercial establishments (shops, offices, hotels, etc.)	1960 - 1996
4) Potable water to industry	1960 - 1996
5) Water supplied to others (unspecified)	1960 - 1996
6) Network system loss (network leakage and treatment plant usage)	1960 - 1996
7) Rural water consumption	Not available

As seen above, historical water consumption records for supplies by the water supply companies (Communal Enterprises) were obtained from the Statistical Office for the period from 1990 to 1996 for each municipality, together with population figures from the recent census in 1994 and without the rural water consumption.

The rural water consumption was calculated with the estimate of population served by Communal Enterprises, etc.

### (2) Estimated Population Served by Communal Enterprises

Communal Enterprises supply predominantly urban areas and a small proportion of rural areas. There is no national data available giving the population served by all the Communal Enterprises across Macedonia. However, the following were obtained:

- (a) Certain information on supply coverage from Communal Enterprises in the major cities
- (b) Data on urban and rural populations for each municipality by the Statistical Office
- (c) Data on supply coverage in rural areas from the Republic Institute for Health Protection (RIHP)

The population distribution across Macedonia is approximately 60 % urban and

40% rural, ranging from 81.5% urban within the Skopje municipality to 100% rural in Makedonski Brod and Demir Hisar. In the Skopje urban area, 426,000 citizens out of an urban population of 449,000 were supplied by Communal Enterprises Skopje in 1995, which represents coverage of 95% of the urban population. Skopje is easily the most representative urban center and the UNICEF data gives the public water supply coverage of 99% of the urban population. Therefore, it is reasonable to adopt the 95% coverage for all urban areas in Macedonia. Likewise in rural areas, the health statistics of RIHP shows that 20% of the rural population in 1991 were supplied by Communal Enterprises.

### (3) Current Municipal Water Requirement across Macedonia

The current municipal water requirement, which is set at the gross municipal consumption in Macedonia, is taken as the sum of domestic households, communal, commercial supplies, including potable supplies to industry, supplies to others, system losses and rural water consumption for the year of 1996. The requirement on the national level in 1996 is tabulated as follows:

**Current Municipal Water Requirement in Macedonia in 1996**

(Unit: 10<sup>6</sup>m<sup>3</sup>)

Category of Municipal Water	Current Municipal Water Requirement
1) Domestic households	70.0
2) Communal facilities	11.2
3) Commercial establishments	8.9
4) Potable water to industry	34.9
5) Water supplied to others	10.6
6) Network system loss	55.4
7) Rural water consumption	39.9
Total	230.9

The rural water consumption is estimated assuming a gross per-capita consumption of 250 liter per capita per day (lpcd).

Mean system losses for 1996 across all municipalities were assessed at 35%, which was midway between the range of 20% to 50% quoted by many water supply companies. The municipal water consumption in Macedonia for the year 1996 is tabulated in Table I.1 for each municipality.

### (4) Per Capita Water Consumption

Per capita water consumption (lpcd) from 1990 to 1996 has been estimated from water supply records and population data. Population census data for 1961, 1971, 1981, 1991 and 1994 were used to determine population trend to fill in data for years of 1995 and 1996.

Per-capita Consumption on National Level from 1990 to 1996

(Unit: lpcd)

Year	(1) Domestic Household Use	(2) Communal Use	(3) Commercial Use	(4) Others (Loss, etc.)	(5) Gross of Municipal Water
1990	137	17	24	79	257
1991	131	21	19	76	247
1992	140	24	19	111	294
1993	151	16	22	97	286
1994	155	16	17	97	285
1995	148	18	19	87	272
1996	149	24	19	70	262

The per-capita consumption estimates compare well with those experienced elsewhere in Europe.

### I.2.2 Agricultural Water

The requirement of agricultural water consists of irrigation water and livestock water. The water consumption of the agricultural water, however, was not recorded in Macedonia like that of the municipal water, and consequently was assessed by analysis on the existing irrigation systems, climate conditions, cropping pattern as well as on results of a water utilization survey of agricultural water.

The fishery water requirement was not considered, because the fishery method in Macedonia involved the continuous flow of water taken from a river into a fish pond and then back to the original river.

#### (1) Irrigation Water

##### (a) Survey of existing irrigation systems

In order to grasp more concretely the present condition of the existing irrigation systems, a questionnaire survey was conducted for all the systems in Macedonia. Questionnaires were distributed to 27 water management organizations (WMOs) now (PWME) that cover 103 irrigation systems. In response to the distributed questionnaires, 12 WMOs presented their answers, from which 50 irrigation systems were clarified about their present conditions such as (i) location of intake, (ii) irrigation service area, (iii) cropping pattern and area, major features of irrigation, (iv) drainage and road facilities, (v) maintenance and repair conditions, and so on.

As for the remaining 81 irrigation systems for which no answers were received, the report titled Analysis of Conditions and Problems in Utilization of Irrigation Systems in Macedonia 1993, Ministry of Agriculture, Forestry and Water Economy, was mainly referred to for grasping the conditions.

In parallel with the above, actual conditions of various systems' facilities were examined through five separate field investigations.

A net registered service area of 168,112 ha is irrigated under the existing 131 systems, as broken down below for each river basin, and tabulated in Tables I.2 (1/2) to (2/2) with a location map shown in Figure I.1.

**Existing Irrigation (Irri.) System**

No. & Area(ha)	No. of System	Designed Irri. Area (ha)	Existing Irri. Area(ha)	Incomplete Area(ha)
- Vardar, upper reaches	42	40,034	38,676	1,358
- Vardar, middle reaches	17	39,980	34,099	5,881
- Vardar, lower reaches	42	63,247	61,352	1,895
- Crn Drim	23	16,047	12,437	3,610
- Strumica	7	21,698	21,548	150
Total	131	181,006	168,112	12,894

According to the Statistical Yearbook 1997, however, the actual irrigated area in 1996 was only 51,677ha, corresponding to 31% of 168,112ha. This was regarded as just a reference.

Further the Sretenovo system of 120 ha irrigated by Lake Dojran shown in the Tables I.2 (1/2) to (2/2) was excluded from the water balance calculation and hence 130 systems were adopted in this Study.

**(b) Basic conditions for estimate**

For estimate of the current irrigation water requirement, the following conditions were applied;

C1: Irrigation water requirement is calculated on 10-day basis in accordance with the Penman-Monteith method with reference to the report Expert Consultation on Revision of FAO Methodologies for Crop Water Requirements, May 1990. The crop water requirement is actually calculated with use of the computer program introduced by FAO Irrigation Drainage Paper 33 CROPWAT Computer Program for Irrigation Planning and Management 1992.

C2: Effective rainfall is, in principle, calculated in accordance with the USDA Soil Conservation Service method introduced by FAO Irrigation Drainage Paper 33 CROPWAT Computer Program for Irrigation Planning and Management 1992. In the method, the effective rainfall is calculated on not 10-day but monthly basis with use of monthly rainfall, and consequently monthly effective rainfall calculated by the original equation was distributed into three 10-day effective rainfalls with use of such ratio as obtained through the following equation which is modified from the original method for estimation of 10-day effective rainfall ( $ER_{10}$ ) with use of 10-day rainfall ( $RA_{10}$ ).

$$ER_{10}=3 \times RA_{10} \times (125 - 0.2 \times 3 \times RA_{10})/125/3 \text{ for } RA_{10} \leq 250\text{mm}/3 \text{ (1)}$$

$$ER_{10}=(125 + 0.1 \times 3 \times RA_{10})/3 \text{ for } RA_{10} > 250\text{mm}/3 \text{ (2)}$$

C3: For the efficient estimate work, 130 irrigation systems are classified into the following five (5) regions, according to the climate conditions such as temperature and rainfall, in particular.

