"Technical assistance and support to fruit and vegetable growers in the Swat Valley (Pakistan) for the improvement of production and marketing in the horticultural value chain"
(ADP SWAT)

Atlas of the Natural Resources Evaluation in Swat Valley, Khyber Pakhtunkhwa, Islamic Republic of Pakistan

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1. Introduction

The Project Titled "*Technical Assistance and Support to Fruit & Vegetable Growers in Swat valley for the implementation of production and Marketing in the Horticultural Value Chain (ADP SWAT)*" is an Italian cooperation initiative funded by the Ministry of Foreign Affairs (MAE) – Directorate General for Development Cooperation (DGCS) of the Government of Republic of Italy, and realised in collaboration with the Ministry of Economic Affairs & Statistics of the Islamic Republic of Pakistan - Economic Affairs Division (EAD), the Agriculture, Livestock and Cooperation Department (Khyber Pakhtunkhwa, hereafter referred to as KP), the University of Agriculture (AUP) of Peshawar (KP), the Agriculture Extension Department (AED) and the Agriculture Research Institute (ARI) of Mingora (Swat District).

The Istituto Agronomico per l'Oltremare (IAO), technical-scientific branch of the MAE, working to fight world poverty and hunger, has been entrusted by the MAE/DGCS as implementing agency. The IAO is involved in Development Cooperation initiatives on integrated rural development, environmental and natural resources management, fight against desertification and food security.

The aim of the following study is the natural resources evaluation of some areas belonging to the Swat Valley (Swat District, KP), taking into consideration several parameters such as climate (temperatures and precipitations), vegetation (land cover), morphology, soils, and water in order to provide clear indications concerning the suitable areas for development of some fruit trees plantations. It is important to point out, that the Swat Valley area accounts for a relevant participation on the fruit production in Pakistan. The main Project activities are carried out in the area belonging to five Farmer Service Centres (FSC), localized in Madyan, Kabal, Barikot, Matta and Khawazakhela *tehsil*.,

In order to better understand the actual Project area reality, it's important to mention that in 2009 the entire area was affected by military operations aimed at suppressing the insurgency rooted in Swat Valley, generating a phenomenon of large-scale internal displacement among the civilian population. Then, in the month of May 2010 the same area, was subjected to the flooding of the river Swat which caused a further state of calamity which severely affected the agricultural

system. These events have changed the face of the valley mainly in its southern sector with loss of wide agricultural areas.

This natural resources evaluation has been carried on primarily by the IAO. Unfortunately, due to security reasons, the GIS expert didn't have the possibility of travelling to the Project area (Swat Valley). Hence the field survey activities were not possible.

2. The study area

The Swat Valley is situated in the North of KP. It lies 34° 34’ to 35° 55’ N and 72° 08’ to 72° 50’ E, with an altitude varying from 2.500 to 7.500 feet (Fig. 1 – Swat Valley location).

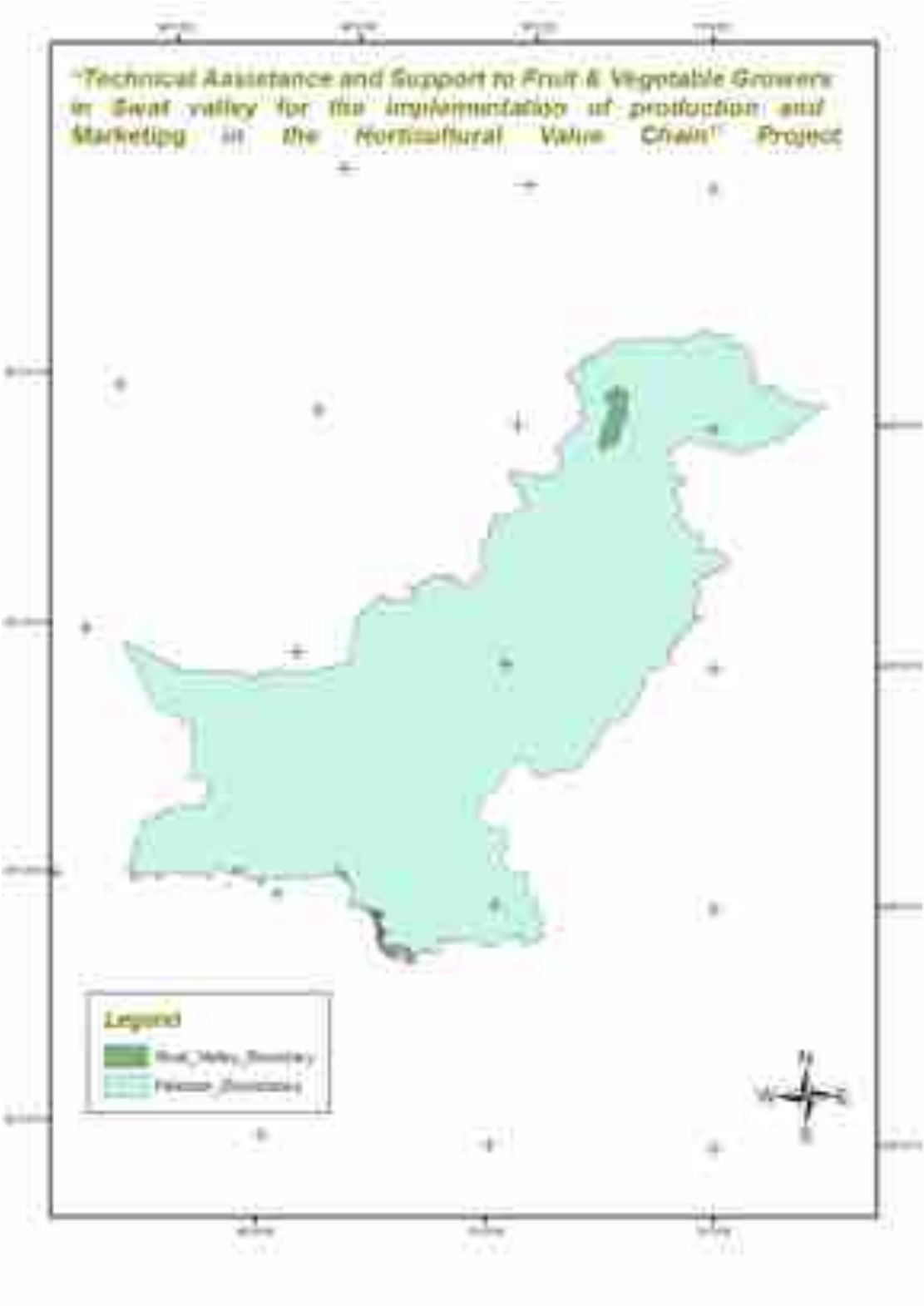


Fig.1 - Swat Valley location

The district is inhabited by poor and small scale farmers with average land holding below one hectare per family. Due to several reasons, the total cultivated area is just 19.36% of the district's area. The Swat District is composed by ten *tehsil* Most of the cultivation is carried out in the southern areas in Saidu Sharif, Kabal, Barikot, Matta and Khawazakhela *tehsils*.

The valley is surrounded by high mountains and bounded by Chitral and Ghizer Districts in the North, Kohistan and Shangla Districts in the East, Buner District and Malakand protected areas in the South and lower and upper Dir districts in the West[1] Total area of Swat valley it's 5.285 km[22] with a population of about 1.250.000[3], with 185.000 farm families.

[1] "Main Report 2011, First Draft" Dr. Zahoor Ul Haq Associate Professor Department of Agricultural Economics, Khyber Pakhtunkhwa Agricultural University Peshawar, Pakistan

[2] "Swat Boundaries" shp

[3] "Main Report 2011, First Draft" Dr. Zahoor Ul Haq Associate Professor Department of Agricultural Economics, Khyber Pakhtunkhwa Agricultural University Peshawar, Pakistan

3. Land resources

3.1 Flora and Fauna

In the study area, climatic conditions (rainfall and temperature) promote a good vegetation development. Above 4500 ft, there is a vast coniferous forest mainly composed by pines, dewdar, cedar and byar trees. In the low land of Swat, the temperature is comparatively high, plants and broad leaves trees such as poplar, bakyan and willow are common. According to FAO LCCS methodology, natural vegetation classification in the north part of valley can be defined as "composed mainly by Closed to Open Needle-leaved Trees, and Closed to Open Shrubs".

3.2 Forestry and Fisheries

An important part of the land area of the Swat district is forest. The government has declared these forests as "Protected Areas" concentrated in the northern part of Kalam and Madyan. Kail, Spruce and chir are the pine varieties which are present in the south of the district, while in the northern and high parts of the area, the most common species are deodar as well as the others which were already mentioned. These forests not only have an aesthetics value, they also supply wood for cooking and heating purposes. In addition to this, besides being the main source of water for agriculture, the Swat river supports fishery activities all year round. The Mahasher fish in lower areas and the Trout fish in upper parts, where the water is very cold.

