CHAPTER 2 CASE STUDY

2.1 LAND RESOURCES EVALUATION

Prior to evaluation of land, grouping of the soils in the areas should be carried out based on the productivity of soils. In principle, every management program such as land use plan, water and fertility management and soil conservation measures should be established for the individual group or unit of soils which has common characteristics in relation to soil productivity.

Soils in the case study areas are characterized as immature, young soils and their different characteristics are accounted for by their different parent materials. Specification of surface deposits in each spot is an essential first step of grouping the soils.

Geographical and geological investigation specified the principle structures of this area as the river side terraces consisting of 1) Alluvial flood plain of current big river of the Morava river with attitude below 149 m, 2) Low terrace derived from Diluvial deposit in the younger Wurm glacial period between 150 m and 155 m, 3) Medium terrace derived from Diluvial deposit in the older Wurm with 155m and higher. The basement of all the area and high terrace are covered by Tertiary deposits characterized by shallow sea-shore sediments. Each point on the plain and terraces can be specified as 1) denudated or 2) deposited areas, identified from density and direction of the contour lines.

Overlapping of geology maps on the geography map may give fundamental information on the basement deposits in each spot. Through field survey and point checks in the field outline of the surface deposit, parent materials of soils in each spot can be specified.

Specification of the soil forming factors and the parent material may give soil types. Final steps of the process are 1) drawing of the boundary lines through a more detailed survey and checking in the field and 2) measuring of the areas covered by each unit of soils. The results are given in Figure 3.3 and the Table shown on the next page. An outline of the two case study areas and soil units are as follows.

(1) Site A (Male Levare and Velke Levare villages)

This district consists of the typical river side terraces on the gentle slope from the East part of a middle terrace to the West part of the flood plain of the Morava river. The surface of the middle terrace is covered by Tertiary deposit, wind blown sand and Diluvial deposit in the older Wurm. The low terrace is covered by Diluvial deposit in the younger Wurm and partly by the wind blown sand. Major parts of the flood plain are covered by the Alluvial sediments of the Morava river, remaining mounds of the Diluvial deposit occur in some spots. Soils in this district are grouped in 5 units; unit A-1, -2, -3, -4 and -5.

A-1 : This unit of soil is characterized by (1) Fluvisols derived from the flood sediment, and located on the flood plain of the Morava, (2) rich in fine clay particles and nutrients transported from the upper reaches, and (3) higher level of ground water. Natural fertility level is high due to larger holding capacity of water and nutrient and also due to abundant nutrient supply. Permanent limitations are 1) water logging in the bottom spots and 2) poor soil tilth due to higher clay contents and poor drainage.

A-2 : This unit of soil is characterized by Fluvic Phaeozem, and found on the running bed of two small streams of the Rudava and the Porec river as well as partly in the flood plain of the Morava river. Thickness of the sediment of the Rudava in Ohrada (near Asparagus farm) is confirmed 1.6 m by boring test. Fluvic Phaeozem is characterized by (1) river deposit in the parent material and by (2) dark surface soil. Due to limited supply of clay from the upper reaches, the texture of these soils is generally classified as sand, loamy sand, and loamy only in some limited spots. Among the sandy soil group, this soil is ranked higher for level of natural fertility. However, generally speaking, fertility level of the soils is not adequate and rather low due to less holding capacity of water and nutrients. Some soils on limited spots have loamy texture and are ranked as medium level in their fertility. Loamy textured soil has compaction problems the same as clay rich soils.

A-3 : This unit of soils is characterized by Eutric Regosols (immature soil derived from rock fragment rich in bases) located in deposited areas on the terraces. This group of soils derives from Diluvial deposit and is located mainly on the low terrace. In order to clarify different levels of fertility among the sandy soils, Eutric Regosols are divided into two groups ; located in deposited areas and denudated areas. Average clay content of this unit of soils range around 5%, and this value is higher than that of A-4 soils.

A-4 : This unit of soil is characterized by Eutric Regosols located in denudated areas on the terraces. A major part of this group of soils is located near and around the slopes between the low terrace and middle terrace. Clay contents range around 3% and less. Fertility level is extremely low due to very poor holding capacity of water and nutrients.

A-5: This unit of soils is characterized by Dystric Regosol (immature soil from rock fragment poor in bases) derived from Tertiary deposit and wind blown sand. Location of coverage is (1) a part of middle terrace between Velke Levare and rail road and (2) surrounding spots of the mounds of wind blown sand that are covered by forest trees. Tertiary deposits in this area derives from the shallow sea sediments. They are extremely poor in clay and nutrients due to washing out by tides. Fertility of the soils is ranked as extremely low, the lowest in this area, because of the extremely low level of holding capacity and poor nutrient supply.

(2) Site B (Gajary village)

This area is located on both sides, North and South of Kostoliste - Gajary road. Eastern and Southern rims of the farm land are adjoining the mound deposits of wind blown sand.The rim areas of the farm land are covered by a mixture of Diluvial deposit and wind blown sand derived from the mounds. It is probable that enlargement of the farmland in 1960’s and 1970’s should have included some part of the marginal land. The Geology map shows that younger and older Wurm deposits share a border on both sides of the center line from South to North. Distribution of lowland plain is limited to only the South East corner below 150m. The major part of the farm lands are on low terrace between 150 and 155m and one spot of farm land in the South East corner is on middle terrace higher than 155m.

B-1 : In the South Western corner of this area, Fluvic-Phaeozems type of soil can be found, probably originating from the flooded sediment of the Morava river. Clay contents of these soils were determined at around 8%, but field judgment with finger-touch suggests occurrence of loamy soils in patches. This unit of soils is distributed only in lowland below 150m. Their fertility levels belong to the low for sandy soils and to the middle for loamy soils. Weakly compacted soils are found in bottom spots where small puddles occur due to poor infiltration.

B-2 : The major part of the low terrace is covered by Diluvial deposit and the soils on this terrace are categorized as Eutric Regosols. Clay contents are around 5% and fertility level is low. Through field survey it is suggested that the main factors related to land productivity in this area are the degree of mixing with wind blown sand. Different from Site A, the soils in this area are characterized by widely-spread coverage and the mixture of the wind blown soils. Division of surface deposit soils into denudated and deposited areas has little meaning and is not useful in this area. From changing colors of surface soils and a slight difference in finger touch soils must be divided into unit groups.

B-3 : This unit of soils is characterized as a transition type of B-2 and B-4. Clay content is less than 5% and fertility level is very low reflecting the mixture of wind blown sand.

B-4 : In the North to North-Western part of the area light colored soil originating from wind blown sand is found. This part is surrounded by the mound of wind blown sand covered mainly by pine trees, and the wind blown sand has been moved out and covered or mixed with deposits of the basement. Soil is categorized as Dystric Regosols and fertility level is extremely low.

(3) Tentative Estimation of Expected Yields for Soil Units in Case Study Areas

Concept of “expected yield of crops” is proposed to represent productivity of farmland soil as a quantitative index and the calculation procedure is also elucidated as above. To complete this concept and to get reliable values of the expected yield accurate and more reliable data should be accumulated about the soil and crop yields in each field. Particularly, there is only a few reliable data to define available soil water because of soil compaction. Most of the farmland has been compressed by heavy farming-machines, and the compacted soil-layer can not give the full holding capacity of water. Destruction of aggregate structure due to long term cropping of cereals promotes this tendency.