#### Climatic Region

No. of Climatic Region	District in Macedonia	Meteorological Station of Adopted Data (No. of Sta.)
I	Western part	Tetovo (ST001)
II	Southwestern part	Bitola (ST025)
III	Northern and central part	Shtip (ST040)
IV	Eastern part	Berovo (ST050)
V	Southeastern part	Gevgelija (ST279)

(See Figure I.1)

It is considered that the water requirement estimated on the basis of the above classification would fulfill the accuracy practically required for the water balance calculation.

C4: As for the cropping pattern, since there is paddy rice cultivation in the Bregalnica irrigation system in the climatic region (III), six (6) kinds of the pattern are formulated as follows, adding the paddy rice cultivation to the region III as one pattern.

#### Cropping Pattern

No. of Cropping Pattern	Climatic Region Applied for the Pattern
1	I
2	II
3a	III (excluding Bregalnica system)
3b	III (for Bregalnica system only)
4	IV
5	V

(See Figures I.2 (1/3) to (3/3))

In preparation of the cropping pattern, crop kind and cropping area of each crop were carefully examined and determined with reference to the Statistical Yearbook 1997 so as to obtain reasonable results on not only the total cultivation area in Macedonia but also the regional cultivation area of each crop.

C5: The current irrigation efficiency of the workable system is estimated to be at 0.58, composed of the following, with reference to Table 37 in FAO Irrigation and Drainage Paper 24 revised in 1977 Crop Water Requirements.

- Conveyance efficiency : 0.8
- Field canal efficiency : 0.9
- Field application efficiency: 0.8



(c) Irrigation water requirement

The irrigation water requirement is calculated for each intake node in the basin model for the water balance calculation, which amounts to 41 nodes in total, on 10-day basis for the period of 36 years from 1961 to 1996 with the following process;

P1: Gross unit irrigation water requirements (lit/s/ha) for the above-mentioned 6 cropping patterns are estimated taking the effective rainfall and irrigation efficiency into the calculation. The gross unit irrigation requirements for the period of 36 years from 1961 to 1996 are tabulated in Tables I.3 (1/6) to (6/6).

P2: Intake discharges at the 41 intake nodes are estimated taking the gross unit water requirement (lit/s/ha) and the total irrigation service area (ha) commanded under the concerned intake point into the calculation. The intake discharges at the 41 intake nodes calculated on the basis of the average gross unit water requirement of 36 years are tabulated in Tables I.4 (1/2) to (2/2).

Total demand for irrigation water was thus calculated for the 36 years and averaged as follows for each river basin.

**Summary of Irrigation Water Demand**

Basin	No. of Intake Node	Total Service Area (ha)	Water Demand (1,000 m <sup>3</sup> /year)
1. Vardar (mainstream)	13	38,513	252,186
2. Tresca	1	2,080	16,406
3. Pchinja	4	12,162	103,661
4. Bregalnica	8	37,628	378,264
5. Crna	5	49,205	402,723
6. Strumica	4	15,967	137,336
7. Crn Drim	6	12,437	94,872
Total	41	167,992	1,385,448

Through the above process, the gross irrigation water requirement per crop for the respective crops and regions were obtained. Those in the climatic region III are presented below, for example, in order of large requirement obtained in this Study.

**Unit Irrigation Water Requirement per Crop in Region III (m<sup>3</sup>/ha/cropping)**

Kind of Crop	This Study (Climate Region III)	Prevailing Standard in Macedonia
1) Paddy rice	22,100	22,500
2) Orchards	8,500	6,250
3) Vineyard	7,100	4,375
4) Maize	6,400	6,250
5) Vegetable	6,200	7,875
6) Wheat	3,700	2,875

Note: Prevailing standard values are obtained from Proceeding of Papers Meeting "Faculty with Farmers" 96 Volume 4 issued by the University

(2) Livestock Water

(a) Basic conditions for estimate of livestock water

For estimate of the current livestock water requirement, the following conditions were applied.

C1: Unit water requirement per head of livestock was determined referring to the criteria provided by the Faculty of Agriculture of the University.

C2: Number of livestock in each (old) municipality as of 1994 was estimated referring to The Book X Agricultural Holdings in the 1994 Census of Population, Households, Dwellings and Agricultural Holdings in the Republic of Macedonia and Statistical Yearbook 1997.

(b) Livestock water requirement

The livestock water requirement in 1994 was calculated for each municipality with use of the above-mentioned unit water requirement and number of livestock. The requirement at the national level is tabulated below.

**Livestock Water Requirement**

Kind of Livestock	(1) Unit Water Requirement (lit/day/head)	(2) Number (heads)	(3) = (1) x (2) Water Requirement (m <sup>3</sup> /day)
1) Cattle	95	281,336	26,727
2) Horse	60	61,797	3,707
3) Pig	25	171,571	4,289
4) Sheep	11	2,466,099	27,127
5) Poultry	1	4,685,021	4,685
Total			66,535

The requirement of the livestock water requirement is calculated at 66,535 m<sup>3</sup>/day (or 24.3 million m<sup>3</sup>/year, which is 1.8 % of the requirement of irrigation water of 1,385 million m<sup>3</sup>/year). The requirement at the municipality level is tabulated in Table I.5.

I.2.3 Industrial Water

The current industrial water requirements were assessed by analysis of historical water consumption records, assessment of water utilization in selected industries, and from a water utilization survey of industrial consumers.

(1) Analysis of Historical Consumption Records

Historical water consumption records for water supplied to industry and water used for production, sub-divided by type of activity for the period from 1990 to 1996, were obtained from the Statistical Office.

It should be noted that numerous inconsistencies were found with this data, but as several years of data were available for each type of industrial activity, it has been possible to identify the types of activity with particular years having suspect data. Such inconsistencies were generally not difficult to identify, being often an order of magnitude different to the data from other years. In these cases the suspect data were re-estimated by observing the trend over the other years for the particular type of activity. This screening process produced a much more consistent data set and a clear picture emerged as to the change in industrial water use over the past decade.

Historical data were obtained for over 30 industrial activities for the period from 1990 to 1996.

## (2) Water Supplied to Mining and Industry

The total water supplied to mining and industry for all Macedonia was assessed by adding the water supplies of raw process water including groundwater and surface water.

The results, regarded as requirement of industrial water, show a pronounced downward trend in industrial water consumption that reflects the reduction in industrial activity witnessed over the past decade following the break-up of former Yugoslavia. This downward trend is particular to Eastern Europe following the break-up of the Soviet Union.

The industrial water requirement from the historical data is tabulated for the period from 1990 to 1996. The industrial water requirement as of 1996 supplied with surface water is set on each node of the industrial water intake.