3.3 Physical Feature

The Swat valley is divided into two physical regions: the Swat-Kohistan and the Swat Proper. The Swat-Kohistan is the mountainous region on the upper reaches of the Swat river up to Ain in the south while the whole south area of Ain is Swat Proper. Ain is subdivided into Bar (upper Swat) and Kuz (lower Swat). The elevation of the valley in the southern borders of the district is over 600 meters above sea level and rises rapidly towards the north. There are several mountain peaks ranging from 4500 to over 6000 meters above sea level, mostly covered with everlasting snow.[4]

3.4 Geology and Land Form

[4] "Main Report 2011, First Draft" Dr. Zahoor Ul Haq Associate Professor Department of Agricultural Economics, Khyber Pakhtunkhwa Agricultural University Peshawar, Pakistan

The Swat drainage area has a complex geological history of orogenic disturbances and erosional and depositional cycles. The result is an extremely varied nature of landforms, mountains , dissected loses plains, out wash aprons, and alluvial plains[5]

3.5 River and drainage

The study area includes the northern part of the Swat watershed, characterized by the presence of some tributaries distributed along both sides. The density and characteristics of the drainage network (mainly dendritic) make it possible for the geological and lithological characteristics to keep more or less the same nature. Generally, the soils in the area are characterized by a not very high permeability.

3.6 Climate

In the Agriculture University of Peshawar main report, the climate was described as follows:

"Swat lies in the temperate Zone. The summer in lower Swat valley is short and moderate while it is cool in the upper northern part. The hottest month is June with average maximum and minimum temperature of 33°C and 16°C, respectively. The coldest month is January with average maximum and minimum temperature of 11°C and -2°C, respectively. The winter season is long and goes from November to March, rain and snowfall occur during this season. The amount of rainfall received during the winter season is more than that of the summer season. The highest rainfall recorded during the month of March is about 242 mm".[6]

The Swat valley is divided into different climatic areas. According to Ahmed (1951), the survey area is part of a broader climatic region. The categories are tentative and are subject to modification when more data will be available:

- Sub-humid subtropical zone: It cover mostly the southern and south – western part of the area. It comprises areas generally below the 1,500 meters of altitude. Natural vegetation is characterized by the presence of the following species: Cynodon dactilon (Kabal)

[5] "Reconnaissance soil survey Swat catchment area". 1976. - Government of Pakistan Ministry of Food And Agriculture , Soil Survey of Pakistan. Lahore 1981

[6] "Main Report 2011, First Draft" Dr. Zahoor Ul Haq Associate Professor Department of Agricultural Economics, Khyber Pakhtunkhwa Agricultural University Peshawar, Pakistan

Dodonaea viscose (sanatha), Acacia modesta (phulai) and Olea cuspidta (kau). Pinus roxburgii (chir) is found above 1,000 meter elevation;

- Humid subtropical zone: It covers the central part of the area below 1.500 meters of altitude. Natural vegetation is comparatively the same as the previous climatic class;

- Sub-humid temperate zone: It covers high mountainous areas, generally between 1.500 and 3.200 metres of altitude. Natural vegetation mainly comprises: Pinus Wallichiana (kail), Cedrus Deodara (deodar), Abies pindrow (fir) and Pinus morinda (sprice);

- Humid temperate zone: It covers the central mountainous part of the area generally between 1.500 to 3.200 meters elevation. The most part of this area is covered by coniferous forest, where Pinus Wallichiana (kail), Cedrus Deodara (deodar) and Abies pindrow (fir) are the dominant species;

- Sub-humid boreal zone: It covers the northern part of the area comprising high mountainous region above 3.200 meter above sea level. Natural vegetation is characterized by the presence of Juniperus spp., (gorgarh) salix spp. (kharwala), Artemisia maritime (Tirkna), Betula spp. (burj) Poa spp., Agropyron spp., Stipa spp. And Festuca spp.

4. Input Data

The Climatic data has been obtained from the Worldclim website. WorldClim[7] is a set of global climate layers (climate grids) with a spatial resolution of 1 square kilometer. The times series data acquired corresponds to the period between 1950 and 2000.

The data acquired are:

- Annual rainfall,
- Annual minimum temperature;
- Monthly minimum temperature in April.

4.1 Roads network

Main road network data set has been digitized using Google Earth satellite images. This information is necessary for the transportation cost analysis. The roads network is an important data for the evaluation of farmers' accessibility to the transportation of fruit to the markets and collection sites.

4.2 Drainage network

Drainage network data set has been digitized from Google Earth satellite images. River and river zone data set have been digitized from Google Earth satellite images. According to the satellite images, the river boundaries of Swat have been digitized and a safety buffer has been considered and digitized on both banks of the river considering that the flooded areas were clearly visible on the images.

4.3 Cities and villages

A total of 135 villages and cities located in the study area have been digitized for the whole downstream. They have been surveyed through Google Earth satellite images and the positions and names have been checked with the use of a set of the 13 topographic maps with a scale of 1:50.000, fourth edition, edited by the Pakistan Government.

4.4 Morphology

The Contour line shp file has been used to define the limits of altitude for fruit trees

[7] http://www.worldclim.org

growing, whereas the altitude is strictly linked to the temperature. Digital Elevation Model (DEM) is the digital representation of the ground surface.

The DEM has been utilized to perform the analysis of the slope and aspect. DEM is a Raster dataset with the reference solution of 30 metres and it is referenced to the WGS84/EGM96 geoid. The ASTER GDEM covers land surfaces between 83°N and 83°S and is composed of 22,600 1°-by-1° tiles and it's in GeoTIFF format with geographic lat/long coordinates. For the Swat valley an extraction has been carried out utilising the shape of boundaries[8].

4.5 Soil data

Soil data is essential for the land suitability analysis. Information was derived from the"Soil and Land form Map" and from the "Reconnaissance soil survey – Swat catchment area, 1976", which has been prepared according to the USDA Soil Survey methodology[9]

4.6 Topographic maps

A set of 13 topographic maps at 1: 50.000 scale have been used for the settlements identification validation and for other data validation (Fig. 2 – Mosaic of topographic maps)[10].

Two SPOT satellite images at 10 meters resolution and covering the south area of the Swat valley, have been used. The two Scenes ID are 51932801110190555502J (Fig. 3 - Image preview 193/280) from 19/10/2011 and 51942801109230556031J (Fig. 4 - Image preview 194/280) from 23/09/2011 have been elaborated at level 2A.

It is also possible to have a quick review of the other main data set, used for the land suitability analysis in Table 1: Main data set review.

[8] www.asterweb.jpl.nasa.gov/gdem.asp.

[9] "Reconnaissance soil survey Swat catchment area". 1976. - Government of Pakistan Ministry of Food And Agriculture , Soil Survey of Pakistan. Lahore 1981

[10] 1997, fourth edition NWF Province, surveyed in 1992 edited by the Government of Pakistan

43 A/6		
43 A/7	**43 A/11**	
43 A/8	**43 A/12**	
43 B/1	**NA**	**43 B/9**
43 B/2	**43 B/6**	

Fig. 2– Mosaic of topographic maps

Topography	**Data source**	**Format**
SRTM Data	http//srtm.csi.cgiar.org	Raster & Vector
Spot Images	http://www.mapmart.com/	Raster
Natural Resources		
Climate	www.worldclim.org	Raster
Drainega	From DEM	Vector
River	From Spot Satellite	Vector
Slope	From DEM	Raster
Aspect	From DEM	Vector
Land Cover	From Spot Satellite	Vector
Administrative Data		
Global Administrative Boundaries	www.gadmin.org	
Villages	From Spot Satellite	Vector
Roads	From Spot Satellite	Vector

Table 1 - Main data set review

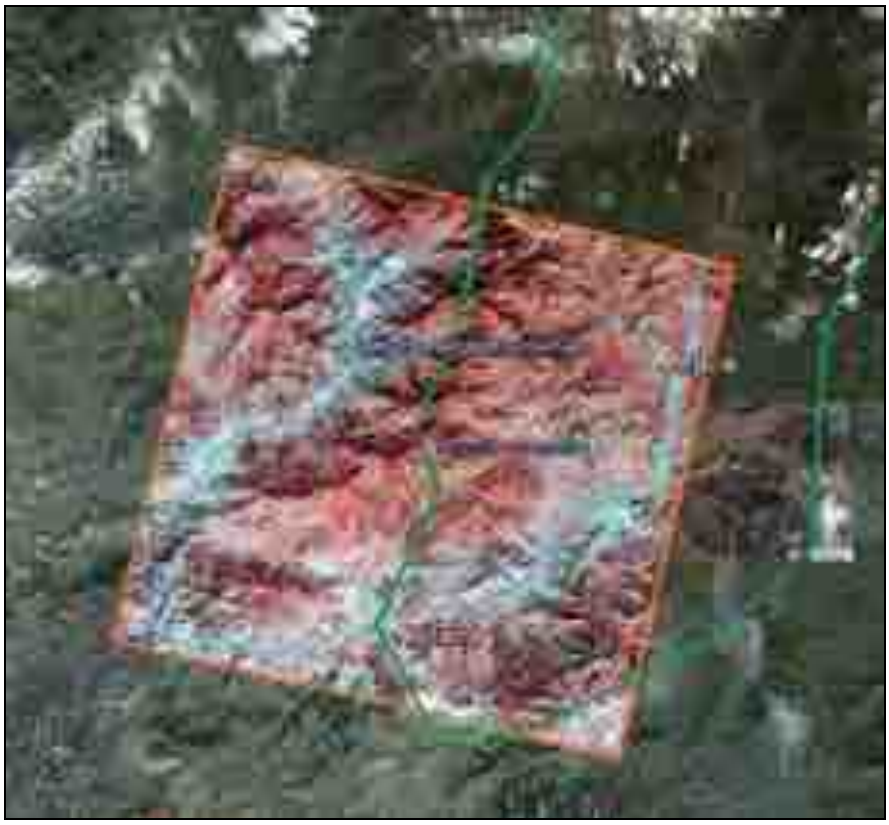


Fig. 3 – Image preview 193/280

Fig. 4 – Image preview 194/280

5. Methodology

Suitability is the attribute of a given type of land to support a defined use (Ongaro, 1998). This methodological approach was mainly based on the FAO guidelines[11] which focus on soil, landforms and agricultural practices as the main sources of agricultural limitations. It also takes into account the concept of the land as a holistic system made of different components: climate, geology, geomorphology, soil, vegetation and agriculture. Those are not considered as individual and singular independent factors but as components which in combination with each other make up land. Each zone has a similar combination of constraints and potentials for land use.

