ROMANIA
AGRICULTURAL POLLUTION CONTROL PROJECT

Assessment of Land-Use Suitability and Proposals for Land-Use Information System

CONTENTS

1. Introduction

This report forms part of the Agricultural Pollution Control Project (APCP) preparation phase. The report was prepared in Romania and finalised in the UK during November 2000. Two missions were undertaken to Romania where the majority of the time was based at the Project Preparation Unit (PPU) located in the DGAIA offices in Calarasi. A number of field visits were made to the project area, both on the terrace and polder areas and a number of communes visited. In addition, a number of institutions were visited including the Romanian Centre for Remote Sensing Application in Agriculture (CRUTA) and the Research Institute for Soil Science and Agro-chemistry (ICPA) in Bucharest, and the Environmental Protection Inspectorate in Calarasi. A detailed mission diary is annexed to this report.

The principle objective of this report is to describe the available map data resources available to the PPU to facilitate the production of a land suitability map for the project area. Gaps in such data have been identified and recommendations acquire such data, in addition investment in a geographical information system (GIS) and global positioning system (GPS) have been made. Finally, an *indicative* land suitability map has been produced based on field visits and consultation with local experts. The map, approximately 1: 50 000, should be used with caution since it only serves to indicate where appropriate crops could be grown and a more detailed map should be developed during the first year of the project, particularly highlighting problem areas.

The terms of reference addressed in this report are as follows:

Evaluation of available data and maps;

- List of available data;
- Results of field verification;
- Commentary

Description of land use suitability supported with map(s) and recommendations;

- Narrative;
- Land use suitability map(s) at 1:50 000;
- Recommendations for use of other sources and systems in monitoring use of natural resources

In addition detailed terms of reference are provided for the supply of additional information and equipment.

The author worked closely with a number of Romanian experts and is particularly grateful to Ion Toncea, Rotaru Constantin, Mateiu Codreanu and Stefan Nicolau.

2. Evaluation of available data and maps

2.1 Institutions and organisations

A number of organisations were visited to ascertain the scope and quality of mapped information that may be of use to the APCP for land suitability assessment and associated activities such as monitoring. A summary appears below and a more detailed list of mapped information is contained in Annex I of this report.

Regional Soil Agency (OJSPA)

A considerable amount of data is available at the Regional Soils Agency (OJSPA) located in DGAIA and under the directorship of Mrs. Marin. The regional agency undertakes detailed soil analyses in the Calarasi Judet in addition to providing advice on remedial action to take concerning the maintenance of the soil resource. A number of maps are available at a variety of scales ranging upward from 1:10 000 and based on field survey describing soil type, irrigation potential and specific soil quality measures for the project area. A comprehensive list is provided in table 1. The availability and accessibility of this data could be improved by maintaining and publishing a list of the soils information managed by the regional agency. The conversion of this data into digital databases, stored on a geographical information system (GIS), would provide a significant asset to the project and to DGAIA.

Research Institute for Soil Science and Agro-chemistry

Such a system has been established at the Research Institute for Soil Science and Agro-chemistry, under the directorship of Dr. Mihail Dumitru, and a large volume of soil databases are maintained and managed on a GIS. Much of the data on the research institutes GIS covering the project area has originated from the regional Soil Agency. The scale of these maps varied from 1:10 000 upwards. Table 1 captures the data available for the project area maintained by this institute, however, it must be stressed again that much of this is available, be it in an analogue format, at the Soils Agency in Calarasi.

Farm maps

Many of the state farms and farm associations have mapped data for the area they manage. It was not possible to fully evaluate or assess the scope of all of these although examples are available at the PPU. Certainly for the state farms associated with the polder area maps are available describing field layout. As part of the privatisation of these farms an assessment of soil quality and irrigation potential was undertaken by the Soil Agency as an annex to the tender documents. This information is available at DGAIA and also held at the associated farm offices.

Local mayors offices

Of the mayors offices visited for the communes falling within the project area a variety of mapped data was held. The different themes of the map to some extent reflected the plans or concerns of the mayors' office. For example, at Vlad Tepes mapped data was available, at 1:5000, describing a large terraced area that had been partly forested to provide fuel wood for the local community. Such information would be useful in the calculation of tree seedlings needed to complete the forestation of the remaining terraces. A more comprehensive search for similar data should be undertaken at the inception of the project.

ISPIF

The Institute of Studies and Design for Land Reclamation Works in Bucharest has undertaken a number of studies on the project area, most notably on the polder area. Two reports[1], published in the 1990's document in detail the reclamation of the polder and the associated impacts of agriculture on the environment, changes to soil and potential for irrigation. Both reports include a number of maps (mainly at 1:100 000 scale) which serve as a useful indication of the land suitability of the area. The reports are comprehensive and give a useful description of the environmental conditions of the polder area, the limitations and potential.

CRUTA

The Romanian Centre for Remote Sensing Applications in Agriculture has developed a number of agricultural and climate databases covering Romania under the EC MARS (Monitoring Agriculture with Remote Sensing) programme. The Romanian MARS project was undertaken in the late 1990's and included the whole of Romania. A detailed archive of SPOT and NOAA satellite imagery is held by CRUTA covering this period. CRUTA have also undertaken work funded by WHO (World Health Organisation) to map waste dumps and areas posing a risk to human health including those associated with APCP. This data is held on the GIS at CRUTA. Additional digital data may also be available at such as transport networks. The databases are mainly at the scale of 1:100 000.

Other data sources

In addition to the institutes and organisations visited it is apparent that there are many others whom have collected data for the project area. The use of GIS as an application of remote sensing in Romania is wide spread and this has encouraged the conversion of mapped data into digital format. Much of this data will not be of use for the project since it will be too coarse a scale, not relevant or fall out of the project area. Nonetheless, a more detailed examination should be made during the inception phase of the project to examine other possible sources of information (particularly that in digital format) that may be of use to the project.

2.2 Recommendations for base data

The project area is not large, nevertheless the establishment of a project geographical information system (GIS) would facilitate the presentation, management and analyses of data collected by the project (this is discussed in more detail later in the report).

[1] Impact Study in the Boianu-Sticleanu Polder Calarasi (1996) and continuation report (1997). ISPIF, Sos. Oltenitei. 35 - 37, Sector 4, 79656, Bucharest.

Land suitability assessment may be restricted to soil properties alone but more commonly refer to land in a broader environmental sense. For the purposes of this project the following factors should also be considered in assessing the suitability of land:

- Soil;
- Topography (elevation, slope, aspect, hydrology);
- Climate;
- Vegetation;
- (Socio-economic features - features of the area that may constrain agricultural development).

2.3 Discussion

Institutions

For the APCP area there is a large body of tabular and mapped data describing soil properties. Associated with much of this data are descriptions of some of the other features listed above helpful in land suitability mapping. However, accessing some of this information is not particularly easy, nor is it in a form that can be quickly manipulated or analysed.