**Industrial Water Requirement for the Period 1990 - 1996.**

(Unit: 10<sup>3</sup>m<sup>3</sup>)

Year	(1) Potable Water	Industrial Water Supplied from		Total (3) = (1) to (3)
		(2) Surface	(3) Groundwater	
1990	43,101	81,944	45,097	170,142
1991	40,890	75,678	41,648	158,216
1992	38,027	74,772	41,150	153,949
1993	38,244	68,605	37,756	144,605
1994	38,678	59,518	32,755	130,951
1995	39,047	54,090	29,768	122,905
1996	34,920	50,933	28,030	113,883

### I.2.4 Biological Minimum

The biological minimum and/or ecological need was determined from the ecological standpoint, as being 10 % of the average flow, according to the Water Economy Basis of Macedonia as mentioned in the National Development Strategy 1997.

According to the hydrological study presented in Appendix A1 in Supporting Report I (Volume III) average flows in major rivers for the 36 years from 1961 to 1996 are as follows, together with 10 % of them as the ecological need.

**Biological Minimum from Ecological Standpoint**

Basin/Gauging Station (Catchment Area)	(1) Average Flow (m <sup>3</sup> /s)	(2)= (1) x 10% (m <sup>3</sup> /s)	Annual Amount of (2) (10 <sup>6</sup> m <sup>3</sup> )
1. Vardar/Gevgelija (22,301km <sup>2</sup> )	136.0	13.6	429
2. Treska/Sveta Bogorodica (1,880km <sup>2</sup> )	23.3	2.3	73
3. Pchinja/Katlanovska Banja (2,794km <sup>2</sup> )	11.9	1.2	38
4. Bregalnica/Shtip (2,897 km <sup>2</sup> )	11.3	1.1	35
5. Crna/Rasimbegov Most (4,526 km <sup>2</sup> )	22.4	2.2	70
6. Strumica/Novo Selo (1,401 km <sup>2</sup> )	3.8	0.4	12
7. Crn Drim/Lozani (-)	23.4	2.3	73
Total			730

**I.2.5 Current Water Requirement in 1996**

From the above, the current water requirement in 1996 is summarized as follows, including the ecological need:

**Current Water Requirement in 1996**

Sector	Water Requirement (10 <sup>6</sup> m <sup>3</sup> /year)	
1) Municipal Water	196*	(362)
2) Agricultural Water	1,410	(950)
3) Industrial Water	114	(270)
4) Ecological Need	730	(653)
Total	2,450	(2,235)

Note: \*) Water requirement of potable water to industry is included in the 3) industrial water.

Figures in ( ) are those for the year of 1995 in the National Development Strategy in 1997.

Table I.1 Municipal Water Consumption in Macedonia for Year 1996

Municipality	Source	by Water Supply Company (10 <sup>6</sup> m <sup>3</sup> )							by Rural Supply		(9) Total excl.(4) (10 <sup>6</sup> m <sup>3</sup> )	(10) Total (1) to (8) (10 <sup>6</sup> m <sup>3</sup> )	(11) Urban Population	(12) Rural Population	(12) Total Population
		(1) Domestic household	(2) Communal	(3) Commerce	(4) Industry (potable)	(5) Others	(6) System Loss	(7) Total excl.(4)	(8) Domestic,etc. (10 <sup>6</sup> m <sup>3</sup> )						
1	Skopje	Spring, well	24.8	4.0	3.1	13.5	10.4	23.3	65.5	5.2	144.6	158.1	454,480	103,242	557,722
2	Gostivar	Spring	2.9	0.5	0.4	2.1	0.0	2.1	5.8	3.4	13.8	15.9	41,768	68,418	110,186
3	Tetovo	Spring	4.0	0.6	0.5	2.7	0.0	2.9	8.0	6.2	18.8	21.5	51,300	124,140	175,440
4	Kichevo	Spring	1.6	0.3	0.2	0.5	0.0	1.2	3.3	1.4	7.0	7.5	25,460	28,196	53,656
5	Makedonski Brod	Spring	0.1	0.0	0.0	0.0	0.0	0.1	0.2	0.6	0.5	0.5	0	10,974	10,974
6	Kumanovo	Reservoir	4.4	0.7	0.6	1.2	0.0	3.1	8.8	2.8	18.8	20.0	72,717	56,634	129,351
7	Kratovo	River intake	0.4	0.1	0.0	0.7	0.0	0.3	0.8	0.2	2.2	2.9	6,419	4,375	10,794
8	Kriva Palanka	Spring	0.7	0.1	0.1	0.4	0.0	0.5	1.4	0.7	3.3	3.7	11,060	13,831	24,891
9	Veles	Well, river in- take, reservoir	2.7	0.4	0.3	1.0	0.0	1.9	5.3	1.0	11.6	12.6	47,107	19,270	66,377
10	Sveti Nikole	Reservoir	0.8	0.1	0.1	0.1	0.0	0.6	1.6	0.4	3.2	3.3	13,276	8,142	21,418
11	Shtip	Well	2.3	0.4	0.3	1.2	0.0	1.6	4.6	0.5	10.4	11.6	42,329	9,113	51,442
12	Probishtip	Well	0.6	0.1	0.1	0.7	0.0	0.4	1.2	0.3	3.1	3.8	10,253	6,482	16,735
13	Kochani	Well, reservoir	1.6	0.3	0.2	0.5	0.0	1.2	3.3	1.1	7.0	7.5	26,653	22,417	49,070
14	Vinica	Well, river in- take	0.6	0.1	0.1	0.1	0.0	0.4	1.2	0.5	2.6	2.7	10,097	9,207	19,304
15	Delchevo	Well, river in- take	0.7	0.1	0.1	0.3	0.0	0.5	1.4	0.7	3.2	3.5	10,685	14,916	25,601
16	Berevo	Reservoir	0.6	0.1	0.1	0.3	0.0	0.4	1.2	0.5	2.8	3.1	9,804	10,065	19,869
17	Demir Hisar	Well	0.1	0.0	0.0	0.0	0.0	0.1	0.2	0.5	0.5	0.5	0	10,304	10,304
18	Krushevo	Spring	0.4	0.1	0.0	0.1	0.0	0.3	0.7	0.3	1.5	1.6	5,498	6,488	11,986
19	Bitola	River intake, reservoir	4.4	0.7	0.6	1.8	0.0	3.1	8.7	1.5	19.3	21.1	77,764	30,858	108,622
20	Prilep	Well, spring	3.8	0.6	0.5	1.2	0.0	2.7	7.7	1.3	16.5	17.7	68,364	26,118	94,482
21	Kavadarci	Spring, river intake	1.8	0.3	0.2	1.0	0.0	1.3	3.6	0.5	8.3	9.3	33,193	9,281	42,474
22	Negotino	Spring, river intake	0.8	0.1	0.1	0.6	0.0	0.6	1.6	0.5	3.7	4.3	12,713	10,807	23,520
23	Valandovo	Well, spring	0.3	0.1	0.0	0.1	0.0	0.2	0.6	0.4	1.4	1.5	4,420	7,847	12,267
24	Gevgelija	Well	1.0	0.2	0.1	0.7	0.0	0.7	2.0	1.0	4.7	5.4	15,192	20,132	35,324
25	Ohrid	Spring, Lake	2.4	0.4	0.3	1.6	0.0	1.7	4.8	1.0	11.1	12.7	41,675	19,869	61,544
26	Struga	Spring	1.4	0.2	0.2	0.6	0.0	1.0	2.7	2.4	6.0	6.6	16,286	47,366	63,652
27	Debar	Spring	0.8	0.1	0.1	0.3	0.0	0.5	1.5	0.7	3.4	3.7	11,727	14,203	25,930
28	Resen	Well, spring	0.5	0.1	0.1	0.4	0.0	0.4	1.1	0.5	2.6	3.0	8,667	8,979	17,646
29	Radovis	Well	1.0	0.2	0.1	0.2	0.0	0.7	1.9	0.8	4.1	4.3	15,263	15,657	30,920
30	Strumica	Reservoir	2.4	0.4	0.3	1.0	0.2	1.8	5.2	2.9	11.3	12.3	34,545	57,780	92,325
	Total		70.0	11.2	8.9	34.9	10.6	55.4	156.1	39.9	196.0	230.9	1,178,715	795,111	1,973,826