For the land suitability analysis, a two phases approach was followed:

a. Morphological analysis

b. Climatic analysis

5.1 Morphological analysis

As for the morphological analysis, the contour lines 719 m was used as bottom limit and the 1.600 m as upper limit of the "Area of interest" in which fruit trees plantations theoretically grow. According to FAO[12], slope is another very important morphological parameter which can limits fruit trees plantations. The slope was classified in a 7 incremental range expressed in degrees: 0-2, 2-5, 5-8, 8-16, 16-30, 30-45, >45. In a pragmatic way, we had to consider a soil slope more than 5 degree as a limit for agriculture practices. This is because we don't know anything about soil structure, stoniness, slope length etc.

Another important morphological parameter is the "exposure" to the influence of the climate (micro thermal conditions). We have considered five optimal and sub optimal exposures: East, South-East, South, South West, West.

The results in terms of Capability surfaces is shown in Table 2 – Swat Valley capability surfaces. The Capability, according to the USDA classification.[13]

[11] Global Agro - ecological Assessment for Agriculture in the 21st Century: Methodology and Results http://www.fao.org/nr/land/databasesinformation-systems/aez-agro-ecological-zoning-system/en/

[12] FAO guidelines "Global Agro-ecological Assessment for Agriculture in the 21st Century: Methodology and Results"

[13] Sys et al., 1991

ID	Area	ha
1	Swat boundary area	528.599.68
2	Area of interest (inland 1600m)	125.848.98
3	Aspect area	37.661.08
4	River and flooded area	5.406.87
5	Surface <5° (&)	32.254.21
6	Surface inside the 1600m (>2°C) (&&)	120.442.11
	(&) difference between ID 3 and ID 4	
	(&&) difference between ID 2 and ID 4	

Table 2 – Swat Valley capability surfaces

5.2 Climatic analysis

An analysis of two climatologic variables (temperature and rainfall) was carried out.

The impact of low temperatures was assessed using historical data of the minimum temperature in April, which coincides with the flowering period for most of the fruit trees species of the region. In addition to this, a comparison between the annual average precipitation and the ideal amount of rain for the fruit tree growth was done. Annual rainfall data was classified with a pixel of 1 square km extension (climatologic data set). Rainfall values were overlapped with the "Area of interest" and to the "Aspect area". The result of this analysis confirms that the "Aspect area" is suitable concerning the rainfall parameter, with a annual average precipitation value ranging from 676 to 964 mm.

In higher areas there are higher temperatures, this could be explained with thermal inversion and less humidity than in the lower and flatter parts of the valley. By overlapping the "Aspect area" with temperature spatial distribution, it was possible to show that the valley is divided into two main zones.

In the south part, annual minimum temperatures are between 0,9 to 19,9°C and in the north part, which is highly mountainous, the annual minimum temperature value is between 0,9

and -26,3°C. In April, in the south part of the valley, the minimum temperature value was between 5,9 and 19,9 °C.

5.3 Land utilization period

In the region of interest, snow is present at least once, either during the *rabi* or the *kharif* seasons[14]. Regarding the land utilization period, in the Table 3 - Land utilization period, *rabi* and *kharif* seasons distribution during the hole year is described.

Rabi season							***Kharif season***				
Nov	Dec	Jan	Feb	Mar	Avr	May	Jun	Jul	Aug	Sep	Oct

Table 3 - Land utilization period

5.4 Fruit Trees Plantation in the Swat valley

The mains fruit trees plantations cultivated in the Swat valley are: Apple, Apricot, Citrus Lokat, Peach, Pear, Persimmon, Plum. Spatial distribution, according to the District *thesil* localization, is shown in Table 4 - Fruit Trees Plantation spread in the Swat valley (the number 1 means that the crop is present, the number 0 meaning that the crop is absent).

	Matta	Khwarakhela	Kabal	Charbagh	Barikot	Bahrain	Babuzai	Tot_FSC
Apple	1	1	0	1	0	1	0	4
Apricot	0	0	1	1	1	0	1	4
Citrus	0	0	0	0	1	0	0	1
Lokat	0	0	0	0	1	0	0	1
Peaches	1	1	1	1	1	0	1	6
Pear	0	0	1	0	0	0	0	1
Persimmon	1	1	1	1	1	1	1	7
Plum	1	1	1	1	0	1	1	6
Tot._Colt	4	4	5	5	5	3	4	

Table 4 - Fruit Trees Plantation spread in the Swat valley

[14] *Rabi* season starts in November and ends in May while *kharif* starts in June and ends in October. From: "Main Report 2011, First Draft" Dr. Zahoor Ul Haq Associate Professor Department of Agricultural Economics, Khyber Pakhtunkhwa Agricultural University Peshawar, Pakistan

5.5 Software Platform

A GIS (Geographical Informational System) has been designed for the collection, storage and analysis of objects and phenomena where geographic location is an important characteristic. In general GIS is a chain of operations that involves the planning of the observation and collection of geo-referenced data, storage, analysis and use of the data for some specific purpose. In this context the crucial steps were the collection of data from World Wide Web.

Open Source software Qgis was the GIS selected for the data management and for data processing[15]. Open Office spreadsheet was also used for tabular data management.

5.6 Land Unit Map

The land unit map has been prepared on the basis of crossing different types of morphological data: height, slope, and aspect. Results were classified as "Aspect Area". In addition to this, boundaries data set[16] and administrative sub-divisions[17] provide a first general Swat valley characterization, from the morphology and agricultural point of view. Land Use and Land Cover classification was done, based on a 10 m spatial resolution SPOT Satellite images photo interpretation. As a result,, two main Land Systems have been identified as well as twelve different Land forms.

According to the Land System and the Land Form, different Land Units were identified. (Table 5 - Land Systems of Swat Valley). A total of 24 Land Unit types in the two Land Systems, according to the "Glossary of Land form and Geologic terms" from the National Soil Survey Handbook[18], have been identified. The Land Use/Land Cover category was checked according to the FAO GLCN – LCCS methodology

[15] http://www.gvsig.com

[16] http://www.gadm.org

[17] http://www.fao.org/geonetwork/srv/en/metadata.show?id=12691

[18] http://www.statlab.iastate.edu/soil

Land System	Landform	Land Unit Code	LCCS (Classe name)	Land Use (LCCS)	Label	Soil_Ass
Southern Swat main river valley	Alluvial plaine	1	Cultivated ad meneged terrestrial areas	Irrigated Tree(s) Crop(s)//Herbaceous crop(s)	Irrigated Ortchard // Croplands	23
		2		Irrigated Herbaceous crop(s)	Irrigated Croplands	21
		3	Artificial surface and associated areas	Urban areas	Urban areas	-999
	Alluvial–colluvial gently slope	4	Cultivated ad meneged terrestrial areas	Rainfed Tree Crop(s)// Herbaceous crop(s)	Rainfed Ortchard// Croplands	21
		5	Natural or semi-natural terrestrial vegetation	Sparse shrubs	Sparsely Vegetated Areas	8
	Colluvial gently slope	6	Natural or semi-natural terrestrial vegetation	Herbaceous close to open Vegetation	Pastures	15
		7	Cultivated ad meneged terrestrial areas	Rainfed Herbaceous Crop(s)	Rainfed Croplands	23
		8		Rainfed Tree Crop(s)//Herbaceous crop(s)	Rainfed Ortchards// Croplands	21
	Terracced areas	9	Cultivated ad meneged terrestrial areas	Rainfed Herbaceous Crop(s)	Rainfed Croplands	17
	Natural waterbodies	10	Natural water bodies, snow and ice	Natural Waterbodies	Swat main river	-999
Southern Swat lateral river valley	Alluvial-colluvial gently slope	11	Cultivated ad meneged terrestrial areas	Rainfed Herbaceous Crop(s)	Rainfed croplands	25
		12		Irrigated cultivation (s)	Irrigated croplands	27
		13		Irrigated Tree Crop(s)//Herbaceous crop(s)	Irrigated Ortchard // Croplands	27
		14	Artificial surface and associated areas	Urban areas	Urban areas	-9999
	Colluvial eroded gently slope	15	Cultivated ad meneged terrestrial areas	Rainfed Herbaceous Crop(s)	Rainfed croplands	17
	Very eroded gently slope	16	Cultivated ad meneged terrestrial areas	Rainfed Tree Crop(s)//Herbaceous crop(s)	Rainfed Ortchards// Croplands	15
	Colluvial eroded terrasses gently slope	17	Cultivated ad meneged terrestrial areas	Rainfed Herbaceous crop(s)	Rainfed Croplands	27
		18		Rainfed Tree Crop(s)	Rainfed Ortchards	17
	Colluvial terrassed gently slope	19	Cultivated ad meneged terrestrial areas	Rainfed Herbaceous crop(s)	Rainfed Croplands	26
		20		Rainfed Tree Crop(s)//Herbaceous crop(s)	Rainfed Ortchards// Croplands	15
		21		Irrigated Tree Crop(s)//Herbaceous crop(s)	Irrigated Ortchard //Irrigated Cropland	25
		22	Artificial surface and associated areas	Urban areas	Urban areas	-999
	Low energy relief	23	Natural or semi-natural terrestrial vegetation	Closed to open Woody Vegetation	Forests	2
	Natural waterbodies	24	Natural water bodies, snow and ice	Natural Waterbodies	Swat lateral river	-999