Soil compaction and destruction of aggregate structure are not permanent limitation factors of soil. Soil properties should be estimated and presented in optimum condition when soil becomes free from compaction and recovers proper soil structure. Technical difficulty with pF determination in the compacted soil column is also apparent. Tentatively, holding capacity of available water is given as an assumed rough value summed up from existing data, water contents of surface soils in early spring and some of the reliable pF values of soils.

The results are given in the following tables for A and B sites in the case study areas.

Trial Calculation of Expected Yield of Wheat in Soil Unit

A Site

Soil Unit	A — 1	A — 2	A — 3	A — 4	A — 5
Soil Type	Fluvisols	Fluvic Phaeozems	Eutric Regosols	Eutric Regosols	Dystic Regosols
Clay Content (%)	18	8	5	3.5	2.5
Available Water (%)	20	12	7	6	5
Expected Yield (t/ha)	5.0	4.4	2.8	2.2	1.8

B Site

Soil Unit	B — 1	B — 2	B — 3	B — 4
Soil Type	Fluvic Phaeozems	Eutric Regosols	Eutric Regosols	Dystic Regosols
Clay Content (%)	8	5.5	4.5	3.5
Available Water (%)	12	8	7	6
Expected Yield (t/ha)	4.4	3.0	2.4	2.2

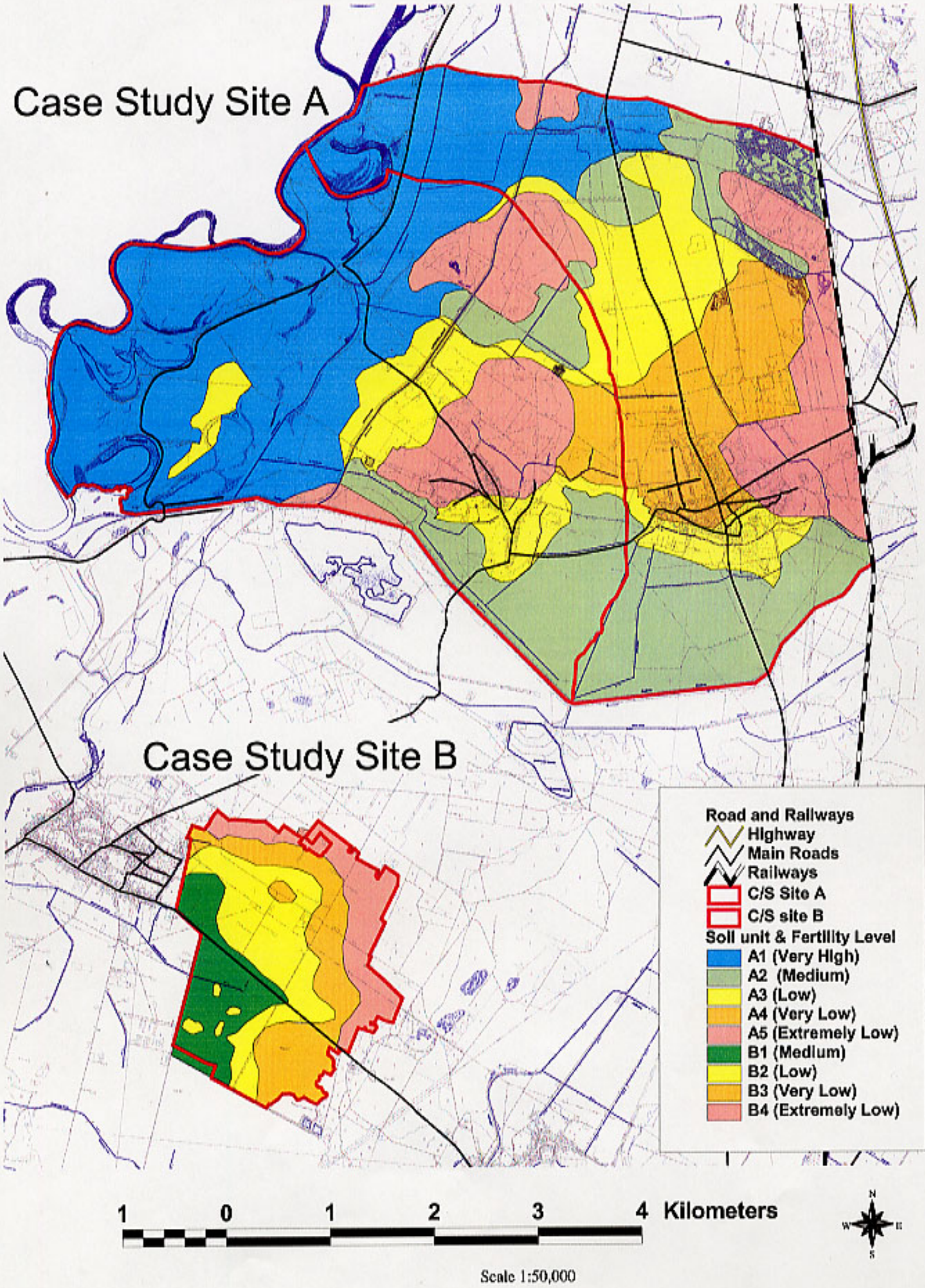

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Figure 3.3 Result of Grouping into Soil Unit

Characterization of Soil Units in the Case Study Areas

Velke Levare and Male Levare Villages (Site A)

	A - 1	A - 2	A - 3	A - 4	A - 5
Location	Flood plain of Morava	Flood plain of Rudava, Porec and Morava	Deposited area on the low terrace	Denudated area on the lowterrace	Low terrace and middle terrace
Parent Materials	River sediment	River deposit	Diluvial deposit	Diluvial deposit	Tertiary deposit and wind blown sand
Soil Type	Fluvisols	Fluvic Phaeozems (Sandy)	Eutric Regosols	Eutric Regosols	Dystric Regosols
Soil Texture (I. S.S.S.)	SL, L, CL,	LS, S	S	S	S
Area of Arable Land Natural Grassland	272ha 165ha	474ha 58ha	245ha -	173ha -	197ha 3ha
Fertility Level	High	Low to medium	Low	Very low	Extremely low
Permanent Limitation	Water logging in bottom spot and poor soil tilth	Poor holding capacity of water and nutrient	Poor holding capacity	Very poor holding capacity	Extremely poor holding capacity
Soil Samples No and Clay Content	L 18 16.6% L 19 18.9%	L 10 8.4% L 11 7.3% V 03 6.7%	L 12 4.8% V 02 4.9%	L 04 2.7% L 05 3.0%	L 06 2.5% V 01 2.4%
Field Plot No. and Grain Yield of Crops	S 10 3.60t/h (Wheat) S 14 1.76t/h (Rye) S 08 1.63t/h (Wheat) S 04 3.83t/h (Wheat)	S 32 3.23t/ha (Rye) S 22 3.67t/ha (Rye) S 34 4.36t/ha (Barey)	S 13 2.61t/ha (Wheat) S 12 0.9t/ha (Mustard)		

Gajary Village (Site-B)

	B - 1	B - 2	B - 3	B - 4
Location	Lowland below 150m	Low terrace	Low and Middle terraces	Low and Middle terraces
Parent Materials	River flood sediment	Diluvial deposit	Diluvial deposit and Wind blown sand	Wind blown sand and Diluvial deposit
Soil Types	FluvicPhaeozems (Sandy and Loamy)	Eutric Regosols	Eutric Regosols	Dystric Regosols
Soil Texture	L.S S.L, L,	LS, S	S	S
Area of Arable Land	81ha	127ha	103ha	54ha
Fertility Level	Medium to Low	Low	Very low	Extremely low
Permanent Limitation	Poor infiltration in spots and poor soil tilth	Poor holding capacity of water and nutrient	Very poor holding capacity of water and nutrient	Extremely poor holding capacity of water and nutrient
Soil Sample No. and Clay Content	K 09 8.0 % B 01 8.0 %	K 04 5.8 % K 10 5.3 %	G 06 4.7 %	B 02 3.8 % G 05 4.5 %
Field Plot No. and Grain Yield of Crop	J 05 4.7t/ha(Wheat) , J 03 2.3t/ha (Oat) J 04 3.6t/ha (Wheat)		J 02 2.2t/ha (Rye) J 03 2.5 t/ha (Rye)	