Table I.2 Existing Irrigation Systems (1/2)

No.	Code No.	Irrigation System	Designed	Existing	Incompleted	River of Water Source				
			Irr. Area (ha)	Irr. Area (ha)	Area (ha)	0	1	2	3	
<b>I. Vardar River Basin, Upper Reaches</b>										
1.	I-1	Shkoza	142	142	0	Vardar				
2.	I-2	Zdunje I & II	2,200	2,200	0	Vardar				
3.	I-3	Gostivarsko polje	4,311	3,914	397	Vardar				
4.	I-4	Banjica	531	400	131	Vardar				
5.	I.4a-1	Lakavica	161	161	0		Lakavichka			
6.	I.4a.1a-1	Melca	230	230	0			Melca		
7.	I.4b-1	Vrapcishka reka	280	280	0		Vrapcishka			
8.	I.4b.1a-1	Balin dol	116	116	0				Tributary	
9.	I-5	Stenche	500	500	0	Vardar				
10.	I.5a-1	Mazdracha	1,180	1,180	0		Mazdracha			
11.	I-6	Radiovce-Bistrica	8,187	8,187	0	Vardar				
12.	I-7	Miletino-Chelopek	856	856	0	Vardar (belongs to 11. Radiovce-Bistrica)				
13.	I.7a.0a-1	Rechica	114	114	0		(Tetovska)	Tributary		
14.	I.7b-1	Ratac	1,040	1,040	0		Tributary (belongs to 11. Radiovce-Bistrica)			
15.	I.7c-1	Djepishte	160	160	0		Tributary (belongs to 11. Radiovce-Bistrica)			
16.	I.7d-1	Neproshteno	114	114	0		Leshachka (belongs to 11. Radiovce-Bistrica)			
17.	I.7e-1	Stari	2,500	2,500	0		Tributaries			
18.	I-8	Radusha	71	71	0	Vardar				
19.	I-9	Rashche	325	325	0	Vardar				
20.	I-10	Saraj	14	14	0	Vardar				
21.	I.10a.0a-1	Bigor-Dolenci	590	590	0		(Treska)	Zajashka		
22.	I.10a.0b-1	Zaec-Greshnica	450	450	0			Tributary		
23.	I.10a-1	Kichevosko pole	1,450	1,040	410		Treska			
24.	I.10a-2	Shishevo	56	56	0		Treska			
25.	I.10a-3	Glumovo	14	14	0		Treska			
26.	I.10b-1	Vuchidol-Orman	85	85	0		Lepenec			
27.	I.10b-2	Novo selo	68	68	0		Lepenec			
28.	I.10b-3	Bardovci-Zlokukjani	140	140	0		Lepenec			
29.	I.10c-1	Radishani	27	27	0		Cickerska			
30.	I.10d-1	Drachevo-Batinci	110	110	0		Markova			
31.	I.10e-1	Kamnik	1,300	1,300	0		Tributaries			
32.	I.10f-1	Petrovec	100	100	0		Tributary			
33.	I.10g-1	Shamak	30	30	0		Tributary			
34.	I.10i-1	Dragomanci	136	136	0		Pchinja			
35.	I.10i.1a-1	Slavishko pole	250	250	0			Kriva		
36.	I.10i.1a-2	Studena bara-Vakuf	400	290	110			Kriva		
37.	I.10i.1a-3	Davezenca-Jachince-Klechovc	250	175	75			Kriva		
38.	I.10i-2	Klechovce	500	265	235		Pchinja			
39.	I.10i-3	Shupli kamen-Zubovce	122	122	0		Pchinja			
40.	I.10i.3a.0a-1	Rechica	60	60	0		(Kumanovska)	Rechica (well)		
41.	I.10i.3a.0a-1	Izvor Jovica	44	44	0			Lojanska		
42.	I.10i.3a.0b-1	Lipkovo	10,820	10,820	0			Lipkovska		
Sub-total			40,034	38,676	1,358					
<b>II. Vardar River Basin, Middle Reaches</b>										
43.	II.0a-1	Mladost (Otoevica)	1,200	1,200	0	(Vardar)	Otoevica			
44.	II.0b-1	Topolka	400	400	0		Topolka			
45.	II.0c-1	Vitanci	98	98	0		Babuna			
46.	II.0c-2	Babuna	100	100	0		Babuna			
47.	II-1	Kochilari	80	80	0	Vardar				
48.	II-2	Zgropulci	24	24	0	Vardar				
49.	II-3	Vinichani	150	150	0	Vardar				
50.	II.3a.0a-1	Crn dol (Pehchevo)	80	80	0		(Bregalnica)	Crn Dol		
51.	II.3a.0b-1	Maleshevsko pole	3,014	917	2,097			Tributary		
52.	II.3a-1	Sandanski (Delchevo)	250	250	0		Bregalnica			
53.	II.3a.1a-1	Jugotutun (Delchevo)	164	164	0			Tributaries		
54.	II.3a-2	Milkovo (Delchevo)	540	495	45		Bregalnica			
55.	II.3a-3	Bregalnica	32,100	28,890	3,210		Bregalnica			
56.	II.3a.3a-1	Osojnica	415	415	0			Osojnica		
57.	II.3a.3a.1a-1	Blatec	915	500	415				Blateshka	
58.	II.3a.3b-1	Belashnica-Zletovo	200	200	0			Zletovska		
59.	II.3a.4c-1	Mavrovica	250	136	114			Orlica		
Sub-total			39,980	34,099	5,881					

Table I.2 Existing Irrigation Systems (2/2)