Table 5 - Land Systems of Swat Valley

5.7 Land Suitability

5.7.1 Methodological approach

"*Land suitability is the fitness of a given type of land for a defined use. The land may be considered in its present condition or after improvements. The process of land suitability classification is the appraisal and grouping of specific areas of land in terms of their suitability for defined uses*[19]."

[19] FAO guidelines "Global Agro-ecological Assessment for Agriculture in the 21st Century: Methodology and Results

The Land Suitability framework has been implemented in strict accordance with Sys et al.[20], by defining a set of Matching Tables for each crop. In the Matching Tables, several environmental parameters have been rated to estimate their overall impact on the crop under assessment.

5.7.2 The Matching Tables

The core of the procedure is the so-called Matching Table; for each crop under investigation a Matching Table has been prepared. The parameters concerning soil characteristics are:

- **Drainage**[21]: the natural or artificial removal of surface and sub-surface water from an area. Many agricultural soils, due to their high water holding capacity, need drainage to improve production or to manage water supplies;

- **Depth**: the unconsolidated material immediate the surface of the earth serves as natural medium for the growing plants. Soil depth defines the root space and the volume of soil from where the plants fulfil their water and nutrient demands;

- **Slope**: soil slope is particularly important in terms of its effect on erosion. Slope can be measured in percent or degrees. The amount of surface residue required to reduce erosion increases with slope and as soil texture gets finer;

- **Texture**: soil texture has an important role in nutrient management because it influences nutrient retention. For instance, finer textured soils tend to have greater ability to store soil nutrients;

- **pH**: Soil pH is an indication of the acidity or alkalinity of soil and is measured in pH units. Soil pH is defined as the negative logarithm of the hydrogen ion concentration. The pH scale goes from 0 to 14 with pH 7 as the neutral point. As the amount of hydrogen ions in the soil increases the soil pH decreases thus becoming more acidic. From pH 7 to 0 the soil is increasingly more acidic and from pH 7 to 14 the soil is increasingly more alkaline or basic;

[20] Sys C., Van Ranst E., and Debaeye J., Land Evaluation. Methods in land evaluation. General Administration for Development Cooperation. Agric. Publ. No. 7. Brussels , Belgium, 1991

[21] http://www.fao.org/geonetwork/srv/en/metadata.show?id=30558.....

- **CaCO3**: Calcium carbonate is a common substance found in rock in all parts of the world, and is the main component of shells of marine organisms, snails, pearls, and eggshells. Calcium carbonate is the active ingredient in agricultural lime, and is usually the principal cause of hard water;

- **EC**: Electrical conductivity (EC) is a measurement of the dissolved material in an aqueous solution, which relates to the ability of the material to conduct electrical current through it. EC is measured in units called Siemens per unit area (e.g. mS/cm, or miliSiemens per centimetre), and the higher the dissolved material in a water or soil sample, the higher the EC will be in that material.

In Table 6 (Matching tables; Drainage parameters) a drainage overview is shown

Apple_Swat2013		**100**
1		
DRAINAGE		
weigth	**1**	
notes	**Rating**	**other**
W	100	
MW	100	
I	70	
SE	50	
E	20	
P	0	
VP		

Table 6.- Matching tables; Drainage parameters

Following Sys et al., the current value of a land characteristic (e.g. slope, pH, soil texture etc.) for a given portion of land (map polygon) is rated according to a set of thresholds to define the percent of yield reduction that is expected, on a scale from 0 (no production) to 100 (no reduction).

The evaluation process is based on a set of tailored spreadsheets. The choice of a spreadsheet as the processing environment is based on the following considerations:

- intrinsic complexity of the matching tables;
- interrelationships amongst parameters;
- ease of data inputs and model tuning;
- ease of troubleshooting;
- general diffusion, availability and knowledge of the tool.

For each fruit tree plantation the values of Matching Tables are matched with each soil parameter; Depth of profile , Drainage, pH, Slope, Texture, CaCO3, EC, concerning a Control Section (Depth >20 cm). The result of the calculation is a synthetic value ranging from 0 to 100, classified into 5 different Scores, where 0 is no production ad 100 no restriction.

Five possible different combinations of calculation are possible considering the values of each score parameter

- Average value;
- Weighted average value;
- Minimum value;
- The worst of the half of data of each parameter;
- The worst of the half of data of each parameter weighted.

Usually the “Average Value” is considered in an average climatic and geomorphological situation. In this study we have considered this:

SCORES	
0	N2
30	N1
45	S3
60	S2
80	S1
999	

Table 6 - Score of synthetic value of Suitability

5.7.3 Land Suitability Classes

Land Suitability orders indicate whether a land is assessed as suitable or not suitable for the use under consideration.

There are two orders represented in maps, tables, etc. by the symbols S and N respectively[22].

- **Order S Suitable**: Land on which sustained use of the kind under consideration is expected to yield benefits which justify the inputs, without unacceptable risk of damage to land resources;

- **Order N Not Suitable**: Land which has qualities that appear to preclude sustained use of the kind under consideration.

Land may be classed as Not Suitable for a given use for a number of reasons. It may be that the proposed use is technically impracticable, such as the irrigation of rocky steep land, or that it would cause severe environmental degradation, such as the cultivation of steep slopes. Frequently, however, the value of the expected benefits does not justify the expected costs of the inputs that would be required. Hence, land suitability Classes reflect degrees of suitability. The classes are numbered consecutively, by Arabic numbers, in sequence of decreasing degrees of suitability within the order. There might, for example, be only two, S1 and S2. The number of classes recognized should be kept to the minimum necessary to meet interpretative aims; five should probably be the most ever used.

If three classes are recognized within the Order Suitable, as can often be recommended, the following names and definitions may be appropriate in a qualitative classification:

- **Class S1 Highly Suitable**: Land having no significant limitations to sustained application of a given use, or only minor limitations that will not significantly reduce productivity or benefits and will not raise inputs above an acceptable level;

- **Class S2 Moderately Suitable**: Land having limitations which in aggregate are moderately severe for sustained application of a given use; the limitations will reduce productivity or benefits and increase required inputs to the extent that the overall advantage to be gained from the use, although still attractive, will be appreciably inferior to that expected on Class S1 land**;**

[22] A Framework of Land Evaluation - FAO Soils bulletin 32, Rome 1976

- **Class S3 Marginally Suitable**: Land having limitations which in aggregate are severe for sustained application of a given use and will so reduce productivity or benefits, or increase required inputs, that this expenditure will be only marginally justified.

Suitability Class S1, Highly Suitable, may sometimes not appear on a map of a limited area, but could still be included in the classification if such land is known or believed to occur in other areas relevant to the study.

Within the Order Not Suitable, there are normally two Classes:

- **Class N1 Currently Not Suitable**: Land having limitations which may be surmountable in time but which cannot be corrected with existing knowledge at currently acceptable cost; the limitations are so severe as to preclude successful sustained use of the land in the given manner;

- **Class N2 Permanently Not Suitable**: Land having limitations which appear so severe as to preclude any possibilities Of successful sustained use of the land in the given manner.

Quantitative definition of these classes is normally unnecessary, since by definition both are uneconomic for the given use. The upper limit of Class N1 is already defined by the lower limit of the roast suitable class in Order S. The boundary of Class N2, Permanently Not Suitable, is normally physical and permanent. In contrast, the boundary between the two orders, Suitable and Not Suitable is likely to be variable over time through changes in the economic and social context.