2.2 IRRIGATION

2.2.1 ACTUALLY IRRIGABLE SECTORS

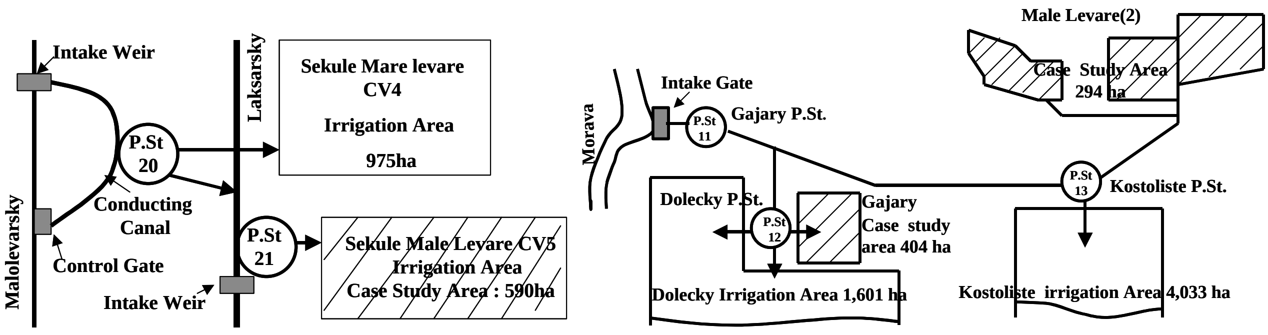
Within the Case Study Area, only the irrigation system classified as Category I at which both pumping and piped irrigation systems are available. Thus, the sector which is classified as Category I and is equipped with an irrigation system can be evaluated as an irrigable sector. Irrigable areas for Male Levare and Gajary sectors are as summarized below.

Irrigation Available Area of the Case Study Area

Agriculture Zones	Gross area with irrigation facilities (registered area by SWME-PD)	Net Irrigation available area	No Irrigation available area	Evaluated year
	(ha)	(ha)	(ha)	
Male Levare	1,131	884	247	August, 2002
Gajary	465	404	61	August, 2002
Total	1,596	1,288	308	-

2.2.2 WATER RESOURCE AND IRRIGATION SYSTEM

Two irrigation systems, Sekule-Male Levare and Kostoliste, are actually in use at the Male Levare sector of the case study area. The Gajary sector falls within the jurisdiction of the Dolecky irrigation system.



(1) Sekule-Male Levare Irrigation System

The Pumping Station P-21 (CSV5) for the Sekule-Male Levare Irrigation System, which is located at the central part of the western zone of the irrigation area, takes water from the Laksarsky River. It is worth while to mention that the station was constructed without legal rights for taking water from the Laksarsky River and, thereby, the said pumping station depends on the Malolevarsky canal for a source of irrigation water. A gross benefitable area of this irrigation system is 759 ha (net area 590 ha) in total.

(2) Kostoliste Irrigation System

Water for the Kostoliste Irrigation System is taken from the Morava River. Under this irrigation system, water supplied from the Gajary Pumping Station (P-11) is boosted at the Kostoliste Pumping Station (P-13) to irrigate a benefitable area of 4,407 ha, of which the case study area accounts for 372 ha (net irrigation area 294 ha).

(3) Dolecky Irrigation System

Water for Dolecky irrigation system depends on the Morava River; water is not taken directly from the river, but is similar to Kostiliste (P-13), which is boosting water at the Dolecky Pumping Station (P-12) conducted from the Gajary (P-11). The total irrigable area of this system in question reaches 2,066 ha, of which 465 ha (net irrigation area 404 ha) is used for the case study area.

2.2.3 FEATURES OF IRRIGATION FACILITY

(1) Water Intake

1) Sekule-Male Levare (P-21)

Water from the Laksarsky River is taken by means of intake works and conducted to the pumping station. The Laksarsky River is closed with two wooden gates and water is conveyed to the water supply tank of the pumping station once garbage materials are excluded by a screen installed at the intake.

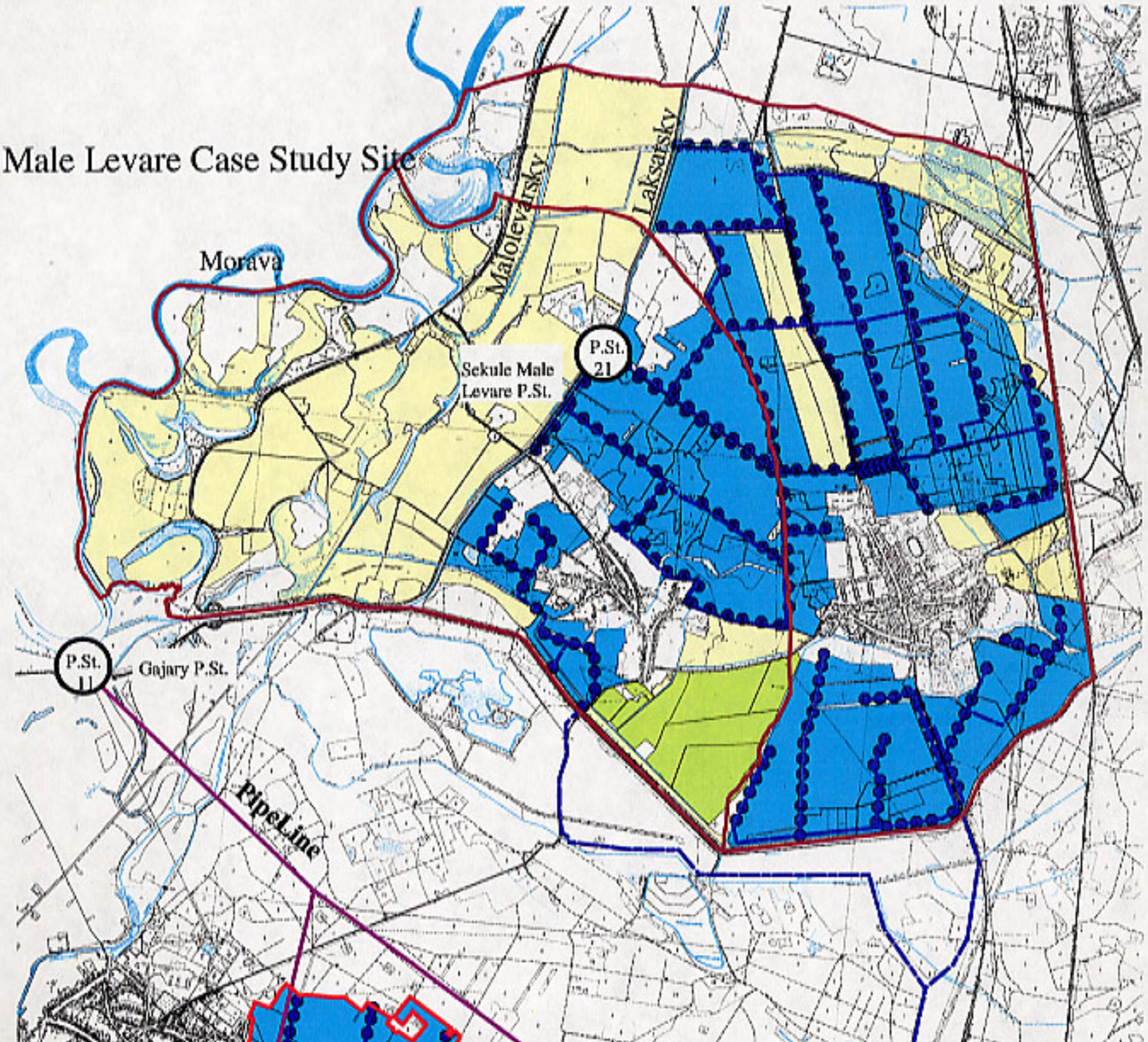


Figure 3.4 Irrigation Condition in Case Study Area

2) Kostoliste (P-13) and Dolecky (P-12)