No.	Code No.	Irrigation System	Designed Irr. Area (ha)	Existing Irr. Area (ha)	Incompleted Area (ha)	River of Water Source			
						0	1	2	3
<b>III. Vardar River Basin, Lower Reaches</b>									
60.	III.0a.0a-1	Obednichki	30	30	0	(Vardar)	(Crna)	Tributary	
61.	III.0a.0b-1	Demir hisar	10	10	0			Tributary	
62.	III.0a-1	Buchin	120	120	0		Crna		
63.	III.0a.1a.0a-1	Debreshite	251	251	0			(Blato)	Tributary
64.	III.0a.1a-1	Crna upper reach	250	250	0			Blato	
65.	III.0a.1a.1a-1	Brailovo	240	240	0				Suvodolichka
66.	III.0a.1a.1a-2	Desovo	280	280	0				Suvodolichka
67.	III.0a.1a.1b-1	Krushevo	220	220	0				Selishva
68.	III.0a.1a.1c-1	Borino (Lazhani)	666	666	0				Tributary
69.	III.0a.1a.1d-1	Prilep	6,200	6,200	0				Stara
70.	III.0a.1b-1	Strezhevo	20,200	20,200	0			Shemnica	
71.	III.0a.1b-2	Shemnica upper reach	50	50	0			Sazdsica	
72.	III.0a.1c-1	Dihovo	270	140	130			Dihovska	
73.	III.0a.1d-1	Bistrica	40	40	0			Zlokuchanska	
74.	III.0a.1d.1a-1	Velushka river	75	75	0				Velushka
75.	III.0a.1e-1	Graeshnica	20	20	0			Tributary	
76.	III.0a.1f-1	Dabnichka reka	300	200	100			Dronska	
77.	III.0a-2	Tikvesh	20,290	19,225	1,065		Crna		
78.	III.0a-3	Vozarci	28	28	0		Crna		
79.	III.0a-4	Trstenik-Gradsko	960	960	0		Crna		
80.	III.0b-1	Boshavica	1,935	1,935	0		Vatashka		
81.	III-1	Peplishko pole	1,600	1,000	600	Vardar			
82.	III.1a-1	Demir kapija	300	300	0		Boshava		
83.	III-2	Gradec	264	264	0	Vardar			
84.	III-3	Udovo-Valandovo	3,624	3,624	0	Vardar			
85.	III.3a.0a-1	Petrushka river	100	100	0		(Stara)	Petrushka	
86.	III.3a-1	Miravci	100	100	0		Stara		
87.	III-4	Grechiste I and II	423	423	0	Vardar			
88.	III-5	Smokvica I and II	110	110	0	Vardar			
89.	III-6	Prejci	200	200	0	Vardar			
90.	III.6a-1	Kovanska, Sermeninska rivers	200	200	0			Kovanska	
91.	III-7	Vinojug	150	150	0	Vardar (wells)			
92.	III-8	Gjavoto	1,340	1,340	0	Vardar			
93.	III.8a-1	Paljurci	800	800	0		C. Luda Mara		
94.	III.8b-1	Konska reka	571	571	0		Konjska		
95.	III-9	Sehovo	200	200	0	Vardar			
96.	III-10	Granica	120	120	0	Vardar			
97.	III.10a-1	Pod anot	120	120	0			Konjushka (wells)	
98.	III-11	Avlakjot	40	40	0	Vardar (wells)			
99.	III-12	Keramadnica	80	80	0	Vardar			
100.	III.12a-1	Selemii	350	350	0			Tributary	
101.	III.13	Sretenovo	120	120	0	Doiran			
Sub-total			63,247	61,352	1,895				
<b>IV. Crn Drim River Basin</b>									
102.	IV.0a-1	Ljubojno	84	84	0	(Lake Prespa)	Brajchinska		
103.	IV.0b-1	Krani	153	153	0		Kranska		
104.	IV-1	Asamati	2,811	2,811	0	Lake Prespa			
105.	IV.1a-1	Pretor	41	41	0		Pretorska		
106.	IV.1b-1	Kurbinovo	78	78	0		Kurbinovska		
107.	IV-2	Sirhan	2,788	2,788	0	Lake Prespa			
108.	IV.2a-1	Ljubanishta	142	142	0	(Lake Ohrid)	Ljubanishta		
109.	IV.2b.0a-1	Trebanishta	50	50	0		(Tributary)	Tributary	
110.	IV.2b.0b-1	Leskoec	100	100	0			Tributary	
111.	IV-3	Velgoshte	60	60	0	Lake Ohrid			
112.	IV-4	Ovoshtarnik	250	250	0	Cm Drim			
113.	IV.4a-1	Izdeglavje	700	700	0		Sateska		
114.	IV.4a.1a-1	Stafino	700	400	300		Sateska		
115.	IV.4a.1b-1	Belchishta-Velmej	1,400	440	960			Tributary	
116.	IV.4a.1b-2	Sateska	1,250	400	850			Tributary	
117.	IV.4a-2	Batum	50	50	0		Sateska		
118.	IV.4b-1	Shum-Vishni	305	305	0		Belichka		
119.	IV-5	Lozhani	550	550	0	Cm Drim			
120.	IV-6	Stari	745	745	0	Cm Drim			
121.	IV-7	Strushko pole	1,600	1,000	600	Cm Drim			
122.	IV.7a-1	Banjiste	150	150	0		Banjishka R.		
123.	IV.7b-1	Gradinar	60	60	0		Graeshnica		
124.	IV.9-1	Debarsko pole	1,980	1,080	900		Radika		
Sub-total			16,047	12,437	3,610				
<b>V. Strumica River Basin</b>									
125.	V.0a.0a-1	Mantovo	5,581	5,581	0	(Vardar)	(Bregalnica)	Kriva Lakavica	
126.	V.0b-1	Oraovica	67	67	0	(Strumica)	Orahovachka		
127.	V.0c-1	Podaresh	250	250	0		Plavja		
128.	V.0d-1	Turija	10,050	10,050	0		Nivichanska		
129.	V.0e-1	Vodocha	4,000	4,000	0		Tributary		
130.	V.0f-1	Podbelasica	1,550	1,400	150		Tributaries		
131.	V.0g-1	Novo selo	200	200	0		Novoselska		
			21,698	21,548	150				
Total			181,006	168,112	12,894				















**Table I.4 Water Demand at Irrigation Intake Node (1/2)**

**(Present Cropping Condition)**

Basin No.	Code No. (by Basin)	No. (Node No.) (Diagram)	Node Name	Total Service Area (ha)	Annual Water Demand on 36 Years Average (1,000 m <sup>3</sup> /year)
1.	B1-1	A1-1	<b>Melca</b>	391	1,912
	B1-1	A1-2	<b>Gostivarsko pole</b>	6,656	32,393
	B1-1	A1-3	<b>Stenche</b>	896	4,368
	B1-1	A1-4	<b>Mazdracha</b>	1,180	5,748
	B1-1	A1-5	<b>Radiovce-Bistrica</b>	13,381	74,722
	B1-2	A1-6	<b>Bardovci-Zlokukjani</b>	390	3,356
	B1-3	A1-7	<b>Kamnik</b>	1,540	13,245
	B1-3	A1-8	<b>Mladost (Otovica)</b>	1,200	10,307
	B1-4	A1-9	<b>Topolka</b>	852	7,329
	B1-4	A1-10	<b>Boshavica</b>	1,935	16,644
	B1-4	A1-11	<b>Pepelishko pole</b>	1,300	11,196
	B1-5	A1-12	<b>Udovo-Valandovo</b>	3,988	32,194
	B1-5	A1-13	<b>Bogdanci I and II</b>	4,804	38,771
<b>Total</b>				<b>38,513</b>	<b>252,186</b>
2.	B2-1	A2-1	<b>Kichevosko pole</b>	2,080	16,406
3.	B3-2	A3-1	<b>Slavishki pole</b>	250	1,226
	B3-2	A3-2	<b>Studerna bara-Vakuf</b>	852	7,329
	B3-1	A3-3	<b>Dragomanci</b>	136	1,166
	B3-3	A3-4	<b>Lipkovo</b>	10,924	93,940
<b>Total</b>				<b>12,162</b>	<b>103,661</b>