5.8 Suitability areas

The results of suitability area for each fruit trees plantations (apple, apricot, citrus, pear, persimmon, plum and peach) are showed in the next tables (Tables 7, 8, 9, 10, 11, 12 and 13):

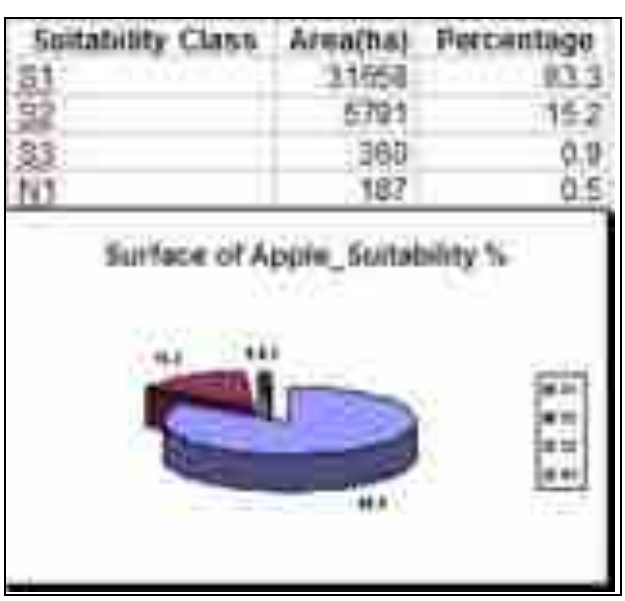


Table 7 - 8 – Surface availability for apple (up left) and apricot (up right)

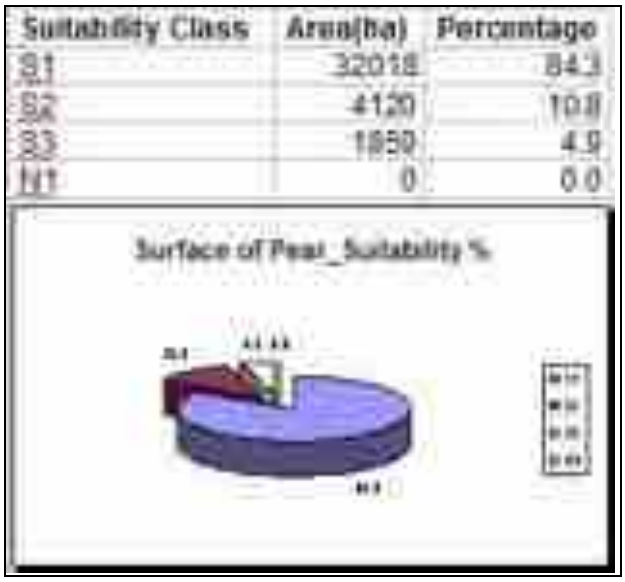
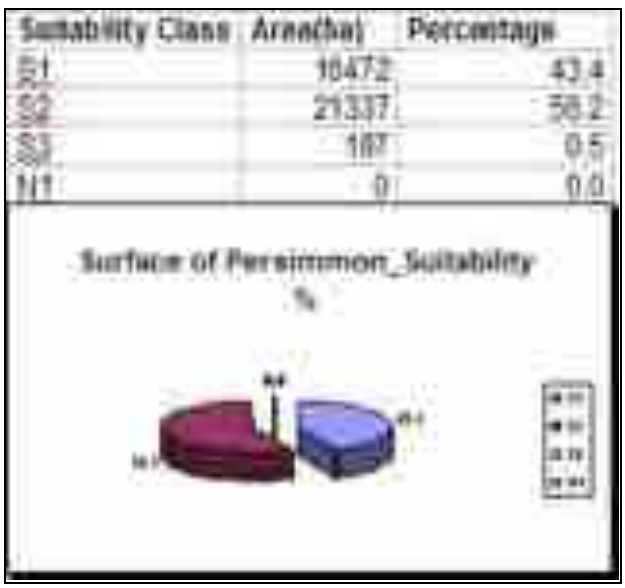


Table 9 - 10 – Surface availability for citrus (up left) and pear (up right)



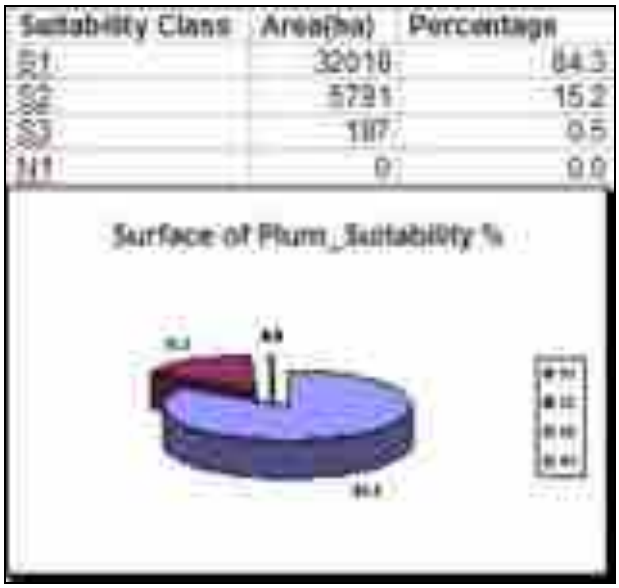


Table 11 - 12 – Surface availability for persimmon (up left) and plum (up right)

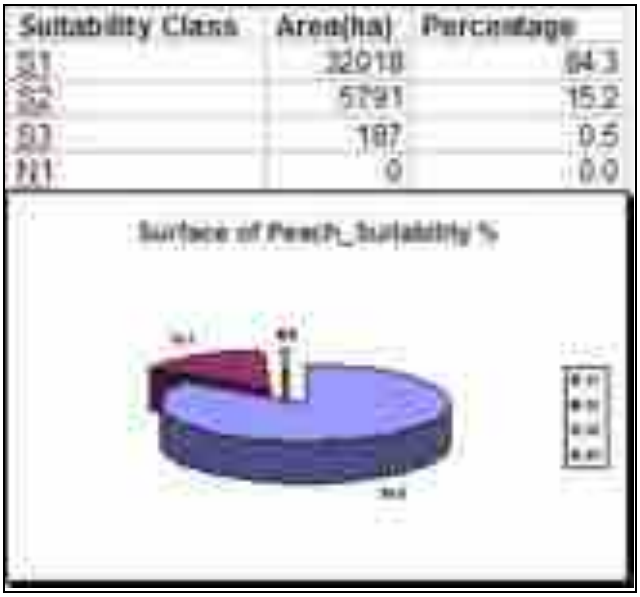


Table 13 – Surface availability for peach

5.9 Transportation cost analysis

In the framework of Project Titled "*Technical Assistance and Support to Fruit & Vegetable Growers in Swat valley for the implementation of production and Marketing in the Horticultural Value Chain (ADP SWAT)*" two **modular units for the processing of the horticultural products** have been realised in the Kabal and Matta tehsil.

The transport, considering the distance from the farms to the modular units and the characteristics of network roads, could have a relevant impact on the cost of production. Based on the characteristics of the road network, an analysis was performed for the sismulation of the transportation costs based mainly on the distance between the different production areas and the modular units. The road is considered as the main physical entity for the calculation of distance. Furthermore for each road is considered a buffer of 1 km on both side (average value of distance between farms and roads) because the production sites aren't generally close to roadsides. The modular units are the start points and the final points are the extreme points of each road. From the start and the end point of roads, the analysis of distance was performed considering the "minimum distance" In other words, the shortest route has been simulated.

The results are displayed in the Network Analysis map (see Annexes), in which the colours represent the ranges of distances (expressed in meters) from the farms to the production areas, or production farms. In the Table 14 (Transportation costs) the simulation of the transport costs is performed considering the maximum distance equal to 100 (maximun cost). In this case, the trasnportaition costs range between 100% and 12%. Since we consider a baffer of 1 km in both side of street, also we consider that the distance with a radius of 1 km round the modular units the cost of transport is equal to 0 (0%).

Range of distance (m)		**Cost (%)**
0	1.000	0
1001	4.400	12
4.401	7.752	22
7.753	10.689	30
10.690	13.625	38
13.626	16.562	47
16.563	19.918	56
19.919	23.833	67
23.834	27.609	78
27.610	31.524	89
31.525	35.580	100

Table 14 - Transportation costs

6. Conclusions

The present study is to be considered as a first attempt of systematic collection and review of existing available data in order to assess the potential of the Swat Valley for a durable and sustainable development of modern fruit production and processing agro industry.

All the data have been harmonized, corrected, checked for quality, and introduced in a Geographical Information System (GIS) for storage and processing. As already stated in other parts of the report, this study had to face the reduced availability of updated field data, especially concerning soil, because of the current security conditions of the area.

Most of the available data used for this study are related to the climatic, topographic and soil characteristics of the area. The study has been conducted in two phases: first, a climatic assessment has been carried out to exclude all those areas that are not suitable due to climatic constraints, such as low temperature and/or insufficient rainfall. Most of the north of the valley has been excluded by this preliminary analysis. Also, many sloping areas have been excluded, as the countermeasures to prevent soil erosion could be very expensive in this region, where the frequency of occurrence of heavy storms is high. Then, a land unit map has been prepared, by visual interpretation of satellite images at medium and high resolution, to identify homogenous portions of territory taking into account the different landforms, soils and types of land cover. This map was then the main GIS layer for all the evaluation models that have been used.

The results clearly show that, due to its peculiar location and climatic condition, a large part of the Swat Valley territory, mainly in the southern valleys, is highly suitable for the cultivation of the most common temperate fruit crops, such as pear, apple, apricot, plum and others (see Annex 1). The difference amongst the results of the suitability assessment for the different crops is in general very little, as their requirements are very similar. Hence, the decision about the production schemes should be based more on socio-economic parameters, such as the market demand for specific products or fruit varieties, the harvest calendar, the availability of skilled manpower, the transportation facilities to the processing plants, etc. All these aspects have not been covered by the present study.