The Regional Soil Agency at DGAIA has much of the soil data necessary for land suitability mapping - generally based on detailed to semi-detailed surveys (i.e. > 1:10 000 or 1:25 000 to 1:10 000). The reports associated with this information include specific crop or natural vegetation variables related to soil parameters - e.g. drainage or salinity effects. These types of survey are sufficiently accurate for the purposes of the project and the derivation of a semi-detailed land suitability map. For particular hot-spots of pollution or where significant changes in land use are anticipated then detailed surveys will be necessary at a scale > 1:10 000 and, in some instances, these will be already available for example the recent soil surveys undertaken on the State farms on the polder area.

The Regional Soil Agency (OJSPA) should be the principle point of contact for the ACPC regarding the provision of soil information and in the development of successive land suitability maps. Co-operation should be sought with other institutes, as described above, to supplement this data.

All of the mapped data and associated information was produced to a high quality. However, there did not appear to be any regular programme for monitoring soil quality or condition (due largely to financial constraints), updating land use or land suitability. This is an important issue and will be addressed by the project.

Field verification

Annex IV provides a summary of the field visits.

The polder area, formerly part of the Danube floodplain, (about 22 000 ha) is a fragile agricultural habitat that is particularly important for waterbirds. This area, having been reclaimed was intensively managed for arable agricultural production although livestock enterprises on the three former state farms were also significant. Over the last decade (post-1989) there has been a general decline in the intensity of management of this area largely due to financial constraints rather than lack of know how (although it is important to note that strategically the focus was on, and still is, production rather than a more balanced approach taking into concern the environmental issues associated with this habitat). Consequently, much of the pollution (nitrates, phosphates and pesticides) associated with the polder is historic in nature, and despite the preponderance of area down to arable land pollution levels are likely to be generally low. The vegetation bordering the canals along the urban fringe with the polder area (e.g. Gradistea) are indicative of high levels of eutrophication and this was confirmed in many places by the high levels of algae in these canals. It is likely though that much of the pollution causing these problems is associated with the gardens of properties that back right onto the canals. In the majority of these gardens it was observed that maize silage garden and animal waste deposited along the banks of the canal. Run-off high in nitrates and other pollutants into the canal is likely to be high and be significant contribution to the pollution of these waterways rather than agricultural activities *per se*. There was no evidence of soil erosion from water, although wind erosion may be a localised problem in some areas.

There is a concern that with the decline in the irrigation and drainage network that water logging is occurring in places and that the soil is becoming more saline (and alkaline) in nature. This will affect yields. Indeed, on the Agroservcom farm over 150 ha of cereals had been lost due to water logging (equivalent to $30 000). From an environmental point of view the lower intensity farming, the re-colonisation of areas by reeds and the reversion of some areas to wetlands is considered positive.

The state farms on the polder area will be privatised. There is concern that following privatisation there will be greater access to credit or funds to rehabilitate the irrigation and drainage network and purchase non-farm resources such as pesticides and inorganic fertilisers leading to a more intensive form of agricultural production. Many of the current farm managers of these farms also expressed a desire to start livestock farming as well (on two of the state farms about 400 sheep are managed). These investments and access to non-farm resources should result in greater productivity however, these foreseen changes will also pose a considerable risk to the environment.

There is now an opportunity to influence the development of the polder area and the type of agricultural practices. Consideration should be given in identifying areas on the polder that can revert to wetlands or extensive grassland to encourage waterbirds. The application and timing of inorganic and organic fertiliser will require careful management to minimise the loss of nitrate to surface and ground waters. The introduction of agro-forestry and shelterbelts will reduce the risk of wind erosion and will encourage biodiversity.

The land use of the terrace area, about 62 000 ha, is almost entirely agricultural, with the exception of some large water bodies and village areas. The agriculture practised here is generally intensive in as much that it is largely mechanised (although the machinery is small relative to field size) and agro-chemical based. The farms associated with the terrace are under capitalised and consequently the inputs in terms of pesticides and fertilisers are relatively low. Agricultural pollution associated with the terrace area is mainly historical and attributed to practices pre-revolution (pre-1990's). Current doses of pesticides are low and fertiliser use conservative. Soil erosion appears to be minimal, wind erosion being apparent in some of the large fields where there are no or poorly maintained shelterbelts. Water erosion occurs on some of the gentle slopes associated with the riparian zones although this is not wide spread. The rates of soil erosion do not appear to be greater than the accepted natural rate of 11 t/ha.

Pollution from point sources, mainly manure platforms, or latrines appears to be a significant problem.

3. Description of land use suitability

Detailed descriptions of the natural vegetation, transport infrastructure and access to markets, socio-economic considerations, climate and agricultural practices are provided in other reports associated with the project preparation for the APCP.

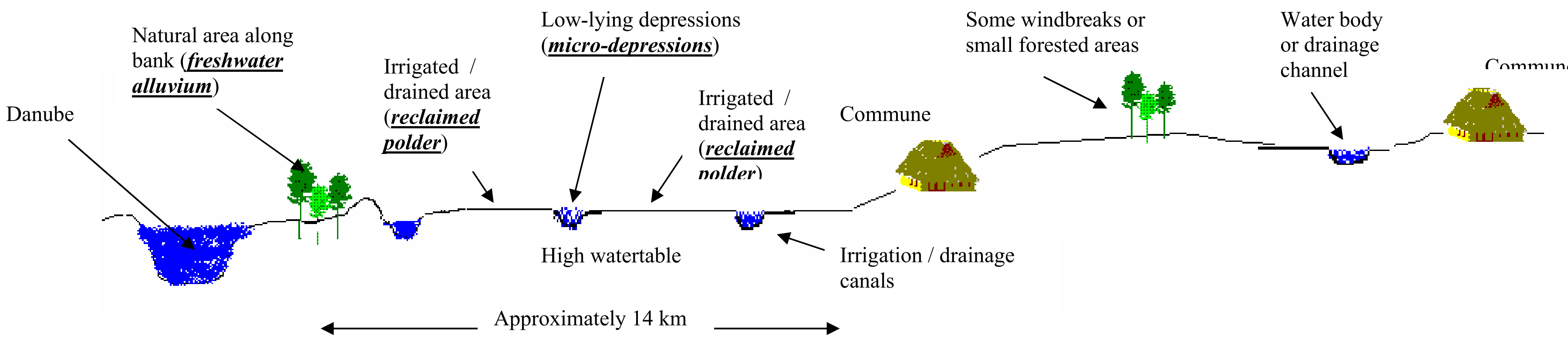
This section deals with the limitations to agricultural productivity, identifies the main land units of the project area and assesses the suitability of the land to the major crops currently grown. Recommendations are given to the management of the land and possible changes in land use to meet the wider objectives of the project.