The Kostoliste (P-13) and Doleccky (P-12) Pumping Stations are equipped with booster pumps and have no intake works. Thus, the direct intake was carried out through the Gajary (P-11) –the trunk station of the relevant irrigation system-, which takes water directly from the Morava River. This intake from the Morava River does not depend on such artificial works as weir but by gravity. Under the circumstances, this intake relies heavily on the water level of the Morava River, but lowering of the river water has not been recorded to cause failure of the water intake in the past. The Gajary (P-11) is working properly, without deterioration in its structures. A legally vested intake volume from the Morava River is 2.4 m^3/s.

(2) Pumping Station

1) Sekule-Male Levare Irrigation System

Water to the Sekule-Male Levare irrigation system is conducted through the P-20(CV4) and P-21, both of which are equipped with structures evaluated at present as category I. In particular, the P-20, which had been evaluated as category II up to 2001, was improved in 2002 to supply irrigation water and it is now upgraded to category I.

2) Kostoliste Irrigation System

Water to the Kostoliste irrigation system is conducted through the Gajary (P-11) and the Kostoliste (P-13) pumping stations. An assessment on functioning of these pumping stations carried out by JICA has ranked both as category I. Due to the fact that irrigation water was supplied through these two stations in 2002, no problem relevant to the functioning of these stations has been revealed.

3) Dolecky Irrigation System

Two pumping stations – Gajary (P-11) and Dolecky (P-12) – are operated within the Dekecky irrigation system. A technical assessment conducted by JICA Study in 2001 ranked both of these two stations as category I and it was revealed at the same time that there was no serious constraint relevant to their functioning due to proper operation in supply of irrigation water. The Gajary (P-11) is 1.6 km from the Dolecky (P-12) and irrigation water between the stations is conducted through the pressured pipeline (ф1,200). Water supplied to the Dolecky (P-12) is boosted to irrigate respective farmlands.

(3) Pipeline

The pipeline for the Sekule-Male Levare Irrigation system is featured by a reticulated pipeline system. The diameter of pipelines ranges from ф125 mm to ф500 mm. In so far as functioning of these pipelines is concerned, a water conveyance test carried out in 2001 relevant to trunk pipelines revealed that 80% of the pipelines in question had served properly. The pipeline for the Kostoliste and Dolecky irrigation system are represented by an arborescent pipeline system. The diameter of pipelines fluctuates between ф150mm and ф500 mm. It is necessary to confirm the functioning of pipeline through water flow tests where irrigation has not been practiced for a long time.

(4) Hydrant and Other Related Structures

Hydrants for water supply are installed every 2 - 7 ha, equipped with control valves and air valves for water management and maintenance of facilities. In so far as maintenance of hydrants is concerned, those which are installed where irrigation is practised show no constraint on their use, meanwhile those which have been left for years without operation have some problems such as growth of weeds within the maintenance box, damage in structure, etc. Furthermore, it is also disclosed that some control valves are beyond man’s strength to turn because of rust in some parts. In the light of this, it is advised that arrangements for repair and test operations are indispensable in advance of operating irrigation systems which have been left unused for a long time.

2.2.4 FACT FINDING ON IRRIGATION SYSTEM

(1) Irrigated Area

An average irrigated area for the Case Study Area from 2000 to 2002 is 19 ha at the Gajary sector and 48 ha at the Male Levare sector. The irrigation is carried out for vegetables such as carrot, onion and parsley in Gajary sector and for asparagus in Male Levare sector.

(2) Irrigation Method

Traditionally, pumping irrigation has been carried out aiming at large-scale farmlands in which cereals and sunflower are planted. In such farmlands, reel hose sprinkler has been employed to suit large-scale lots, representing about 85% of sprinklers owned by farmers. Nevertheless, underground drip irrigation on a small scale is introduced at Male Levare sector.

(3) Maintenance and Management

Irrigation facilities including pump to hydrant in the field are a property of the SWME-PD (State), so that they carry out operation and maintenance for the facilities. However, operation, maintenance and repair for irrigation facilities are entrusted to private companies on a contract basis. Farmers manage sprinklers in the field without a hydrant. Presently, a water users association does not exist among farmers and SWME-PD, including the private companies. Five pumping stations are related to the Case-Study Area, and two (2) private companies (In-service and HMU) manage those main facilities.

2.2.5 GROUNDWATER CONTROL AREA IN THE CASE STUDY AREA

The groundwater control area is located on less undulating lower plains along the Rudava River, in the southern part of Male Levare sector. In this area, irrigation water is taken from the drainage canal (Tributary of the Rudava river) to supply, in turn, the underdrains; in such an area ground water level is controlled by the relief well of underdrains and groundwater irrigation is carried out experimentally to cover a control area of 102 ha.

2.3 DRAINAGE

2.3.1 LAND CAPABILITY CLASSIFICATION ACCORDING TO DRAINAGE CONDITIONS

With a view to assisting land use planning, land capability of the two sectors of the case study area (Male Levare and Gajary) has been classified as shown below, taking account of prevailing drainage conditions and relevant constraints on crop farming development.

(1) Male Levare Sector

According to drainage conditions, the Male Levare sector is divided into three sub-sectors: i) the sub-sector vulnerable to frequent flooding and inundation (river field of the Morava River), ii) the sub-sector depending on pumping drainage (including environment protection zone), and iii) the sub-sector depending on drainage by gravity (eastern zone). The extent for each sub-sector is shown below:

Drainage Area of Three Sub-sectors

Drainage characteristic of district	District which received flood & ponding	District with necessity of pump drain	District where possible to drain by gravity	Total (km^2)
District	The Morava River land	The Environment Protection District and Drainage area by siphon	The East zone	
Area (km^2)	4.76	20.16	8.36	32.96
Farming risk	The risk to farming is high due to lack of drainage facilities.	The risk to farming depends on the pump drain.	The farming risk is small.	-

Of the above three sub-sectors, the sub-sector depending on pumping drainage, which consists of the environment protection zone and the underdrainage zone, is the area in which consistent drainage by pump is indispensable during the thaw season in spring which falls between March and May and the flooding season in summer. Drainage condition there is directly related to the availability of pumps, which intimates that this is farmland with a higher cost for drainage. At present, owing to the operation of the Male Levare pumping station, the area is not vulnerable to inundation, although the limited depression area is inundated during the thaw season. It is reported that pumps for the Male Levare drainage pumping station had been operated for 63 days during spring season (January to March) in 2002.