However, using the existing information, a demonstrative study has been conducted to show how the use of a modern GIS system can support the decision makers with socio-economic information, such as logistic constraints. In the example, using the road network and the location

of the two fruit processing plants of Matta and Kabal, a simple model has been built to assess the average transportation costs for the neighbouring territory. This analysis shows clearly that the left bank of the Swat River is generally more disadvantaged than the right one (see Annex 5).

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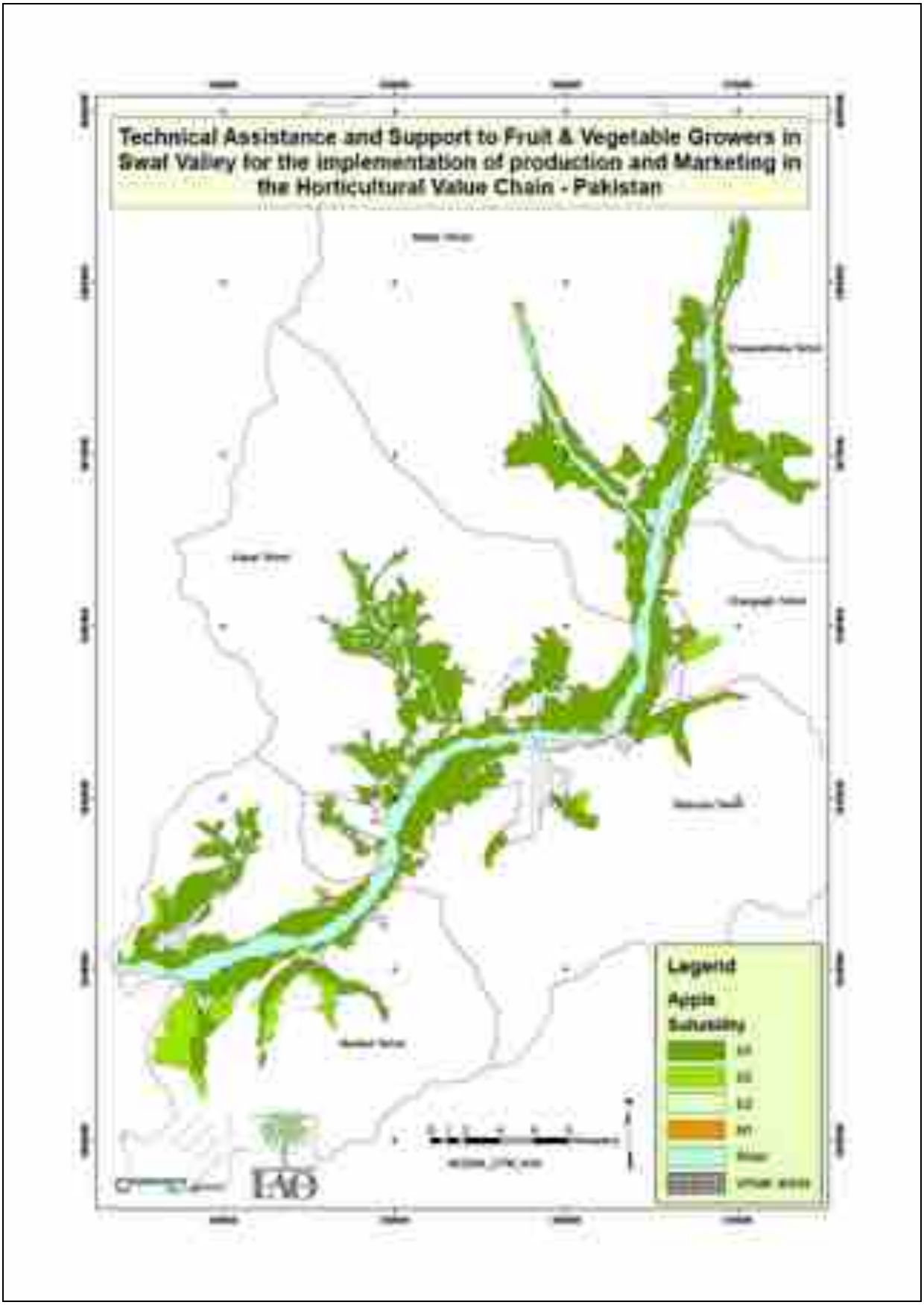
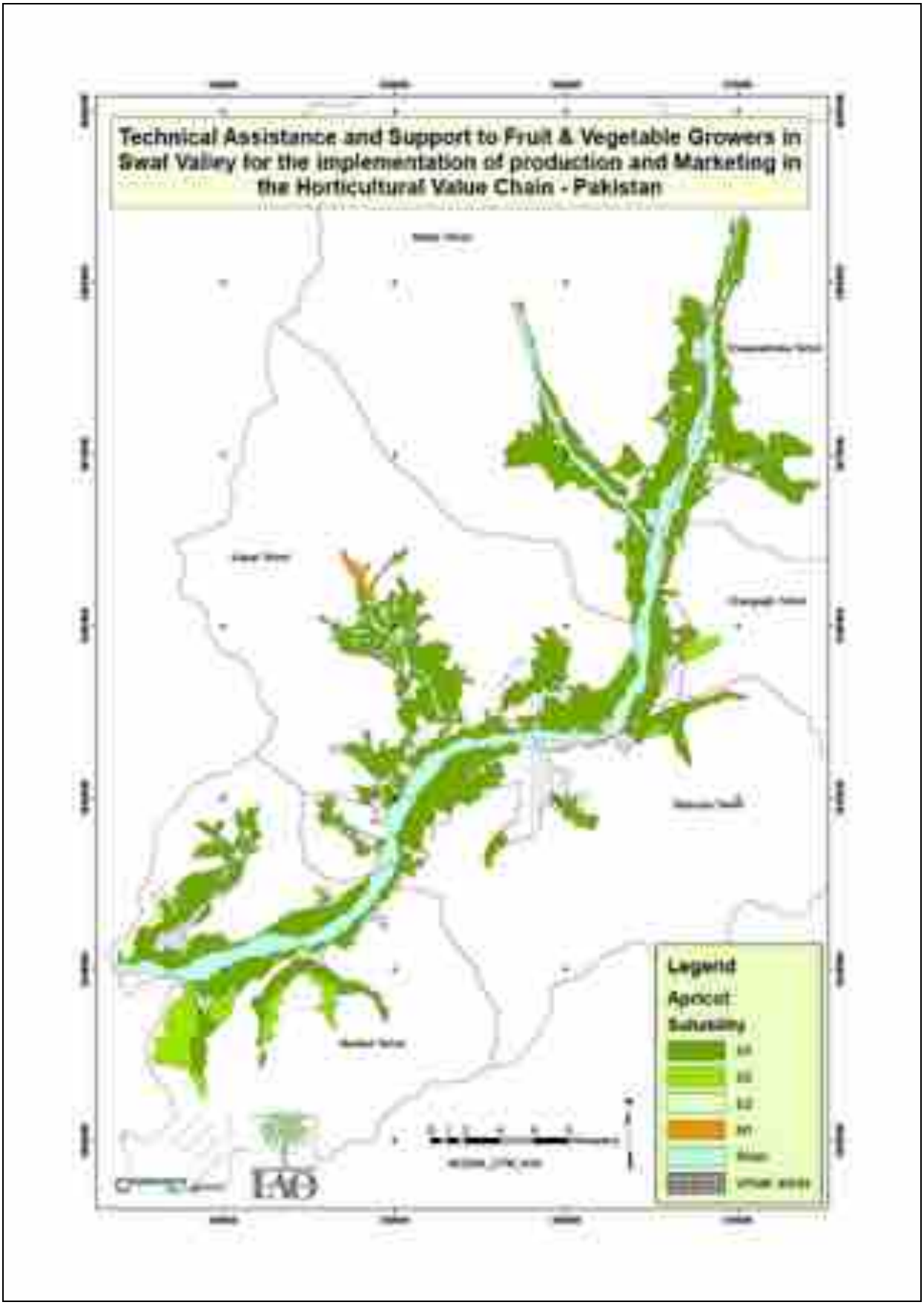
ANNEX 1 – Suitability maps