3.1 The main land elements of the project area

The terrace and polder areas distinguish the project area. The terrace area has a uniform topography being largely flat with sloping lands leading into ephemeral or permanent drainage areas. The southern 'tail' of the terrace slopes gently down onto the floodplain of the Danube (now reclaimed agricultural land). The landscape is dominated by agriculture that is mainly arable with some grassland areas to support livestock. Field size is typically large (> 50 ha) with few physical field boundaries creating a landscape which should be considered as 'open'. Bisecting this landscape is artificial irrigation and drainage canals (poorly maintained), an irregular network of windbreaks, and a number of small villages. The transport network is well established, although not dense, the major roads sealed with a high density of unmetaled farm tracks.

The polder area is a reclaimed floodplain of the Danube. The landscape is typically flat and uniform with a patchwork of depressions of various sizes. The land is drained, although this system is not well managed and frequently these depressions become waterlogged. At the northeastern end of the polder area is a large expanse of freshwater, the Iezer Calarasi, providing an important habitat for waterbirds. The immediate area around the southern part of this water body is grassland. Along the edge of the Danube River is an area of natural vegetation and wetlands including forest areas. The landscape is bisected by an extensive network of poorly maintained irrigation and drainage canals and unmetaled farm tracks. Field size is large (> 50 ha), with few physical field boundaries or natural areas of vegetation. There are no villages associated with the polder area and only some farm buildings.

A transect of the project area is captured in figure 1.



After Ion Toncea, (2000)

	Polder area	Terrace
Soils	Alluvial soils with various textures and stages of siltation	Dark brown to reddish carbon based chernozems; cambic chernozems; clayed chernozems, formed on a loess base with a fine to medium texture
Crops	Wheat Barley Maize Sunflower Soya-bean	Wheat Barley Sunflower Maize
Key issues	• Poorly maintained irrigation and drainage infrastructure (mixture of soil moisture problems, i.e. water logging or draughtiness in dry years) • Wind erosion • Soil compaction • Soil salinity • Soil alkalinity • Decrease in organic matter • Eutrophication	• Poorly maintained irrigation and drainage infrastructure (soil moisture problems in dry years) • Soil erosion (water erosion on sloping land,, wind erosion elsewhere) • Soil compaction • Decrease in organic matter • Soil contamination (isolated and largely associated with manure platforms) • Lack of fuel wood for communities

Schematic transect of the project area showing the polder and terrace area

3.2 Land Units

During the mission it was not feasible to determine a comprehensive and detailed description of the land units of the project area. Nonetheless, this section seeks to indicate the minor landforms associated with the project area and to briefly characterise them. However, the mapped information (appended to this report) has only been approximately transcribed to the land suitability map since it was not feasible to determine the exact geographical extent of these land units.

Polder area

Freshwater alluvium

This 'strip' of land extends along the northern embankment of the Danube and is a remnant of the former floodplain. The strip of land is effectively a buffer between the reclaimed polder area and Danube river. The vegetation associated with this area is a mixture of wetland grasses, reed beds and trees (e.g. various willows). The alluvial soils occur with various textures and stages of siltation and generally waterlogged.

This area is suitable as a natural habitat providing an important haven for wildlife and in particular waterbirds. The area also acts as important buffer zone between the agricultural area acting as a biological filter trapping silts, toxic compounds and diffuse pollutants. The area could be more actively managed to improve the biodiversity of the surrounding area i.e. where it borders the reclaimed polder (i.e. establishment of wildlife corridors into the polder area and may also benefit from the development of agro-tourism.

Reclaimed polder

A reclaimed floodplain bordering the Danube this substantial agricultural area (22 000ha) is characterised by a range of alluvial soils including chernozems, mollic alluvial soils and alluvial protosoils with large areas which are either waterlogged and / or salinised. Irrigation and drainage is widely practised in this area, although in the last decade the overall management and infrastructure has declined significantly.

The productivity of this area is mixed and highly dependent on appropriate irrigation and drainage practices. According to the ISPIF reports[2] about 60% of the land area in the polder area is considered as suitable for irrigation, and only 26% as good or very good land suitable for irrigation. The crops grown (typically wheat, barley, maize, sunflower and soya-bean) give low to medium yields receiving low inputs of inorganic fertiliser and pesticides. The scope to improve yields is significant but it is important that this is not at the expense of the environment. The increase in the area affected by alkalinity is a concern as is the threat of salinity.

[2] ISPIF (1996 & 1997). Impact study on the Boianu Iezer Polder Calarasi - land reclamation study.

Nutrient management for the area will be critical to minimise diffuse pollution, Nitrate levels associated with the polder are recorded as low[3]. Practices in the past have not been conducive to low nitrate levels e.g. irrigation using waste water from livestock enterprises and poor manure management on the terrace area giving rise to run-off onto the polder.

Micro-depressions

There a number of areas that forms lower lying areas or depressions that are commonly waterlogged. These would generally have been wetland areas or small lakes and the soils of these features are of a low productivity and difficult to manage.

Given the current decline in irrigation and drainage capital these areas would be more suitable for agro-forestry (e.g. willows), extensive grassland production (for grazing purposes) or to be left to revert to a natural habitat (mixture of reeds and grasses). Wildlife corridors could be established from Calarasi lake to the freshwater alluvial area to encourage biodiversity and generally enrich the habitat.

Terrace area

Riparian zone

These areas are associated with the water bodies and ephemeral drainage networks of the terrace area. These areas may be prone to water erosion since they are associated with sloping land and will also be potential hot-spots for diffuse sources of agricultural pollution such as run-off carrying sediments, nitrates or pesticides. The banks around water bodies are also prone to collapse in places, particularly where cultivation is taking place right up to the edge of these banks.

For sloping land associated with natural drainage networks agricultural practices are acceptable as long as measures are taken to minimise the risk from water erosion (e.g. cultivation across the slope). Buffer strips, particularly at the foot of slopes, would minimise the sedimentation of water courses and act as a filter thereby improving water quality. In some areas, particularly in close proximity to communes, the establishment of agro-forestry or community forestry as a source of fuel wood may be considered as a more suitable land use.

Terrace

Agriculture is the dominant land use of the terrace area that is composed of largely uniform and fertile soils, typically chernozems, cambic chernozems and clayed chernozems. Crop productivity is low to medium, the main hindrance being soil moisture particularly in dry years, and lack of inorganic fertiliser and pesticides. Concern at the decline in fertility has been expressed and greater use of organic fertiliser and introduction of soil moisture conservation practices (these will be addressed by the APCP) could address this.

[3] Op cit.

3.3 Land use suitability

The development of a detailed land suitability assessment within the scope of this report is not feasible due to the lack of readily available information. Nonetheless, based on the indicative land units described in section 3.2 Land Units an indication of the land suitability for the predominant crops gown in the APCP area are given in the table below[4]. Crucially, for the polder area, agricultural productivity and land suitability will depend on the viability of the irrigation and drainage infrastructure, and the careful management of waters and soil. Whilst irrigation and drainage are not so significant for the terrace area (although would certainly improve yields during dry seasons), the maintenance of soil fertility will be crucial.