(2) Gajary Sector

The Gajary sector has a gentle slope from east to west, so water is drained by gravity. The majority of rainfall is infiltrated into the ground and drainage canals and underdrains for surface flow water have not been constructed within the sector. Due to the gentle slope, the western part of the depression area has limited inundation in spring. At the western boundary of the sector, a drainage canal is constructed to collect excess water (including infiltrated water in the ground) within the sector. Thus, the Gajary sector (465 ha) is assessed as an area in which water can be drained by gravity.

(3) Maintenance of Regulation on Development within Environment Protection Zone

An environment protection zone with an area of 200 ha is found within the Male Levare sector, of which a swamp protection zone under the Ramsar Convention accounts for 50 ha. In the environment protection zone (approximatly 150 ha excluding swamp), which is bounded by the rivers of Morava, Rudava and Laksarsky, construction of irrigation and drainage works is not permitted. Furthermore, forest swamplands along the Porec River are designated as a protection area to regulate crop production. The environment protection zone is one of destinations for eco-tourism. Under the circumstances, farming is practiced under the regulation on development and farming in the future is required to follow this regulation.

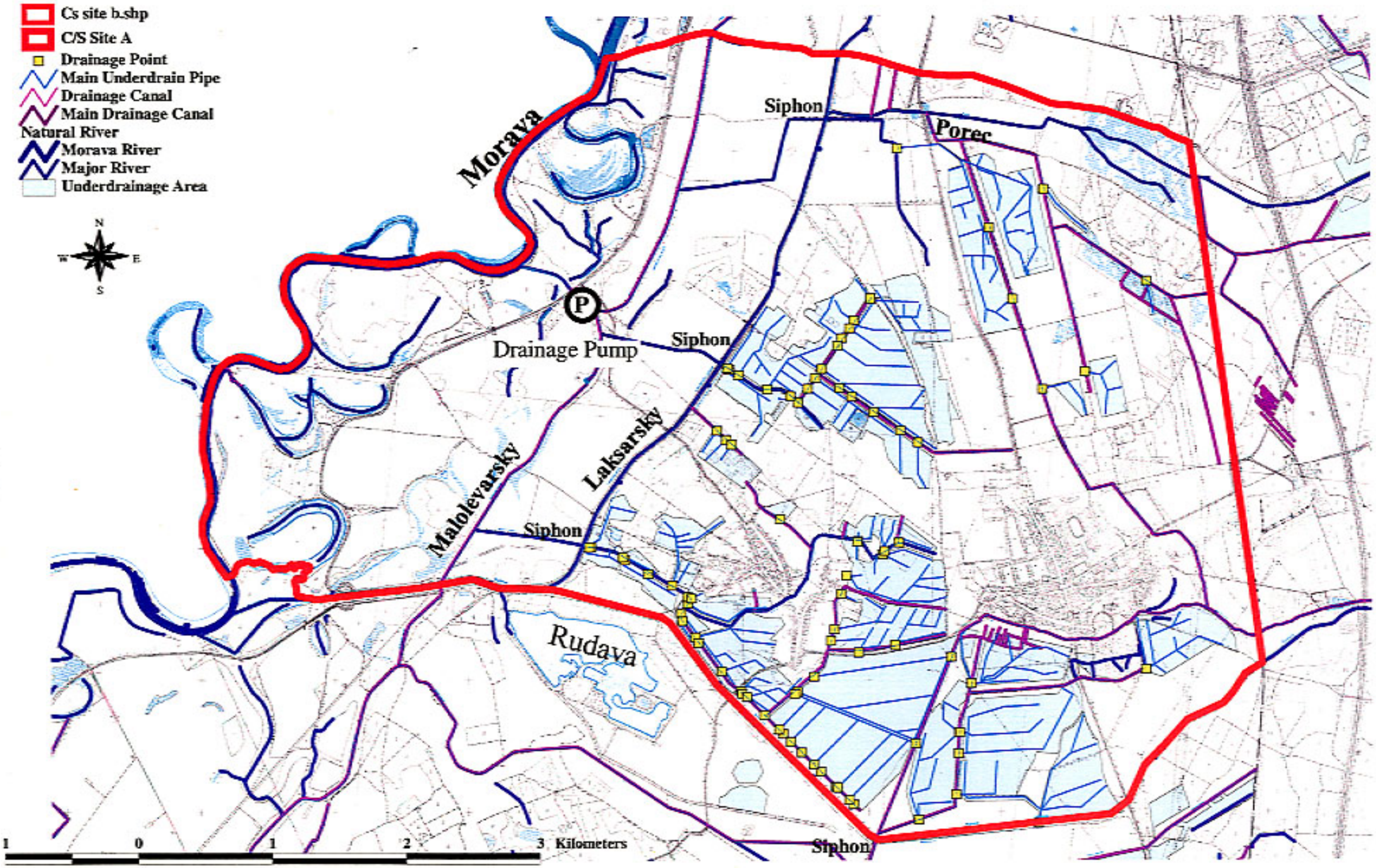


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Figure 3.5 Drainage System in Male Levare

2.3.2 FUNCTIONS OF OPERATION AND MAINTENANCE OF DRAINAGE SYSTEM

(1) Male Levare Sector

1) Natural Drainage Rivers

Within the Male Levare sector, three rivers, Rudava (located to the south of the sector), Porec (to the north) and Laksarsky (to the south), play the role of natural drainage canals; the Laksarsky and Porec rivers are tributaries of the Rudava River, which is confluent with the Morava river – the final drainage river of the case study area. At the time of flooding, all of these rivers are affected by the backwater of the Morava River, but owing to embankment works, the river basins under influence of the said rivers are not subject to damages caused by flooding.

2) Maloleversky Canal – Dual-Purpose Canal

Water flowing through the Maloleversky canal is taken from the Morava River near Holic and is taken to the study area after passing through the Myjava River by means of a siphon. In turn, water is taken from this canal through two pumping stations (Sekule Male Levare CSV3 and CSV4). The same canal functions as a drainage canal to collect excess water from surrounding lands. Irrigation water is finally taken from the canal at the CV4 Pumping Station and the lower length of the canal from this pumping station has only the single function as a drainage canal. Water collected to the Malolevarsky canal is discharged into the Morava River or conveyed to the Zohorsky canal, located downstream of the Malolevarsky canal. Due to the fact that the water level of the Morava River becomes higher than that of the Malolevarsky during the thaw season in spring as well as in the flooding season in summer, the excess water discharged to the Morava River is dependent on pumping.

3) Male Levare Drainage Pumping Station

The Male Levare drainage pumping station aims to drain surface water from the lower plain land (46.87 km^2), situated to the south of the Myjava River, of which the case study area represents 20.16km^2 (43%). It consists of an area of 6.80 km^2 between the Morava River, western part of the case study area and the Laksarsky River, the eastern part of the area and an underdrainage area of 13.36 km^2, to the east of the Laksarsky River. The task for operation and maintenance of the pumping station is adequately carried out assigning administrators who are stationed at the pumping station.