1. Apple



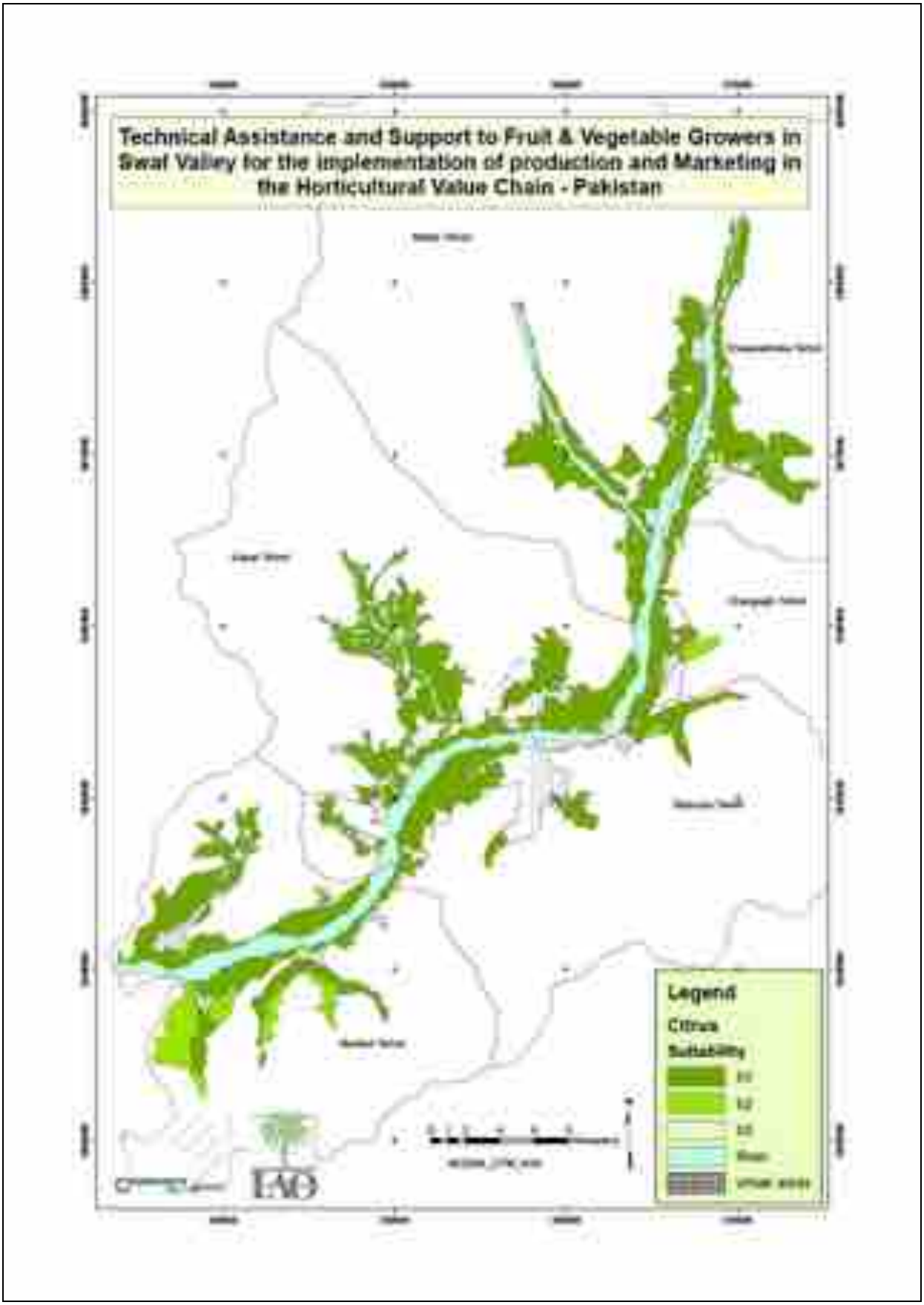
ANNEX 1 – Suitability maps

2. Apricot



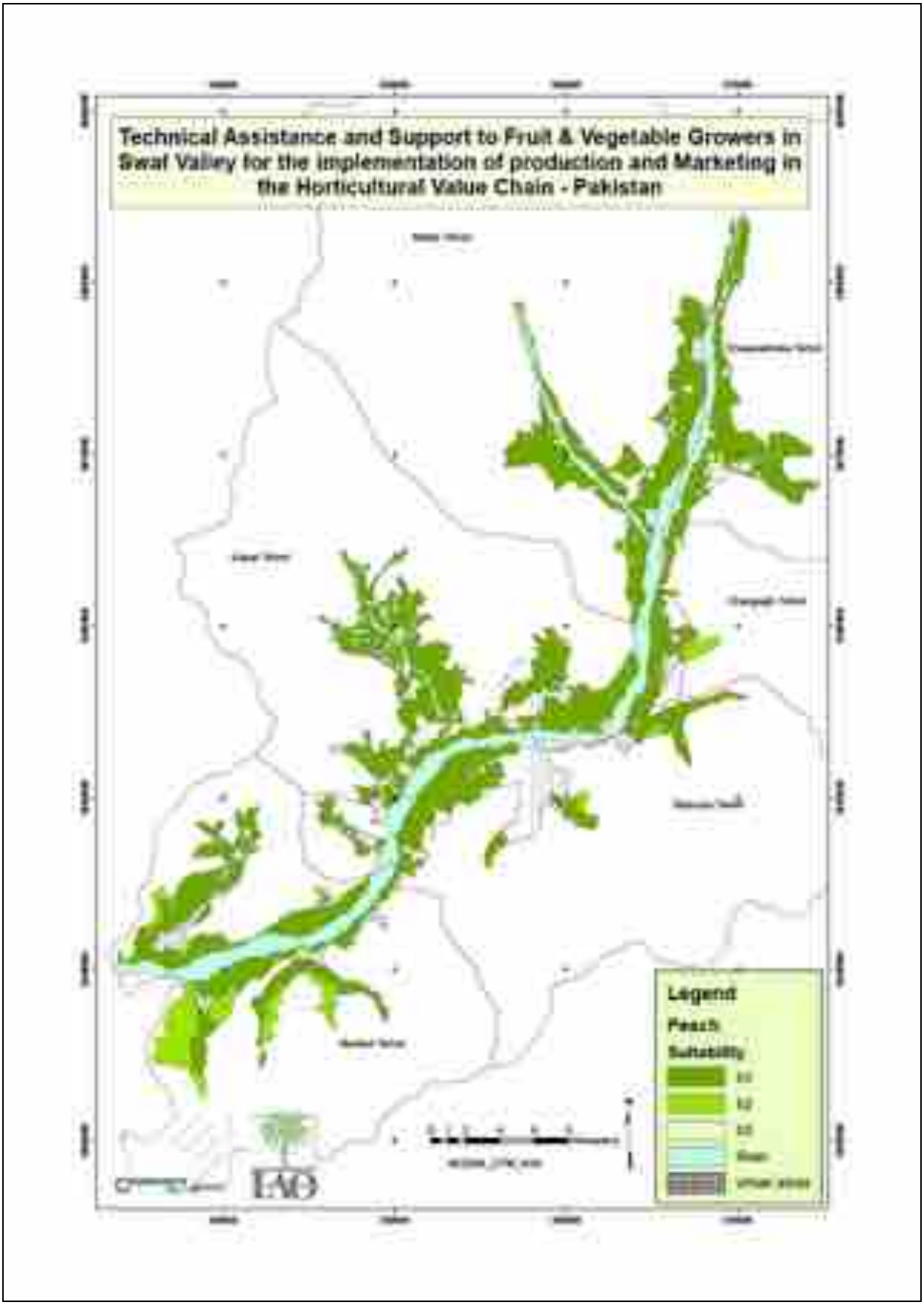
ANNEX 1 – Suitability maps

3. Citrus



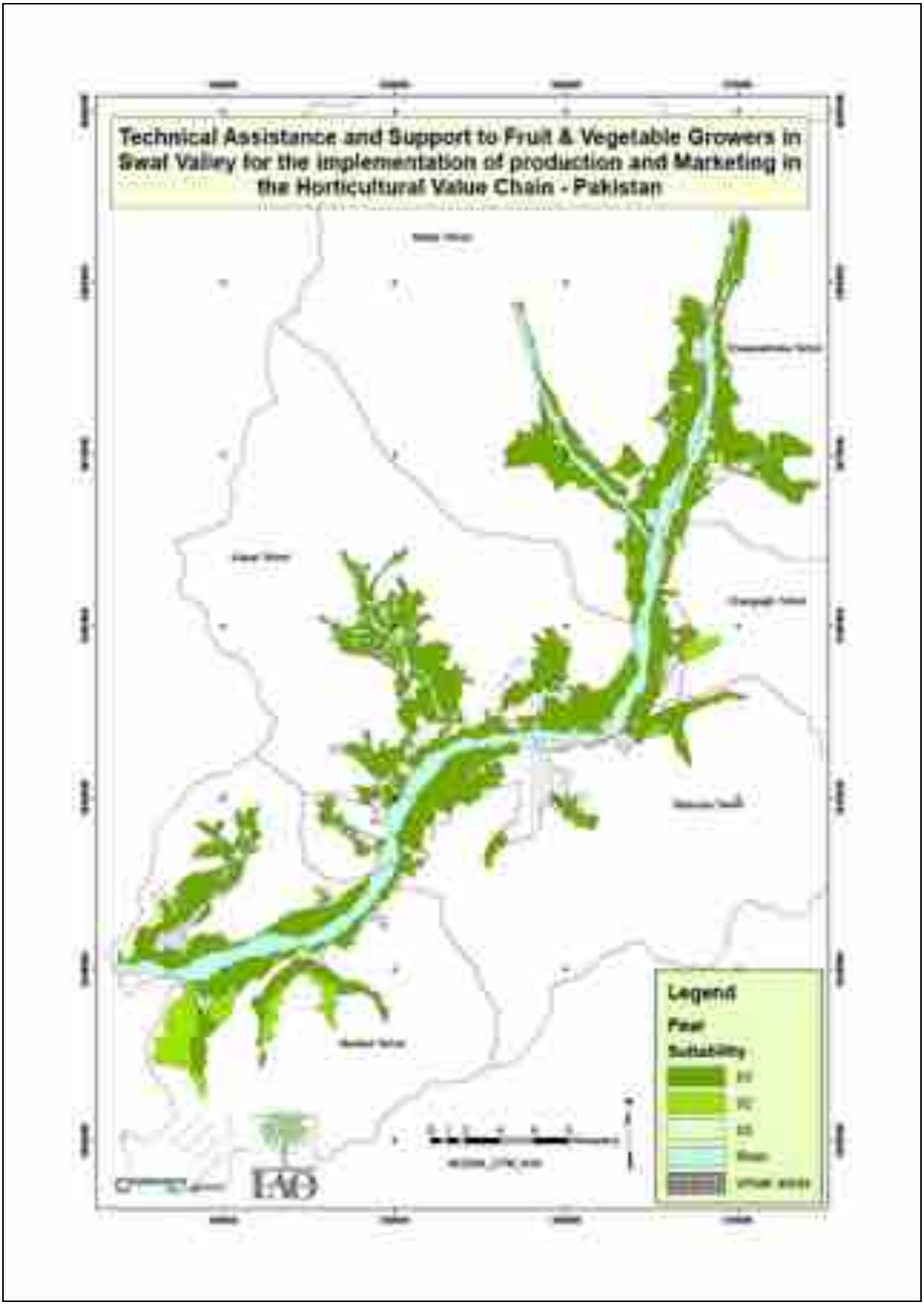