Table of suitable crops

Land Unit	**Natural fertility**	**Erosion risk**	**Crop Suitability (Small holder or commercial production)**						
			Wheat	Maize	Sun-flower	Barley	Soya beans	Grass	Agro-forestry
Polder area									
Riparian plain	Low	Low	*	*	*	*	*	****	*****
Reclaimed plain	Medium	Low	****	****	****	****	****	****	**
Micro-depressions	Low	Low	***	***	***	***	***	****	*****
Terrace area									
Riparian zones	High	Medium	****	****	****	****	***	****	****
Terrace	High	Low	*****	*****	****	*****	***	****	***

Key to crop suitability

*****	Highly suitable
****	Suitable
***	Marginally suitable or partially unsuitable
**	Largely unsuitable
*	Totally unsuitable

Alternative crops are not discussed in this report, although the land is suitable for growing vegetables, root crops such as sugar beet, and sorghum. However, a more detailed study into the economic viability of establishing these crops would be required and are outside the scope of this report.

Livestock production is not as significant as historically (pre-revolution). A more mixed farming system could play an important role in the management of the APCP environment via the recycling of organic manures and the use of rotational grasslands to improve soil structure and maintain or increase organic matter.

In the polder area the introduction of extensively managed grassland breaks in the rotation could contribute to minimising the amount of nitrogen leached. The use of cover crops during the autumn, such as mustard, may also reduce the amount of

[4] Based on Landon (editor) (1991). Booker tropical soil manual. Longman. ISBN 0-582-00557-4.

nitrate leached. Livestock production is suitable for the polder area but the associated manure management will be critical to ensure the loss of nitrate to the environment is minimised.

3.4 Additional considerations

Land is well suited to agricultural production within APCP area, however, there are a number of other related issues that could be considered to enhance the environment and rural community and a brief description of them follows.

3.4.1 Agri-environment

Agri-environment schemes are an increasingly important part of the EU's Common Agricultural Policy (CAP) to which Romania will have to comply before joining the EU. The overarching objective of the agri-environment programmes implemented by Member States is to minimise or reduce the impact of agricultural activities on the environment. The SAPARD (Special Accession Programme for Agriculture and Rural Development) pre-accession instrument provides opportunities to introduce and develop appropriate agri-environment schemes. Consideration for a SAPARD programme in the APCP area would seem appropriate since the objectives are mutually beneficial.

3.4.2 Environment legislation

Important EC environmental legislation relevant to the project area include the Nitrates Directive (EC 676/91) and Habitats and Birds Directive (EC 43/92 and EC 409/79 respectively). Allied to these latter Directives is the international Ramsar convention.

The Nitrates Directive, address both nitrate pollution in surface and groundwaters through the designation of nitrate vulnerable zones (NVZ's). The Directive requires that a set of rules are put in place in NVZ's to reduce existing nitrate pollution from agricultural land and to prevent further pollution from arising. The rules are known as *Action Programme* rules or measures. Compliance with the rules is a legal requirement within those areas designated by the government as NVZ's. The APCP will be a good basis on which to develop and educate farmers of this forthcoming piece of legislation that they may be required to adhere to if the project area is designated an NVZ.

The Birds Directive seeks to conserve all species of naturally occurring birds in the wild state in the European territory of the Member States. Whilst the Habitats Directive seeks to contribute towards ensuring biodiversity through the conservation of natural habitats and wild flora and fauna in the EU. The Ramsar convention addresses the stemming of loss of wetlands and to ensure their conservation and wise use.

Section 3.1 and raised the importance of Iezer Calarasi as an important habitat for waterbirds. The Iezer Calarasi wetland is about 3200 ha and the waterbody itself about 400 ha and is an important migratory passage. There is a risk that increasing agricultural activity in the area will threaten this important habitat and therefore the site has been put forward to be gazetted as a protected area by the government, the 400 ha forming the core area and the remainder making up a buffer zone. A detailed management plan will be required to ensure that the objectives of the proposed protected area are fully met. Consideration must be given to getting the co-operation of local farmers and farms in the implementation of the management plan and cross compliance with other agri-environment measure and programmes should be fully explored and developed to ensure maximum benefit.

3.4.3 Fuel wood

Fuel wood is an important supplement to heating during the winter months for the village population. There appears to be a shortage of fuel wood in the local vicinity and consequently people have to travel considerable distances, frequently relying on crop residues as an alternative. There is considerable scope to develop community wood lots to supplement the source of fuel wood and the land around villages appears quite suitable for this. High calorific and fast growing species such as poplar and willow would be appropriate.

4. Recommendations

4.1 Productivity and management

A number of important land characteristics must be observed when assessing a particular area regarding its agricultural suitability and need for any specific soil management and recovery practices. Important land facets include topography and rainfall and these will influence land management practices and ultimately land productivity. In addition, the productivity of the soil will be limited by the following:

- Acidity;
- Alkalinity and sodicity;
- Salinity;
- Low cation exchange capacity;
- Phosphorus fixation and;
- Cracking and swelling properties.

Working with the Regional Soil Agency at DGAIA the APCP should seek to regularly monitor the above soil facets so as to determine whether the land and soil is being appropriately managed. Information concerning these facets combined with additional soil and water quality measurements can be applied to develop strategies to ensure that agricultural activities in the APCP area enhance the environment.

4.2 Systems and sources for geographical data

Mapped data for preparation of land suitability and to assist in monitoring and selection of demonstration sites for the project activities is available although the distribution is disparate and not readily accessible nor in a format (i.e. digital) that enables easy manipulation or analyses. Much of this data, as already described is available at DGAIA in one form or another however during the early stages of the project (year 1) it will be necessary and important to capture the appropriate data digitally. These digital geographical databases can then be stored in a geographical information system.

A geographical information system (GIS) is computer-based software that stores digital map data associated attribute data. A PC based GIS is recommended for the project serving as a database of mapped data and other monitoring data collected during the project. The PPU and DGAIA will be able to easily produce colour map (up to A3 size) to communicate monitoring results and progress. In addition, as this capability strengthens DGAIA will be able to develop value added and new services to its existing products.

Additional data, to assist in project monitoring and planning, should include land cover / land use. This should be collected at least twice in a growing season (autumn and spring since these are critical times during which nitrate leaching will occur). This data can be easily collected from satellite data at a suitable scale (1:10000 or 1:50000) from a variety of platforms including:

- Landsat TM
- SPOT XS

- IKONOS
- IRS - C or IRS - D;
- KVR 1000

According to consultation with CRUTA the Russian imagery (KVR 1000) is not yet available in Romania and, the software necessary to process the imagery is prohibitively expensive (about 30000-40000 $ USD). If high resolution imagery is the preferred choice then IKONOS images, which is available in Romania, would be a suitable alternative, with each scene covering about 10 km x 10 km and having a resolution of 1-2 m in panchromatic mode and 3-5 m in multi-spectral mode. This imagery can be processed with readily available software (e.g. ERDAS Imagine.