4) Drainage Canal and Drainage-Related Works

a) Drainage Canals

The number of drainage canals within the study area is 20 in total; most of which are civil engineering works but some are natural canals that have been upgraded to serve as a drainage canal. 80% of the canals have been protected by block concrete at their bottom and some portion of slope. The sedimentation in the canals is 1.0 m at maximum and 27 cm on average. Condition of block concrete could not be observed because of thick growth of weeds in most of the canals. At some points an investigation was carried out and it was observed that the block concrete was in proper condition. It was also observed that most of canals have constraints on conveyance of water because of thick growth of weeds. In addition, weeds grow on the canal bottom with thick sedimentation.

b) Siphon

In the eastern area, water is naturally drained through the underdrain system where collecting canals are connected by siphon to the Laksharsky and the Rudava river, then to the Malolevarsky canal in the lowland area. In case of a flood, floodwater is drained by pump at Male Levale drainage pumping station. The number of siphons is three to cross the Laksarsky River and one to cross the Rudava River. These siphons are made of concrete pipe with a diameter of 0.8 to 1.50 m and no outstanding damage to impair their functioning was found. It is worthwhile to point out that a siphon installed at the lowest stream of the Laksarsky River has deficient flowing capacity because of sedimentation, which calls for urgent task of clearance.

c) Underdrains

Underdrains are installed to benefit 689 ha of farmland within the Male Levare sector of the case study area. Most of these underdrains were constructed in the 80’s and their pipes are made of polyvinyl chloride or unglazed earth pipe. And, the majority of these structures are installed within the farmlands in which irrigation works are provided. Underdrains are gathered in the range of every 2 - 10 ha and are equipped with an outlet box to connect to drainage canals. 84 outlet boxes have been installed in this area, most of them are filled with sedimentation that reduces flowing capacity of underdrains except in the groundwater irrigation area.

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(2) Gajary Sector

The drainage system in the Gajary sector relies on two canals constructed at the western boundary of the sector. Land in the sector has a downward slope from east to west and both surface water and groundwater are discharged into these two canals. The Depression area, situated to the western part of the sector, has a limited swamp in spring, but this area is an exceptional zone within the sector. In general terms, lands in the sector have good drainage capacity without underdrains.

2.3.3 OPERATION AND MAINTENANCE OF DRAINAGE SYSTEM

The operation and maintenance of pumping stations, drainage rivers and drainage canals is in charge of SWME-PD (Malacky office). Underdrains constructed with farmlands belong to land owners, so farmers are responsible for their operation and maintenance. Nevertheless, farmers are unlikely to undertake improvement of underdrains. It is worth while to point out that, the outlet box, an important structure of underdrains, is filled with sedimentation, which impairs the proper functioning of underdrains.

2.4 SOIL CONSERVATION - WIND EROSION

After the Phase-I Study, the conclusion for soil conservation problems was that the possibility of water erosion is negligibly small in this area because the sandy soils can be characterized by higher water permeability with reduced surface running water. On the other hand, this area is characterised by the highest level of wind erosion risk potential due to the high velocity of wind, and the large scale of farmland with sandy soils which are easy to dry with an abundance of light quartz particles which are easily blown. During the field survey in April and May 2002, a series of works had started in order to evaluate the reality of wind erosion in Gajary village. Several parameters related to wind erosion such as wind velocity, plant coverage on farmland and water contents of surface soils were measured. It is impossible to measure actual amounts of soil removed by the wind during short periods of time, and the survey was focused on the protecting effect of crop covers against wind erosion based on the kind recommendation of Prof. Dr. Jozef Stredansky (Nitra Agricultural University).

According to the result of observation in the spring of 2002, the observed wind velocity was somewhat lower than an average year in the case study site. Throughout the field observation during that period, a sand storm was not observed and only a small level of sand blowing on the dried sandy soils was observed.

Water content in surface soil was measured over time. Water content stayed within the range of 6~13% in weight at the beginning of April. After a small amount of rain of around 28 mm in the middle of April, water content in surface soil on 14, 15 May came down to 9.4~3.2%, step by step with rising temperature. Tunnel experiments proved that the sandy soils in this area begin to blow under the following combined conditions: water content in surface soil less than 5% and wind velocity higher than 7 or 8 m/sec. These values of water content suggest the substantial existence of high risk potential of wind erosion.

Coverage of land surface, which is the most effective and realistic measure for wind erosion, was also measured in April 2002 as a percentages of effective coverage on each spot by counting the exposed area of land surface on photographs taken in a vertical direction. Growing plants of rye, rape and turf performed the effective coverage of soil surface. Cover ratios were 58 - 95% for rye, 58 - 85% for rape and 21 - 24% for spring barley. Turf coverage was the most effective -nearly 100%- in growing periods but the turf production brings intermittent removal of surface soils at every harvest. Turf is therefore not considered.

Rye plants are characterized by cold resistance and creeping type of growth, and they can achieve effective coverage in early spring when they grow well. Rape plants are also effective in covering the soil surface. Spring barley was just an infant seedling. According to the table "The Protecting Effect of Agricultural Crops against the Effect of Wind Erosion" by Prof. Dr. Stredansky, percentages of soil protection effectiveness given were 46% for oil rape, and 43% for winter wheat and winter rye. Total through-year contribution of planting of winter crops for prevention of wind erosion, should be near to these levels, but land cover with stubble and harvest residues (stubble mixture) promote the effects. Prof. Dr. Stredansky gave the following final conclusion in his booklet "Soil is best protected by cultivation of the main crop and inter crop in combination with winter mixture".

Reflecting the particular situation in this area, another important problem is large scale movement of sand and silt particles from the mound of Tertiary deposit and wind blown sand. Estimated annual total amounts of this movement were given: 89.77 mm in depth for sandy soil in Bratislava and 102.59 mm for sandy soil in Kuchyna. These values represent the total amounts of movement. Real amounts actually removed or denudated from the spots might be much smaller by offsetting the amount incorporated. When the mound of sand is kept near bare land and it has significant slope, the denudation process dominates and the blowing sand particles are scattered on surrounding farm fields. Cover by forest trees and herbs is effective in protection against the wind blowing sand, and it is now playing an important role for the conservation of soil in this area.

2.5 WATER MANAGEMENT OF SOIL

Water management practices on farm fields can be divided into 1) under excess supply and 2) under deficient supply. Both of the extremes, excess and deficient supply, cause water stress to growing crop plants and disturb normal growth and yield of crops.

2.5.1 EXCESS WATER SUPPLY - WATER LOGGING

When soil drainage is prevented by low permeability of underlying subsoil or by high ground water level, lands become under occasional or permanent water logging when the soil pore-spaces are almost entirely occupied with water. Under this condition oxygen in trapped air is exhausted rapidly by soil and root respiration, and further oxygen supply is effectively cut off by the very low rate of oxygen diffusion through water. Waterlogged soils rapidly become anaerobic and aerobic respiration rates fall to a very low level. Anaerobic soil conditions negatively affect plant roots in two ways : (1) accumulation of toxic materials in root cells through anaerobic metabolism and (2) exposure of root cells to a wide range of inorganic and organic toxins in the soil.

For effective countermeasures for water logging, the identification of the main cause is essential. Field survey showed that major cases of water logging come from high ground water level. Main evidences are : (1) the waterlogged soils could be found only in bottom spots of the farm land along the rivers and canals, (2) water level of the Laksarsky canal is very often kept higher than the ground level of adjoining land, water level of the Morava river also rises up sometimes to higher levels than farm lands, and (3) boring survey could not confirm the occurrence of underlying impermeable layer.

Practical and effective countermeasures for water logging are restricted to (1) uniform leveling as a reasonable mechanical measure for land reclamation and (2) introduction of resistant crops and appropriate cropping pattern avoiding winter crops. Field observation suggests that maize plant is more adaptable than other crops such as sunflower, wheat and barley. Experimental evidence shows, that the new nodal root of maize plants, replacing the dead original root, can have well-developed aerenchyma

(air space in cortex of root) and develops 15 cm new root within 9 days when anaerobic conditions had developed gradually. Sunflower is more susceptible to water logging and it is easily subject to “wind throw” due to weakened or dead roots. On waterlogged sunflower fields “wind throw” and “stalk bending” are very common together with very poor growth of plants.