**Table I.4 Water Demand at Irrigation Intake Node (2/2)**

(Present Cropping Condition)

Basin No.	Code No. (by Basin)	No. (Node No.) (Diagram)	Node Name	Total Service Area (ha)	Annual Water Demand on 36 Years Average (1,000 m3/year)
4.	B4-1	A4-1	Crn dol (Pehchevo)	80	377
	B4-1	A4-2	Maleshevsko pole	917	4,453
	B4-1	A4-3	Milkovo (Delchevo)	909	4,411
	B4-2	A4-4	Bregalnica	28,890	310,304
	B4-2	A4-5	Blatec	915	7,867
	B4-3	A4-6	Belashnica-Zletovo	200	1,709
	B4-4	A4-7	Mantovo	5,581	47,977
	B4-4	A4-8	Mavrovica	136	1,166
Total				37,628	378,264
5.	B5-1	A5-1	Desovo	2,067	16,305
	B5-1	A5-2	Prilep	6,200	48,931
	B5-2	A5-3	Strezhevo	20,525	161,959
	B5-3	A5-4	Tikvesh	19,425	167,028
	B5-3	A5-5	Trstenik-Gradsko	988	8,500
Total				49,205	402,723
6.	B6-1	A6-1	Podaresh	317	2,727
	B6-2	A6-2	Turija	10,250	88,161
	B6-3	A6-3	Vodocha	4,000	34,410
	B6-3	A6-4	Podbelasichki	1,400	12,039
Total				15,967	137,336
7.		A7-1	Asamati	5,955	46,996
		A7-2	Ljubanishte	142	1,123
		A7-3	Leskoec	210	1,663
		A7-4	Izdeglavje	2,240	17,667
	B7-2	A7-5	Strushko pole	2,810	22,175
	B7-2	A7-6	Debarsko pole	1,080	5,248
Total				12,437	94,872
<b>Grand Total</b>				<b>167,992</b>	<b>1,385,448</b>

**Table I.5 Livestock Water Requirement**

Unit Water Requirement:		1994	
Cattle	95 lit/day/head	281,336 heads	
Horse	60 lit/day/head	61,797	
Pig	25 lit/day/head	171,571	
Sheep	11 lit/day/head	2,466,099	
Poultry	1 lit/day/head	4,685,021	
		<u>7,665,824</u>	

1994

No.	Code No.	No.	Municipality (old) concerned		Kind of Livestock										Total Water Demand m3/s	
			No.	Name	Cattle		Horse		Pig		Sheep		Poultry			
					heads	m3/s	heads	m3/s	heads	m3/s	heads	m3/s	heads	m3/s		
<b>Basin-1: Vardar River Basin</b>																
1.	B1-1	1	02	Gostival	24,439	0.027	4,249	0.003	865	0.000	113,810	0.014	156,484	0.002	0.046	
		2	03	Tetovo	47,511	0.052	7,770	0.005	11,043	0.003	135,492	0.017	435,327	0.005	0.083	
2.	B1-2	3	01	Skopje	21,968	0.024	5,742	0.004	14,057	0.004	151,810	0.019	416,299	0.005	0.056	
3.	B1-3	4	09	Veles	6,923	0.008	1,331	0.001	1,963	0.001	150,474	0.019	156,619	0.002	0.030	
4.	B1-4	5	22	Negotino	1,498	0.002	702	0.000	2,800	0.001	24,388	0.003	69,803	0.001	0.007	
5.	B1-5	6	23	Valandovo	2,674	0.003	480	0.000	2,422	0.001	11,858	0.002	47,775	0.001	0.006	
		7	24	Gegelija	5,165	0.006	1,449	0.001	3,095	0.001	40,085	0.005	91,116	0.001	0.014	
<b>Basin-2: Treska River Basin</b>																
6.	B2-1	8	04	Kichevo	15,722	0.017	1,945	0.001	1,884	0.001	69,707	0.009	141,719	0.002	0.030	
7.	B2-2	-	-	-	-	-	-	-	-	-	-	-	-	-		
8.	B2-3	9	05	Brod	5,087	0.006	555	0.000	1,559	0.000	23,854	0.003	46,547	0.001	0.010	
<b>Basin-3: Pčinja River Basin</b>																
9.	B3-1	10	06	Kumanovo	15,849	0.017	3,047	0.002	20,329	0.006	183,734	0.023	372,990	0.004	0.053	
10.	B3-2	11	08	Kriva Palanka	9,586	0.011	1,493	0.001	7,954	0.002	53,463	0.007	109,874	0.001	0.022	
		12	07	Kratovo	3,263	0.004	475	0.000	3,608	0.001	39,095	0.005	54,142	0.001	0.011	
11.	B3-3	-	-	-	-	-	-	-	-	-	-	-	-	-		
12.	B3-4	-	-	-	-	-	-	-	-	-	-	-	-	-		
<b>Basin-4: Pčinja River Basin</b>																
13.	B4-1	13	16	Berovo	5,682	0.006	2,039	0.001	5,010	0.001	130,175	0.017	61,845	0.001	0.026	
		14	15	Detchevo	7,978	0.009	684	0.000	10,338	0.003	76,603	0.010	109,439	0.001	0.023	
14.	B4-2	15	14	Vinča	1,996	0.002	333	0.000	3,899	0.001	48,626	0.006	74,507	0.001	0.011	
		16	13	Kochani	6,447	0.007	1,459	0.001	14,052	0.004	62,648	0.008	191,613	0.002	0.022	
15.	B4-3	17	11	Ship	2,907	0.003	428	0.000	2,841	0.001	81,886	0.010	83,796	0.001	0.016	
		18	12	Probishtip	2,422	0.003	185	0.000	4,190	0.001	47,144	0.006	71,803	0.001	0.011	
16.	B4-4	19	10	Sveti Nikole	1,920	0.002	500	0.000	3,890	0.001	81,665	0.010	92,810	0.001	0.015	
<b>Basin-5: Crna River Basin</b>																
17.	B5-1	20	17	Demir Hisar	4,158	0.005	1,421	0.001	2,637	0.001	29,513	0.004	82,107	0.001	0.011	
		21	18	Krusevo	4,104	0.005	1,234	0.001	708	0.000	35,850	0.005	29,607	0.000	0.010	
		22	20	Prilep	16,026	0.018	3,834	0.003	6,526	0.002	257,246	0.033	279,957	0.003	0.058	
18.	B5-2	23	19	Bitola	16,455	0.018	1,931	0.001	7,498	0.002	220,761	0.028	378,968	0.004	0.054	
19.	B5-3	24	21	Kavadarci	988	0.001	1,119	0.001	2,891	0.001	39,864	0.005	72,854	0.001	0.009	
<b>Basin-6: Strumica River Basin</b>																
20.	B6-1	25	29	Radovish	4,379	0.005	3,014	0.002	4,894	0.001	75,546	0.010	161,576	0.002	0.020	
21.	B6-2	26	30	Strumica	14,466	0.016	11,243	0.008	15,448	0.003	107,198	0.014	380,662	0.004	0.045	
22.	B6-3	-	-	-	-	-	-	-	-	-	-	-	-	-		
23.	B6-4	-	-	-	-	-	-	-	-	-	-	-	-	-		
<b>Basin-7: Crn Drim River Basin</b>																
24.	B7-1	27	27	Debar	2,849	0.003	1,049	0.001	0	0.000	52,891	0.007	18,308	0.000	0.011	
25.	B7-2	28	28	Resen	6,501	0.007	77	0.000	1,659	0.000	20,249	0.003	101,477	0.001	0.011	
		29	25	Ohrid	7,342	0.008	727	0.001	8,389	0.002	51,195	0.007	168,891	0.002	0.019	
26.	B7-3	30	26	Struga	15,031	0.017	1,282	0.001	5,122	0.001	49,269	0.006	226,106	0.003	0.028	
					281,336	0.309	61,797	0.043	171,571	0.048	2,466,099	0.314	4,685,021	0.054	0.768	