Up to two satellite images should be acquired each year and processed to derive land cover information for the project area (it is more likely that a more precise land cover database will be derived from more than one satellite image). The satellite imagery, if acquired at a suitable time, could also be used to detect alga blooms in water bodies and therefore serve as an indicator for water quality. Crop and grassland quality could also be determined to quantify improvements in management. Satellite processing in Romania is readily available. The processed imagery can then be stored on the project GIS for further analyses or combination with other geographical data.

Additional data will be collected during the project (soil and water quality data). Using a global position system (GPS) accurate (± 10m in x and y) geographical information can be quickly and easily collected including point (e.g. monitoring stations, wells, spot heights etc.) and line data (e.g. boundaries, networks etc.). The data can then be uploaded into the project GIS database. Such data can be used to facilitate project monitoring including areas planted under agro-forestry, converted to grassland or natural areas.

The project should establish close links with the Romania institute responsible for implementing the Corine Land Cover program and MARS (Monitoring Agriculture using Remote Sensing). These data will prove useful additional data sources for the project. In addition, the GIS unit should forge working links with the Danube Delta GIS at Tulcea Research Institute.

4.3 Cost benefit of the geographical information system

The investment in a geographical information system is justified on the added value it will bring to the project as a means of storing and analysing mapped based data and information and the ability to produce quality cartographic products for stakeholders of the project.

The benefits to the project and DGAIA are listed below:

- Storage of project data;
- Improved efficiency in handling and manipulating geographical data;
- Improved access to geographical data;
- Functionality to combine databases to derive new information;

- Spatial analyses functionality enabling interpolation of database to derive new information e.g. spot height information interpolated to derive a slope or aspect database;
- Ability to produce quality map and cartographic products;

The investments associated with establishing the GIS and GPS capability are captured below.

Item	**$**
Hardware (PC, printer and digitising tablet)	6700
GPS (x 3)	19350
GIS software	4000
Data capture	8600
Sub total	**38650**
Consumables (annual)	1500
TOTAL	**40150**

4.4 Services

In principle a number of improved or new services could be offered by DGAIA on the basis of the investment. Some of these services are:

- Automated map production (GIS);
- Automated geographical data collection (GPS);
- Derivation of new information (e.g. slope or aspect maps from elevation data);
- Added value to soil analyses service (soil maps and interpolated surfaces of soil properties).

4.5 Income generation

The calculation of income derived from the establishment of a GIS and GPS capability is based on a number of assumptions. It is assumed that the market for map based products will grow, this is likely as the agricultural sector is reformed and new instruments and markets opportunities for agriculture develop under the EC SAPARD programme and accession process. Certainly with the planned privatisation of the state farms associated with the polder area there will be a demand for regular analysis of soil quality and the opportunity to assist in the planning and allocation of land for different farm enterprises. The ability for DGAIA to offer a geographical data collection service (GPS), to produce soil maps (GIS and GPS) should be highly attractive to these new enterprises. This assumption can also be applied to the larger farms associated with the terrace area although the amount of disposable income to invest in soil mapping for example may be less in the short term.

There will be ample opportunity during the project life to demonstrate the utility of GIS based maps to assist farmers and growers, not only in the project area but also Calarasi Judet. The income stream captured below does not reflect staff costs (assumed to be already costed since DGAIA staff will be trained by the project and no staff will have to be recruited to operate the GIS and GPS) and is based on the area covered by DGAIA, rather than just the project area. The estimates are considered therefore to be rather conservative.

Service	**Units / yr.**	**$**	**Total (annual)**
Map production	50	50	2500
Data collection (GPS)	50	100	5000
Data processing	50	100	5000
Total			**12500**

4.6 Customers

A number of potential customers would utilise the service making it necessary to provide differential costing depending on the client. Certainly, different prices should be imposed for the public and private sectors. Full costs and a margin should be charged for the private sector, and for the public sector costs should be at least recovered. Potential customers might include:

Private sector

- Individual farms;
- Private farms (particularly those on the Polder);
- Farm associations and family farms;
- Private industry, construction and engineering companies;
- Non-government organisations (particularly those associated with nature protection).

Public sector

- Local government offices (e.g. ENVIRONMENTAL PROTECTION INSPECTORATE, Forestry service);
- Communes and mayors office;
- Research institutes and universities.

4.7 Un-quantified benefits

In addition to the more tangible benefits associated with the establishment of the GIS and GPS capability there are a number of un-quantified benefits that will also accrue to DGAIA:

- The ability to quickly produce new products from existing data held at DGAIA
- Improved access to geographical data held at DGAIA;
- Greater efficiency in the management and distribution of mapped data.

ANNEX I - Summary and description of mapped information

Evaluation of available data and maps

Source	Data	Description	Comments / Suitability
ISPIF - 'Impact study in the Boianu-Sticleanu Polder Calarasi' (1996)	Maps / plans all at 1:100 000	Map 4 - ownership of land in 1990 on Polder Map 5 - ecological areas on the flood plain Map 6 - area before land reclaimed Map 7 - land reclamation plan; dykes; drainage channels etc Map 8 - irrigation network Map 10 - Potential for irrigation in 1969 (6 classes) Map 11 - Potential for irrigation in 1990 Map 12 - extent of salty soils in 1990 Map 13 - depth of water table in 1975 Map 14 - depth of water table in 1990 Map 18 - planned land to be reclaimed	Scale too large for derivation of suitability map but serves as a useful guide to evolution of the project area covering the Polder
ISPIF - 'Impact study in the Boianu-Sticleanu Polder Calarasi' (1997)	Maps / plans at 1:100 000	Map1 - river drainage to Danube in Romania Map 8 - soil potential Map 9 - ecological zones Map 10 - proposal for new ecological zones	Scale to large for derivation of suitability map but serves as a useful guide to evolution of the project area covering the Polder
Topographic map (National Survey)	1:100 000(?)	Commune, roads, drainage / irrigation network, water bodies, administration boundaries	Initial planning purposes
Topographic map (National Survey)	1:50 000	Commune, roads, drainage / irrigation network, water bodies, forested areas, administration boundaries	Useful base map for developing indicative suitability map
DGAIA - OJSPA	1:50 000	Soil description (4 different soil types in project area)	Useful for suitability map
DGAIA - OJSPA	1:10 000	Soil potential map(s) for Commune in APCP	Appropriate for suitability maps Note that much of the data held at the Regional Soil Agency has been used, along with other sources, to develop a