2.5.2 WATER DEFICIT - DROUGHT

Water management practices, without irrigation, for drought in the field can be divided into (1) improvement of water balance - protection of water losses from soil surface, and (2) selection of the crops which are more resistant to drought.

Traditional dry farming has developed a wide range of practices such as mulch farming, non-till farming, fallow system and trashy farming to improve water balance. During modernization of farming practice represented by mechanization and use of chemicals, most of these traditional practices lost their support from the planned economy. Some of them would be valuable and adaptable to present conditions of farming in this area.

Mulch farming is the first priority in improving water balance. Mulch farming can bring two beneficial effects : namely (1) maintaining a mulch on top of farm land to retard erosion, maintaining of surface soil structure, increasing water intake, making maximum use of crop residue to improve soil tilth and fertility, and (2) making more efficient use of water and chemical fertilizer to increase crop yield. Introduction of mulch planter is possible for some crops in this area.

Selection of resistant crops is very important where amounts of evapo-transpiration exceed precipitation. Every plant has a different level of adaptability to drought due to their inherited character. This different level of adaptability can be achieved through (1) effective acquisition of water, (2) effective use of water, and (3) tolerance to drought.

Some kinds of grasses and legumes can develop deep root system within a short period of time, and can survive in dry environments competing with other kinds of plants.

Planting of Alfalfa is to be recommended in this area for two major reasons : (1) autumn sown Alfalfa plants can develop their deep root system reaching ground water level before next summer and can maintain their vigorous growth for 2 or 3 years, (2) planting of Alfalfa can improve nitrogen balance by their nitrogen fixing ability, and also can improve soil fertility with recovery of granular structure through leaving extremely large amounts of root biomass. Other species of legumes and grasses can contribute to improvements of water balance and granular structure.

2.6 SOIL FERTILITY MANAGEMENT

The principle meaning of soil fertility is categorized as “Ability of soil to supply simultaneously water and nutrients to plants growing on it”. In order to achieve this simultaneous supply, soil must have adequate micropores to hold necessary water and also macropores to keep soil air that is necessary for respiration of plant roots; this is in addition to an abundance of calcium and other nutrients. Each component of fertility plays a different role depending on various natural and technical conditions, and management practices should be considered separately for each unit of soil.

Fluvisols (Soil Unit A-1):

Major attention must be paid to their two permanent limitations which are water logging and poor soil tilth. Usually, Fluvisols can be rated at the higher level of natural soil fertility under proper drainage since they derive from river sediments rich in clay and nutrients. Water logging and soil compaction are preventing the manifestation of their natural fertility. Since water logging has been already discussed in Section 2.5, soil compaction problems will be investigated in this chapter.

Soil compaction disturbs penetration of roots and also produces poor soil tilth. Under heavy pressure of giant farming machinery, part of the soil water in micropores is pressed out, and mobilized suspension of soil particles pours into the macropores of the soil. Step by step, most of the soil pores are filled with small particles and the soil compaction process goes on. Repeated wetting and drying accelerate this process.

Compacted soil condition is specified by (1) lower porosity (2) higher bulk density and (3) larger penetration resistance.

Soil testing in Spring 2002 proved that most of soil samples collected from the case study areas had high values of the bulk density, very often higher than the critical values to qualify as compacted soil. For example, representative values of bulk density are 1.64 g/cm^3 for Fluvisols of L-17 (loamy) in the surface (0-10cm), 1.83 for Fluvic Phaeozems of L-10 (sand) in the surface (5-10) and 1.69 for Fluvic Phaeozems of K-9 (loamy sand) in the surface (5-10 cm). The critical values that specify compacted soil are set by SWME on $\geq$ 1.35 for clay soil, $\geq$ 1.45 for loamy soil, $\geq$ 1.60 for loamy sand and $\geq$ 1.70 for sandy soil. A higher level of clay content contributes to strengthening the harmful effects of soil compaction through stronger cohesion and adhesion of the compacted soil crumb, resulting in poor soil tilth.

On the compacted farmland, selection of timing of farming practice by machinery becomes very difficult. When soil remains wet, running of the machine becomes difficult due to slipping of wheels and also accelerates further compaction. On the contrary, if soil becomes dry, compacted soil crumbs increase their rigidity and it becomes more difficult to fallow the land. Mechanical reclamation of the compacted soil by high power machinery can improve the condition to some extent, but that improved condition cannot continue for long, particularly under careless farm management. It is very common that the improving effect diminishes within several years. Only if the mechanical reclamation is combined with biological measures to recover the granular structure of soil, can we expect a continuous improving effect. Although liming and heavy application of domestic organic manures are also helpful, full-scale recovery of the granular structure can be done by systematic rotational cropping of legumes and grasses.

<u>Fluvic Phaezems (A-2 and B-1 units):</u>

Although the fertility levels of this unit of soils are rated from low to medium, these soils are specified as the most easily manageable in this area, in practice, due to the temporary limitation, particularly when the soils are close to a loamy texture.

The only drawback is the thin coverage of the flood deposit, and careful management is necessary to prevent removal of the favorable surface soil. For example, Fluvic Phaeozems in B-1 unit has only 50 cm of deposit over the Diluvial sand layer. When this flood deposit cover was denudated, favourable soils in these spots would change into poor soil of the same quality as other units of sandy soils. Soil compaction is found in patches and occasional planting of legumes and grasses is preferable to improve soil structure.

Eutric Regosols (A-3, 4 and B-2, 3 units):

Although these units of soils are rated as low and very low level of fertility, management of these soils may play the key role to assure the sustainable development of agricultural production in this area because a major part of the arable land (more than 50~60% of total) is covered by these soils. There is no single measure to overcome the limitations of sandy soils. Combined measures of farming practices such as heavy dressing with domestic organic manures, mulching, crop selection, legume and grass production and conversion to natural grass land, should be applied together with supplementary or full time irrigation.

Dystric Regosols (A-5 and B-4 units):

This unit of soil is rated as extremely infertile. Most soils originate from Tertiary deposits and wind blown sand which are very poor in fine particles and nutrient elements. These soils are located near the rim of farmlands adjoining the mounds of forest cover. It would be better to consider these soils as a damaged scar formed by unreasonable enlargement of farmland during the planned economy which neglected profitability. Even in the current condition, most of these areas are kept as abandoned fields and natural grassland, and conversion of land use is essential in systematic planning, including the particular case of land use for turf production. Otherwise, it would result in further degradation of land resources and also in destruction of the rural environment.

2.7 CROP CULTIVATION TECHNIQUES

<Necessity of "Good farming practices">

The Zahorska area has various constraints in climatic conditions and soil characteristics for crop production, and, hence, the arable lands require large amounts of agricultural inputs such as fertilizers, agricultural chemicals and irrigation. An increase in crop yield will be achieved if these inputs are increased. However, the current agricultural situation has already been in potential surplus, and agriculture in SR is required to develop environment-friendly practices by the political and economic needs of accession to EU. In this situation priority should be given to the following items, to:

- increase agricultural profits with more emphasis on the environmental conservation than the production increase,
- improve profitability by increasing more valuable and higher quality products, specialization of production and reducing production cost,
- strengthen self-help efforts in agricultural production by the appropriate development of environment-friendly agriculture in the less favored areas.