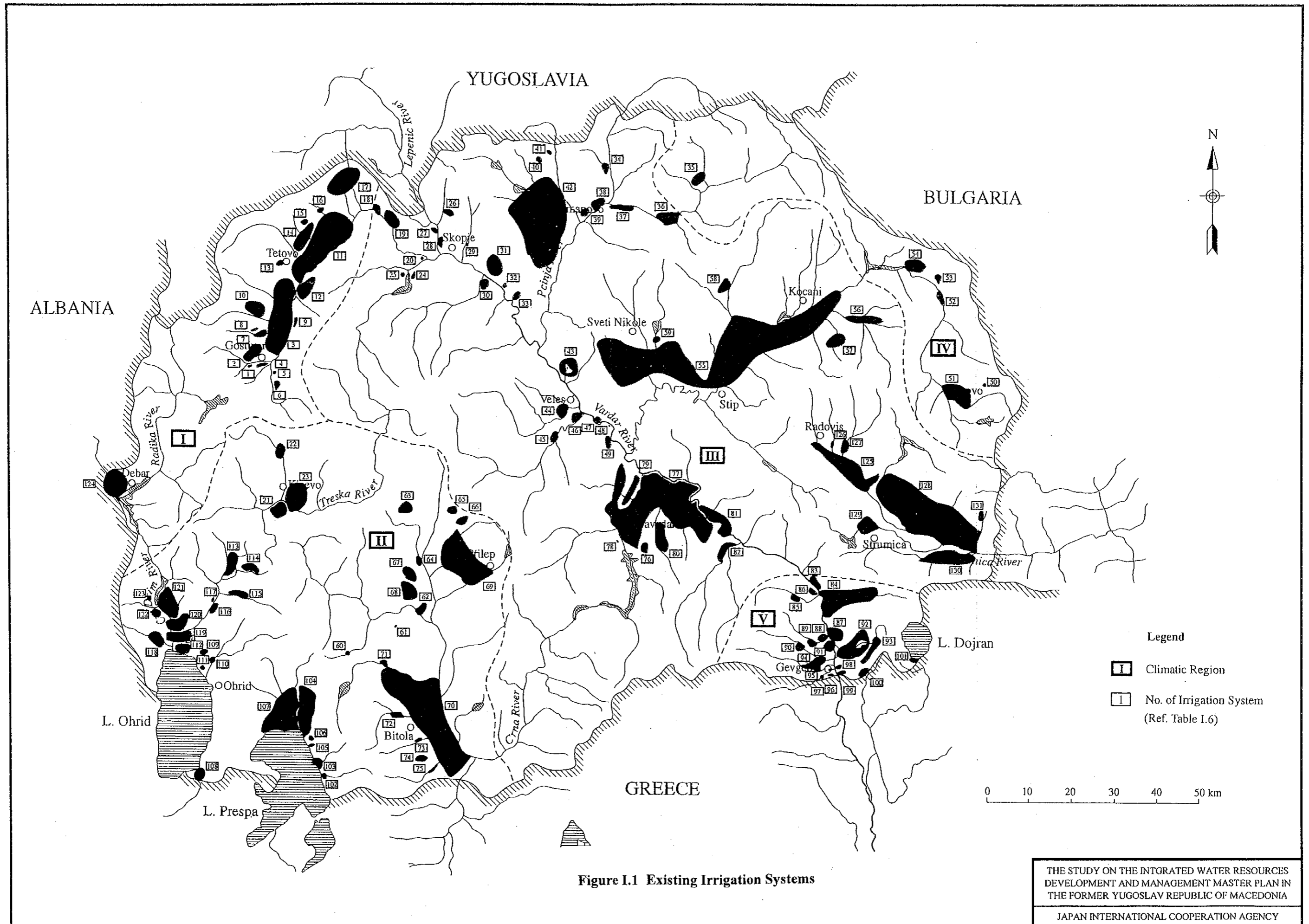


Figure I.1 Existing Irrigation Systems

THE STUDY ON THE INTEGRATED WATER RESOURCES DEVELOPMENT AND MANAGEMENT MASTER PLAN IN THE FORMER YUGOSLAV REPUBLIC OF MACEDONIA  
 JAPAN INTERNATIONAL COOPERATION AGENCY