			GIS at the Research Institute of Soil Science and Agro-chemistry. There is no reason why the Regional Agency under the Directorship of Mrs. Marin should develop a land information system (using GIS technology) and based on the data held at DGAIA.
Add hoc maps from Commune and state farms	1:50 000	Mainly plans of farms or terraced areas	Useful for developing specific suitability plans for associated areas
Research Institute for Soil Science and Agro-chemistry	1:200 000 although sufficiently detailed to derive 1:50 000 maps	The data described below is based on a variety of published and un-published data sources, at different scales, collected by the Institute and stored on their GIS. - Ecological unit - Soil ➢ Soil type ➢ Sub-type ➢ Family ➢ Variety - Physical and geophysical unit ➢ Altitude ➢ Major form of relief ➢ Micro-relief ➢ Slope ➢ Aspect - Climate ➢ Annual mean temperature ➢ Annual mean rainfall ➢ No. days equal or exceeding 10°C	Much of the data described is held in the Institutes geographical information system allowing efficient retrieval and manipulation. Inspection of the soil database illustrated the degree of detail available that would be highly relevant to the APCP and greatly facilitate planning and monitoring activities. See note above regarding the development of a similar capability at DGAIA based on the Regional Soil Agency data of paper maps and allied reports. The Institute also has developed a number of agri-environment models that operate at field and catchment scales. The catchment based models are relatively easy to parameterise and would be relevant to modelling the

		➢ Moisture exceedence or deficient - Water table depth ➢ Range of variation in water table ➢ Degree of mineralisation of water table Parent rock description ➢ Depth to parent rock ➢ Presence of leaching at recorded depth Soil description and structure ➢ Horizon A ➢ Horizon B ➢ B profile ➢ Soil texture - Other physical features ➢ Organic matter content ➢ Presence of waterlogging ➢ Salanisation ➢ Alkalinity ➢ Erodability value ➢ Resistance to ploughing ➢ Water capacity ➢ Permeability ➢ Porosity (%) - Agro-chemical features ➢ Humus content (%) ➢ Humus description ➢ Nitrogen index ➢ Mobile P reserve ➢ Mobile K reserve - Floodability - Sources of soil pollution	impact of changed husbandry, land management practices and land use on sources of agricultural diffuse pollution.

		- Existing land reclamation infrastructure	
Centre for Remote Sensing Applications for Agriculture (CRUTA)	Maps at a variety of scales including 1:50 000	Topographic	CRUTA have an extensive computer centre utilising both Unix and PC platforms in a networked environment. Erdas Imagine software is used extensively for processing of remotely sensed data. ArcInfo and ArcView GIS software is used for the storage and manipulation of geographical databases. An extensive collection of satellite imagery (Landsat and SPOT) is available covering the APCP area for 1997, 1998 / 1999. Historic aerial photography is also believed to exist covering the area (1960's). The satellite data has been processed to derive agricultural classes based on the MARS (Monitoring Agriculture using Remote Sensing) nomenclature.

ANNEX II - Terms of Reference for Land Cover Mapping

Terms of Reference
Provision of remotely sensed land cover information

Background

The wider objective of the APCP is to reduce agricultural sources of pollution to the river Danube and Black Sea. There is considerable evidence of poor water quality arising from agricultural activities such as fertiliser and pesticide application and poor manure management and a decline in the drainage and irrigation infrastructure resulting in water logging, salanisation and alkaline soils particularly in the polder area. In some years farmers have witnessed algae blooms, an indicator of poor water quality, in some of the larger water bodies associated with the project area.

The reduction of agricultural sources of pollution will be achieved using a number of techniques including the introduction of improved land practices and environmentally friendly farming practices, such as integrated crop management, the introduction of agro-forestry measures and wind breaks. Associated with these new practices a large area falling within the project will be designated a nature reserve affording a degree of protection from agriculture activities and other forms of economic activity. The core nature area, which includes lake Calarasi, will be protected by a substantial buffer zone within which there are anticipated land use changes, for example afforestation with native tree species and less intensive forms of agriculture.

Monitoring these changes will be an important part of the project. Although there will be an extensive field campaign to collect soil and water quality data and to assess and measure (using GPS equipment) changes in land use it is unlikely that a comprehensive assessment of the whole project (75,000 ha) will be achievable.

Therefore to supplement the data collected via the soil and water monitoring campaign, and ancillary data alluded to above, the use of remotely sensed information is deemed appropriate to the overall scheme of monitoring. The remotely sensed information will be stored and managed by the project GIS which will include other thematic layers of information such as soil type, hydrological network, topographic information, elevation, slope and so on. It is anticipated that the general scale of the digital geographical databases will range from 1:10 000 - 1:50 000 and will be projected on the standard national co-ordinate system.

At this stage it is not clear what imagery will be most appropriate for the project, although it is likely to be SPOT XS or panchromatic or IRS - C or D since these provide sufficient spatial accuracy to derive 1:10 000 - 1:50 000 geographical databases. However, it may be appropriate to utilise the high resolution KVR 1000 imagery from the Russian space mapping system, Kometa, which although only providing panchromatic images are of high resolution (1 metre) and would enable mapping of small features such as manure platforms, wind breaks, community forest lots and so on.

The land use of the project area is primarily agricultural and therefore in deriving land cover information the agricultural growing season must be accounted for. In terms of assessing the impact of agricultural activity on the environment an assessment of land cover at the beginning of the agricultural season (i.e. drilling or sowing of crops), that is the autumn period coinciding with September - October, will be important. This information combined with land cover information in the spring (when the crops are emerging and when spring cereals are drilled (April - May) would also be preferable. Naturally, obtaining suitable imagery for these windows in the growing season will depend on a number of variables particularly weather.

Objectives

The purpose of the contract will be to meet the needs of the GIS unit at DGAIA with remotely sensed derived information.

The primary objective of the contract is to:

1. Provide advice and procure the most suitable imagery to monitor land cover within the project area;
2. To acquire the imagery and process to derive a geo-rectified image (corrected and filtered for any geometric and atmospheric distortions) of the project area (if necessary the image should split into a number of tiles to facilitate data management and manipulation within the project GIS);
3. To derive a geographical database describing land cover of the project area. The exact attributes will be agreed with DGAIA, but should include the principle crop types and natural vegetation types of the project area, water bodies, wet lands, urban and village areas. The land cover database should be supplied in a format that can be stored on the project GIS, and include full documentation.

The secondary objective of the contract will be to provide more general advice concerning remotely sensed information anticipating future or additional information products that may complement or enhance the basic land cover information and monitoring programme of the project.

Requirements

The contractor should be well informed of the different remotely sensed imagery available covering the project area and with anticipated developments of the technology.