This agricultural style is required to achieve production which is in good balance with various factors in conflict with agricultural production. Therefore, it can be called "Good farming practices". In these conditions the agriculture should reduce inputs which will cause heavy loads to the environment and make best use of environmental sources. This type of agriculture has already been established and developed in major countries in the EU (Ex. EUREP-GAP: EU Retailers program-Good Agricultural Practices). The developed agriculture in the future should be in harmony with surrounding countries as well as having good prospects.

In this survey the major items used to develop the appropriate cropping systems and their techniques were examined and discussed from a view point of farmers through various interview surveys and field observation.

2.7.1 CROP ROTATION AND CROPPING PATTERN

(1) Necessity of Crop Rotation and Principles of Appropriate Cropping Pattern

The crop rotation is traditionally introduced because of the necessity of:

- crop protection from soil-born diseases and pests such as nematodes and specific diseases to crops
- maintenance of soil fertility by cultivation of soil resting crops, for example, leguminous crops due to their N fixation capacities

In SR the crop rotation has been widely established and carefully maintained. It will be important to improve it in the advanced farming.

In market-oriented farming market needs are the most important parameter to select appropriate crops except for the production of self-supplied feeds. After the selection of the appropriate crops, it is necessary to examine the adaptability of crops to the soil conditions and crop rotation. The following steps are suggested for the selection of appropriate crops :

1st response to market needs,
2nd establishment of contracts and marketing channels
3rd applicability of cropping techniques and adaptability of soil and land conditions.
4th appropriateness of crop combination.

In addition, from a technical point of view, for the Third: applicability of cropping techniques and adaptability of soil and land conditions and the Fourth: appropriateness of crop combination mentioned above, the following items are important:

a. Better use of fertile land resources, i.e. continuous use of arable lands without fallowing by reducing detrimental biological and chemical substances. Less fertile lands need to be used with longer intervals.

b. Introduce gramineous crops (e.g. Wheat, barley, rye and maize) for the soil resting crops among various crops.

c. Efficiently use fertile farm lands with irrigation facilities with cash crops and high profit crops. These crops will be combined in same crop rotation to produce more profits. <e.g. Crop Rotation with high profitable crops as wheat for food, sunflower, rapeseeds, spring barley, etc. >

d. Put longer intervals for oil crops in crop rotation <Sunflower: 4-5 years, rapeseeds: 2-3 years and soybeans: 3-4 years after 1-2 year soybean cropping>

e. Use leguminous crops and increase soil animals for the development of sustainable agriculture by maintaining soil fertility.

  * N is usually fixed by leguminous crops as much as 100 kg/ha in one season. These N compounds have immediate effects on crops, and the majority of them can be used by the following crops in a year. It is equivalent to normal application of N fertilizers.

f. Improve physical soil structure by breaking subsoil and hard-pan by crops which have large straight roots

g. Cultivate high N requiring crops after leguminous crops. e.g. soybeans - winter wheat - alfalfa (for several years) - rapeseeds.

h. Avoid low N requiring crops after leguminous crops. Spring barley requires to be cultivated under low N application from the necessity of low protein content as material for beer brewing. Characteristics of leguminous crops can not be efficiently used if spring barley follows them.

i. Select crops which have similar agronomic traits and similar categories in economic needs/characteristics.

Diversification in cropping is indispensable to stabilize farming. The land use is also varied according to the crop diversification. It is important to combine crops in a similar cropping pattern considering the economic efficiency of cropping and agricultural inputs.

j. Cultivate vegetable groups in a vegetable rotation to improve and maintain soil fertility of arable lands. Vegetables are usually cultivated in light soil under irrigation with rather high fertilizer dose. In addition root and tuber crops require appropriate soil conditions: mature soil such as deep soil layer and low gravel content. These conditions are not necessarily required by cereal crops. The rotation of crops is recommended for vegetables.

k. Select resistant crops to natural hazards to avoid crop damage. As observed in the Zone-III, the crop growth is often inhibited by water logging and weed damage, resulting in unexpected low crop yields in spite of high soil fertility. The damage by water logging is mainly caused in early spring. Therefore, the winter crops such as winter wheat, rye and rapeseeds all of which are susceptible to excess water damage can not be included in the cropping pattern. As an example, the combination of maize - spring barley - sunflower will be appropriate.

* Maize: resistant to excess water,
  Spring barley: possible to select appropriate seeding time
  Sunflower: selection of seeding time and large crop architecture

(2) Examples of Cropping Patterns in Appropriately Classified Farmland in the Zones II and III

In this survey the land classification was examined to improve crop productivity and profits. The farm land classification was recommended to be based on the agricultural resources such as irrigation, soil fertility and soil water availability. The cropping pattern was prepared based on the land classification and the requirements mentioned in the previous section. In the cropping pattern, the following criteria are introduced:

a. Fertile and irrigated fields are used for high return cash crops.
   <e.g. sunflower - s. barley - rapeseeds - winter wheat for food>

b. Fertile and abundant soil water areas are also used for similar crops.

<e.g. sunflower - s. barley - rapeseeds - winter wheat for food - maize - soybean>
4 - 5 appropriate crops can be selected

c. Alfalfa is introduced for low fertility areas but good water conditions.
<e.g. winter wheat for food - maize - alfalfa - alfalfa - alfalfa>

d. Low fertility and poor soil water areas are used for crops resistant to environmental stresses such as rye and winter wheat including triticale.
<e.g. rye - winter wheat for feeds - triticale>

e. Fertile but water logging areas.
<e.g. maize - spring barley - sunflower>

Based on the principles mentioned above, a promising pattern of crop rotation was shown in *3.2.3 Possible Crop Rotation*.

2.7.2 ADVANTAGES IN WINTER CROPS

(1) Necessity of the Development of Winter Crops

The Zahorska area is exposed to dry weather with low rainfall and strong winds. In these conditions crop production is facing various forms of damage. These are not very serious in normal weather, but appropriate measures are required for stable agricultural production. Besides, the solar radiation is quite high in early summer. Therefore, it may exceed the necessary radiation for vegetative growth, and can be suitable for crop ripening with thick foliage. Major forms of damage are as follows:

- water deficit in summer,
- wind erosion in early spring,
- weed damage, and
- high solar radiation suitable for ripening of crops with thick foliage.

(2) Characteristics of Advantages of Winter Crops

The winter crops generally have several advantages in crop production in these conditions. From an agronomic point of view, the advantages of cereal winter crops in the Zahorska area can be characterized as follows:

a. Considerable rain fall can be expected during winter, and relatively abundant soil water can be expected during autumn and winter due to low temperature.

b. Although damage by water logging happens at thawing in early spring, it is limited in area and abundant water is useful for crop growth.

c. The high solar radiation in summer is useful for crop ripening, when crops have thick foliage,

d. Damage by pests and diseases is generally low, and damages by weeds, one of the most serious hurdles in cropping, can be suppressed because crops can cover young weeds,

e. Soil of the arable lands can be protected from wind erosion by the land cover of winter crops in early spring. In the winter crop cultivation, the arable lands are not tilled, leaving the surface of the land coated by rainwater. Leaves and stems have functions as wind shields to the surface which can protect arable land from wind erosion.

f. The land use will be more diversified by introducing a crop rotation for winter crops and their better management.

[Rough surface of lands is fragile to wind erosion. But if rainfalls can make the land surface coated, it turns resistant to winds. Small but frequent precipitation is effective.]

[There are several crops such as wheat, rye and triticale, which are resistant to environmental stresses and the Zahorska area has advantages for crop selection.
In these severe climatic conditions, target cultivation is useful for the efficient and stable cultivation.]