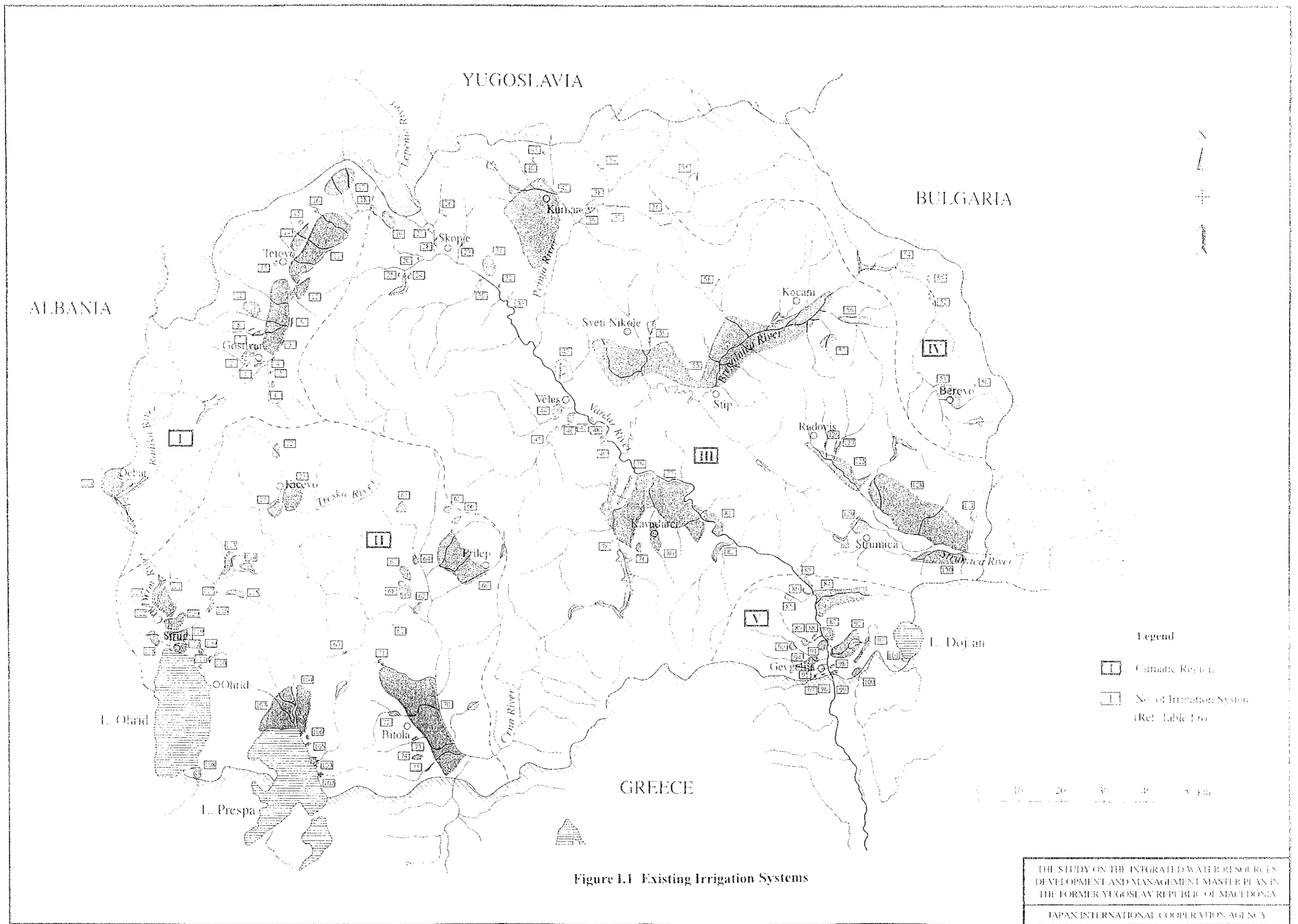


Figure 1.1 Existing Irrigation Systems

THE STUDY ON THE INTEGRATED WATER RESOURCES DEVELOPMENT AND MANAGEMENT MASTER PLAN IN THE FORMER YUGOSLAV REPUBLIC OF MACEDONIA  
 JAPAN INTERNATIONAL COOPERATION AGENCY







1996

Cropping Pattern No.	Code No. (Sub-Block)	Irrigation System No. (Diagram)	Irrigation System	Irrigation Service Area (ha)	No.	Climatic Region	No.	Crop	Cropping Area				Cropping Period												Cropping Duration			
									1st Crop		2nd Crop (summer)		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	months	Decades		
									No.	Area (ha)	Ratio	Area (ha)	Ratio	1	2	3	1	2	3	1	2	3	1	2			3	1
4.	B3-2	A3-1	35.	Stavishko pole	250	1.	Tetovo - Gostivar	1. Wheat	14	216	0.10	0															7	2
	B4-1	A4-1	50.	Cm dol (Pehchevo)	80	2.	Bitola - Prilep	2. Maize	24	0	108	0.05															4	1
	B4-1	A4-2	51.	Maleshevsko pole	917	3.	Shitip - Skopje	3. Rice	34	0	0																	
	B4-1	A4-3	52.	Sandanski (Delchevo)	250	4.	Berovo - Kriva P.	4. Tobacco	44	0	0																	
	B4-1	A4-3	53.	Jugotutun (Delchevo)	164	5.	Gevgelija	5. Sunflower	34	0	0																	
	B4-1	A4-3	54.	Milkovo (Delchevo)	495			6. Cabbage	64	0	0																4	1
				<b>Total</b>	<b>2,156</b>			7. Tomatoes	74	0	43	0.02															4	1
							8. Peppers	84	0	0																4	1	
							9. Other Vegetables	94	0	65	0.03															4	1	
							10. Apples	104	0	0																12	0	
							11. Plums	114	1,509	0.70	1,509	0.70														12	0	
							12. S. Cherries	124	431	0.20	431	0.20																
							13. Other Orchards	134	0	0																		
							14. Grapes	144	0	0																		
							<b>Total</b>	<b>2,156</b>	<b>1.00</b>	<b>2,156</b>	<b>1.00</b>																	
5.	B1-5	A1-12	83.	Gradec	264	1.	Tetovo - Gostivar	1. Wheat	15	2,198	0.25	0														7	2	
	B1-5	A1-12	84.	Udovo-Valandovo	3,624	2.	Bitola - Prilep	2. Maize	25	0	2,198	0.25														4	1	
	B1-5	A1-12	86.	Miravci	100	3.	Shitip - Skopje	3. Rice	33	0	0																	
	B1-5	A1-13	85.	Petrushka river	100	4.	Berovo - Kriva P.	4. Tobacco	45	0	0																	
	B1-5	A1-13	87.	Grechiste I and II	423	5.	Gevgelija	5. Sunflower	55	0	0																	
	B1-5	A1-13	88.	Smokvica I and II	110			6. Cabbage	65	2,638	0.30	0														6	2	
	B1-5	A1-13	89.	Prdajci	200			7. Tomatoes	75	0	879	0.10														4	1	
	B1-5	A1-13	90.	Kovanska, Sermeninska rivers	200			8. Peppers	85	0	440	0.05														4	1	
	B1-5	A1-13	91.	Vinojug	150			9. Other Vegetables	95	0	1,319	0.15														4	1	
	B1-5	A1-13	92.	Gjavoto	1,340			10. Apples	105	0	0																	
	B1-5	A1-13	93.	Paljunci	800			11. Plums	115	0	0																	
	B1-5	A1-13	94.	Konska reka	571			12. S. Cherries	125	0	0																	
	B1-5	A1-13	95.	Schovo	200			13. Other Orchards	135	0	0																	
	B1-5	A1-13	96.	Granica	120			14. Grapes	145	3,956	0.45	3,956	0.45													12	0	
	B1-5	A1-13	97.	Pod anot	120			<b>Total</b>	<b>8,792</b>	<b>1.00</b>	<b>8,792</b>	<b>1.00</b>																
	B1-5	A1-13	98.	Avlakjot	40																							
	B1-5	A1-13	99.	Keramudnica	80																							
B1-5	A1-13	100.	Selemi	350																								
			<b>Total</b>	<b>8,792</b>																								
			<b>Grand Total</b>	<b>167,992</b>																								
						1. Tetovo - Gostivar	1. Wheat	10	109,151	0	0																	
						2. Bitola - Prilep	2. Maize	20	0	46,244																		
						3. Shitip - Skopje	3. Rice	30	0	4,333																		
						4. Berovo - Kriva P.	4. Tobacco	40	0	15,141																		
						5. Gevgelija	5. Sunflower	50	0	9,163																		
							6. Cabbage	60	2,638	0																		
							7. Tomatoes	70	0	8,775																		
							8. Peppers	80	0	8,293																		
							9. Other Vegetables	90	0	24,173																		
							10. Apples	100	6,334	6,334																		
							11. Plums	110	3,620	3,620																		
							12. S. Cherries	120	3,131	3,131																		
							13. Other Orchards	130	7,089	7,089																		
							14. Grapes	140	31,696	31,696																		
							<b>Total</b>	<b>163,659</b>	<b>0.97</b>	<b>167,992</b>	<b>1.00</b>																	

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Figure I.2 Cropping Pattern (3/3)