The contractor should have considerable experience in the acquisition of satellite and remotely sensed imagery. They will have already gained experience in undertaking the processing of this imagery to derive land cover information suitable for GIS databases. It would be desirable if they were familiar with the CORINE land cover mapping programme and the associated typology since there may be synergies between ongoing national land cover mapping programmes. Ideally, they will be familiar with the associated land cover and vegetation types peculiar to the project area and, since the area is predominately a agricultural landscape, with the associated agricultural practices and crop rotations.

The contractor will be expected to liase closely with DGAIA, the Project Management Unit (PMU) and, if necessary the ENVIRONMENTAL PROTECTION INSPECTORATE to determine the most appropriate land cover types that can be derived from the chosen satellite sensor. Since this is only a small component of the overall project the contractor should assume that they would be limited to a maximum of two images a year (although this may be negotiable subject to budget). Therefore they must be confident that what they are recommending in terms of derived land cover information will be achievable.

Deliverables

The APCP is planned for five years and at least one comprehensive land cover database should be produced per agricultural season (five in total), based on two remotely sensed images per season. However, it is expected that an intermediary land cover database will be derived at the start of each season (i.e. autumn). This will be based on the first image acquired for that season (and using supplementary knowledge from the previous seasons land cover database combined with an understanding of the crop rotations and allied agricultural practices).

Therefore two land cover databases will be produced a season, an intermediary and final product.

In summary, and based on the above, the deliverables from the contractor will include:

1. GIS compatible (geo-rectified and processed for atmospheric and geometric distortions) remotely sensed imagery of the project area (two images a season is anticipated) on CD-ROM or preferred media as specified by the PMU;
2. GIS land cover database with complete attribute database, based on agreed land cover typology, minimum mapping unit and agreed scale (likely to be 1:10 000 - 1:50 000 depending on selected satellite sensor) to be supplied on CD-ROM or preferred media as specified by the PMU;
3. Full documentation of the methodology, description and limitations of the land cover database.

The contractor will be expected to undertake some field checking of the classified remotely sensed data and a break down of this with budget should be specified in the proposal.

ANNEX III - Equipment specification GIS and GPS capability

Equipment specification

Background

During the APCP life considerable data will be collected to monitor the progress of the project against milestones. For example, there will be an extensive water and soil monitoring programme to assess the impact of different farming practices and land management techniques on the reduction of diffuse and point pollution from agricultural activities. Associated with these changes, in current farm practices there are anticipated changes in land-use, for example an extensive afforestation programme, designation of protected areas for nature conservation, increase in grassland and wetland areas, uptake of small community forest programmes and introduction of soil conservation techniques such as windbreaks and shelterbelts.

Monitoring these land use changes will be an essential element in assessing the uptake of new practices and to determine the overall impact of the project on the environment and local communities. All of the changes described above will be associated with an area or point in the project area and therefore, using technologies such as geographical information systems (GIS) and global positioning systems (GPS) it will be feasible to develop a detailed geographical database of the project area describing where these changes are occurring.

GPS technology will be employed to regularly update these changes and to collect data determining exactly where soil and water monitoring programmes have been established in the project area.

The GIS technology will be used to store, manage and manipulate the geographical database to derive maps and associated products for the stakeholders and policy makers operating in the area. Furthermore the GIS will provide a powerful means of communicating to the wider public the impacts of the project on environment.

Requirements

The GIS and mapping unit will be based at DGAIA in Calarasi and staffed by the organisation. Training and technical support, will form an important part of the procurement of the equipment specified below. Indeed, basic training should be provided to DGAIA staff concerning the operation and use of the GIS software and GPS hardware and associated software. All of the equipment and software specified below is available through agents operating in Romania, and to facilitate implementation and development of this capability within DGAIA every effort should be made to obtain the equipment in country.

It should be clearly specified in the offer of equipment what technical support would be available to DGAIA following installation of software, and what costs, if any, may be necessary should technical assistance, either via telephone or a site visit be necessary. Furthermore, it should be clearly stated if there are any anticipated upgrades to the GIS or GPS software likely to occur in the foreseeable future and whether will be made available to DGAIA freely or will incur a cost. An estimate should be provided.

Personal computer and printer

The project will invest in a GIS to maintain and facilitate the analyses of the data collected by the project and also to allow the production of simple A3 maps, initially of the project area. The project anticipates the need for only one GIS licence and therefore there is only the need for one PC to operate the GIS software.

The minimum specifications of the PC to operate the GIS software are set out below:

- Pentium III processor 800MHz
- 128MB 100 MHz SDRAM
- 15GB Hard Drive
- 17" Colour SVGA Monitor
- 256KB Integrated L2 Cache
- 20/48X[2] CD-ROM Drive and floppy drive

- Window 98 OS
- Microsoft Office Professional (to include MS Access)

The minimum printer specifications are:

- Colour inkjet
- Printing up to A3 size
- Windows drivers

Geographical Information System

There is a requirement for **one** GIS software license for the APCP. The GIS software selected for this project should be PC based and compatible with Windows software (i.e. Window2000 or Windows NT). The software should provide the functionality to manage and store geographically referenced data (vector based geographical databases) in a number of native, and commonly used, formats such as those complying or using MapInfo or ArcView formats. The GIS software must provide for linking to a relational database such as Microsoft Access.

The software should also be able to store and present raster or image based databases such as satellite images or digital photographic imagery that has been geo-referenced (e.g. jpeg, tiff, Erdas Imagine formats and associated world reference files).

It is anticipated that there will be a requirement to capture point, line and polygon data from paper maps. The GIS software should provide either via an additional module or built in functionality for data capture via a digitising tablet or on screen data capture from raster images.

Ideally, the GIS software will be modular allowing the expansion of functionality to suit the users needs. For example, it is anticipated that as the experience grows within the organisation in the use of GIS software there may be a need to expand the functionality to undertake spatial analyses such as kriging or interpolation.

Full and comprehensive training should be provided with the GIS software. In particular the training should focus on:

1. data capture (using the digitising tablet and 'head up' or on screen data capture);
2. data storage and relating geographical data to a relational database such as MS Access;
3. basic data manipulation;
4. map production.

Digitising tablet

The project expects to undertake some digitising of maps in order to propagate the GIS database. **One** digitising tablet is required. The required digitising tablet should be A3 and commonly available and supported in Romania. The product should be fully compatible with the selected GIS software and operate on the Wintab driver.

Global Positioning System

Global positioning system (GPS) technology will provide the project with an easy means of collecting geographically referenced data that can be uploaded and stored in the GIS.

Since the GPS will be used principally for mapping and GIS data collection functionality should exist for the post processing of the GPS data into files compatible with the GIS software. It would also be highly desirable, although not an essential requirement if the GPS software could handle the native formats of the GIS data (e.g. coverage, shapefile or MapInfo files).

The minimum functionality of the GPS should include:

- Collection of point, line and features with attribute information
- 1 to 5 meter precision after differential correction[5]
- Integrated high-performance 12-channel GSP receiver and antenna
- Rugged and water-resistant design
- Carrier phase processing for sub-meter precision
- Creation and storage of multiple data dictionaries in the office or directly on the unit

[5] * Without post processed or real-time differential correction, all GPS receivers are subject to degradation of position and velocity precision under the U.S. Department of Defence-imposed Selective Availability (S/A), although the S/A has recently been removed by Presidential decree. Nonetheless precision may be degraded so that 95% of positions are within 100 meters (330 feet) of truth. The above precision values assume tracking of 4 satellites (5 satellites for carrier phase), a PDOP of <6, SNR >4 and reasonable multipath conditions, Ionospheric conditions, multipath signals or obstructions of the sky by building or heavy tree canopy may degrade precision by interfering with signal reception. Real-time precision assumes a standard RTCM SC-104 format broadcast from a reference station. Notwithstanding this, with the removal of S/A precision of 10 - 12 metres or better should be achievable.

- Upload of existing data for data maintenance (relocation, verification, and update)
- Real-time map display
- Graphical satellite skyplot
- Graphical navigation skills
- Internal digital compass for navigation at low velocity
- National and custom coordinate system support
- NMEA output
- All-day internal rechargeable battery
- Two-level backlit screen with 160 x 160 pixel graphical display
- Selectable English, French, German, Spanish, Portuguese, and Russian language interface

It is anticipated that there will be a heavy requirement for GPS and therefore it is recommended that **three units** be supplied, one of these units should be capable of serving as base unit for the continuous collection of data to provide differential correction to the roaming units if required.

ANNEX IV - Field visit notes

Field visits - general observations / comments

Polder area (area visited **Gradistea**) - signs of eutrophication (algae bloom in canals); nitrate 'loving' plants evident; inappropriate use of land (i.e. on Agroservcom State Farm 150 ha of cereals lost due to waterlogging, equivalent to $30 000); considerable scope to improve land management particularly in view of nutrient management (Polder area candidate area for Nitrate Vulnerable Zone); enhancing wetland areas along Danube; little evidence of soil erosion (although feasible that wind erosion may occur); alkalinity increasing (although farm Director nor aware) with soil pH as high as 8.9 (unsuitable for cereal production); yields are generally good though.

Lake Calarasi and surrounding area - irrigation canals appeared in varying degrees of maintenance, reeds (*Phramites*) fringe these canals. Water table in adjacent fields was about < 0.50m below soil surface. Evidence of soil crusting and a plough pan. Area visited had been recently harvested of soya-beans (harvesting was still going on) and in many fields weed infestation was very high.

Lake Calarasi - grassland surrounding southern area of lake, north-eastern areas bordered by abandoned industrial complex, eastern area by cultivated land (cereals), western area by grassland onto urban area (Gradistea commune). Narrow reedbeds (*Phramites*) fringe the lake which is an important feeding site for waterbirds particularly those breeding at Sreberna reserve (Bulgaria), in riverine forest along the Danube and at other wetland sites. It is also an important stop over site during spring and autumn migration. Bird species include: Pygmy Cormorant (*Phalacrocorax pygmeus*), Dalmatian Pelican (*Pelecanus crispus*), Night Heron (*Nycticorax nycticorax*) and White-fronted Goose (*Anser albifrons*).

Terrace area
Gradistea (Rasa Comuna - Agras S.A.) - yields generally good; low inputs (relative to intensive system); farmers observed algae blooms occasionally in Lacul Potcoava; reed beds evident around lake shore; bank erosion of lake evident particularly when lake high; cultivation observed up to lake edge (or within 10 - 20 m); soil moisture limiting factor to production; where land not cultivated around lake evidence ladybirds observed and other beneficial insects; no evidence of soil erosion.

Vlad Tepes (Mihai Viteazu) - in particular small lake draining into Barza; terraces on east side of lake leading up to common grassland; terraces in reasonable condition; *Accacia* planted on some terraces - establishment good but generally lacked good management - appears to be little community commitment to the trees; desire to increase wooded area here to supplement fuel source; poor sward on grassland - overgrazed (?); water courses need protecting; little water erosion observed.

Cuza Voda (Total Chim) - yields good; soil generally fertile; soil moisture limiting productivity; little grassland in the rotation; low use of inputs; OM declining; phosphorous declining; interested in use of agro-forestry to improve productivity; some wind erosion.

ANNEX V - Cost tables for GIS, GPS and Land Cover Mapping

Cost tables for land suitability mapping and monitoring

Romania APCP - Cost table

TOR 3 Land-Use Suitability Map and Programmes for environment-friendly agricultural practices and agro-forestry

A Investment

	Activity	**Unit**		**Unit Cost US$**	**Pre-project**	**PY1**	**PY2**	**PY3**	**PY4**	**PY5**	**Total**
1	**Civil works:**										0
	none										0
2	**Goods**										0
2.1	Vehicles	item		0							0
	list vehicle types			0							0
2.2	Equipment										0
	PC		1	1500		1500	0	0	0	0	1500
	MS Windows 98 OS		1	500		500	0	0	0	0	500
	MS Office (include MS Access)		1	1000		1000	0	0	0	0	1000
	GIS software		1	1400		1400	0	0	0	0	1400
	GIS spatial analysis software		1	2600		0	2600	0	0	0	2600
	Digitising tablet		1	2500		2500	0	0	0	0	2500
	A3 Colour printer		1	1200		1200	0	0	0	0	1200
	Digital map data	lump		8600		8600	1000	1000	1000	1000	12600
	Global Positioning System (GPS)		3	10500		31500	0	0	0	0	31500
	GPS processing software		1	6500		6500	0	0	0	0	6500
	GPS ancillaries (batteries, battery charger etc)		2	2350		4700	0	0	0	0	4700

	3 Technical assistance									
	3.1 International		0.25	13200	3300	0	3300	0	3300	9900
	3.2 Local (Geometric corrections to images)	10 images in total		1600	3200	3200	3200	3200	3200	16000
	3.3 Local (Derivation of land cover from images)	2 land cover databases / yr		3000	3000	3000	3000	3000	3000	15000
	4 Field observations	Unit cost or lump sum								0
	4.1 Field work for image checking to produce land cover database		1	2320	2320	2320	2320	2320	2320	11600
	5 Training									0
	5.1 Conference (dissemination of GIS work)		1	2500	0	0	2500	0	2500	5000
	5.2 Short courses (GIS)		1	3500	3500	3500	0	0	0	7000
	5.3 Short courses (GPS)		1	2500	2500	0	0	0	0	2500
sub-total										**133000**
B	**Recurrent costs**									
	Satellite imagery	10 images (2/yr)		4000	8000	8000	8000	8000	8000	40000
	Printer consumables		1	1500	1500	1500	1500	1500	1500	7500
sub-total										**47500**
TOTAL (A + B)										**180500**