ANNEX 1 – Suitability maps

4. Peach



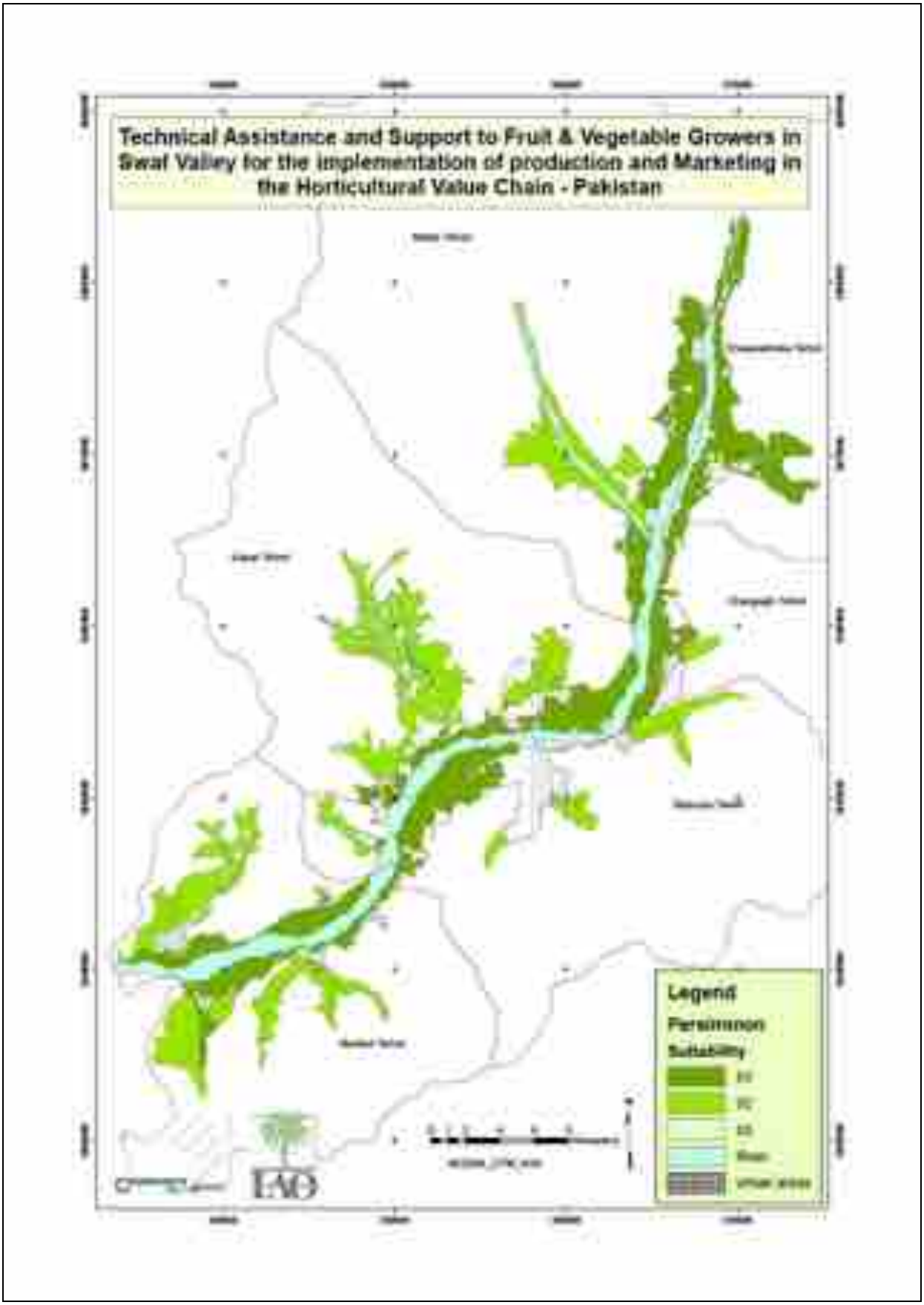
ANNEX 1 – Suitability maps

5. Pear



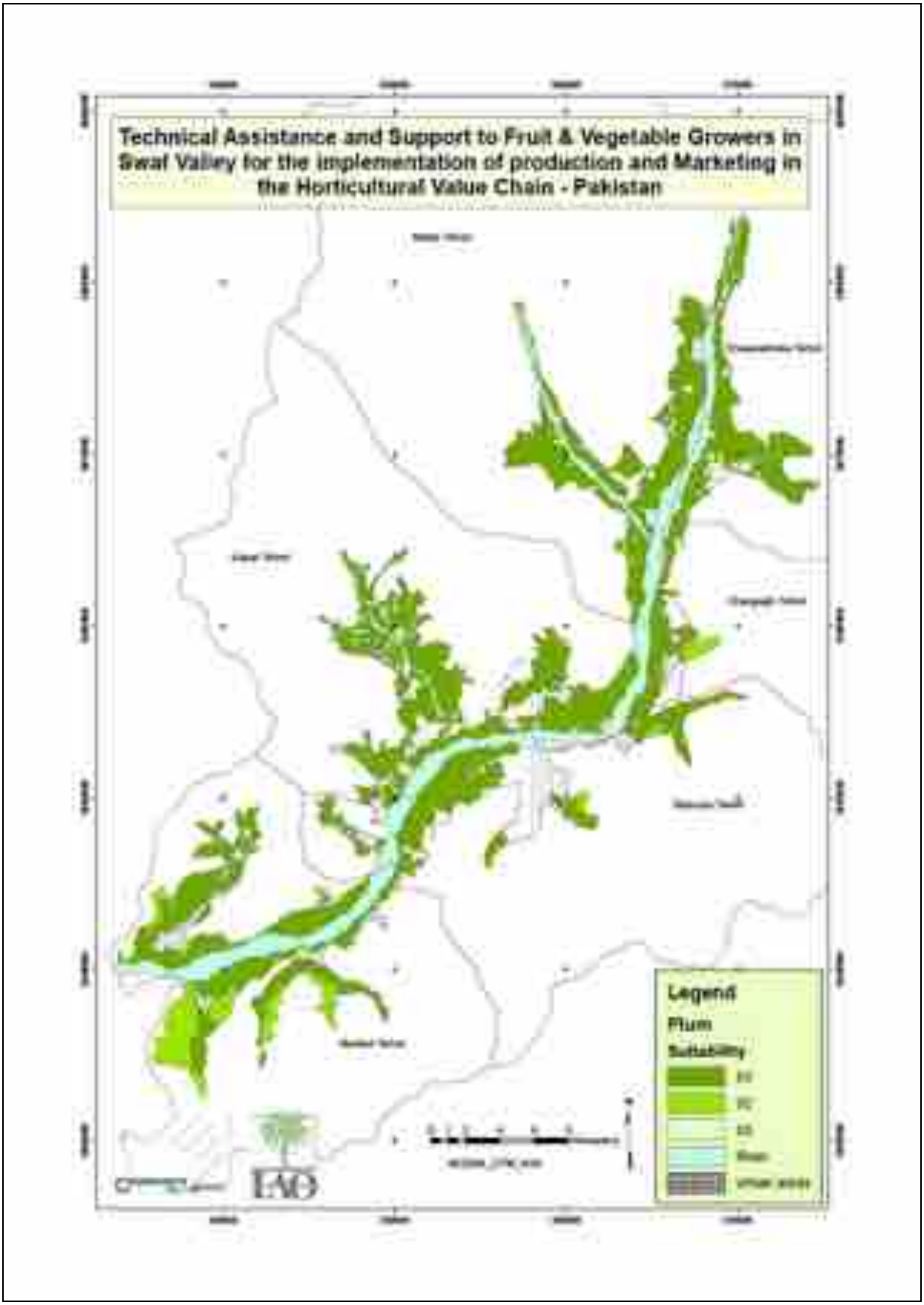
ANNEX 1 – Suitability maps

6. Persimmon



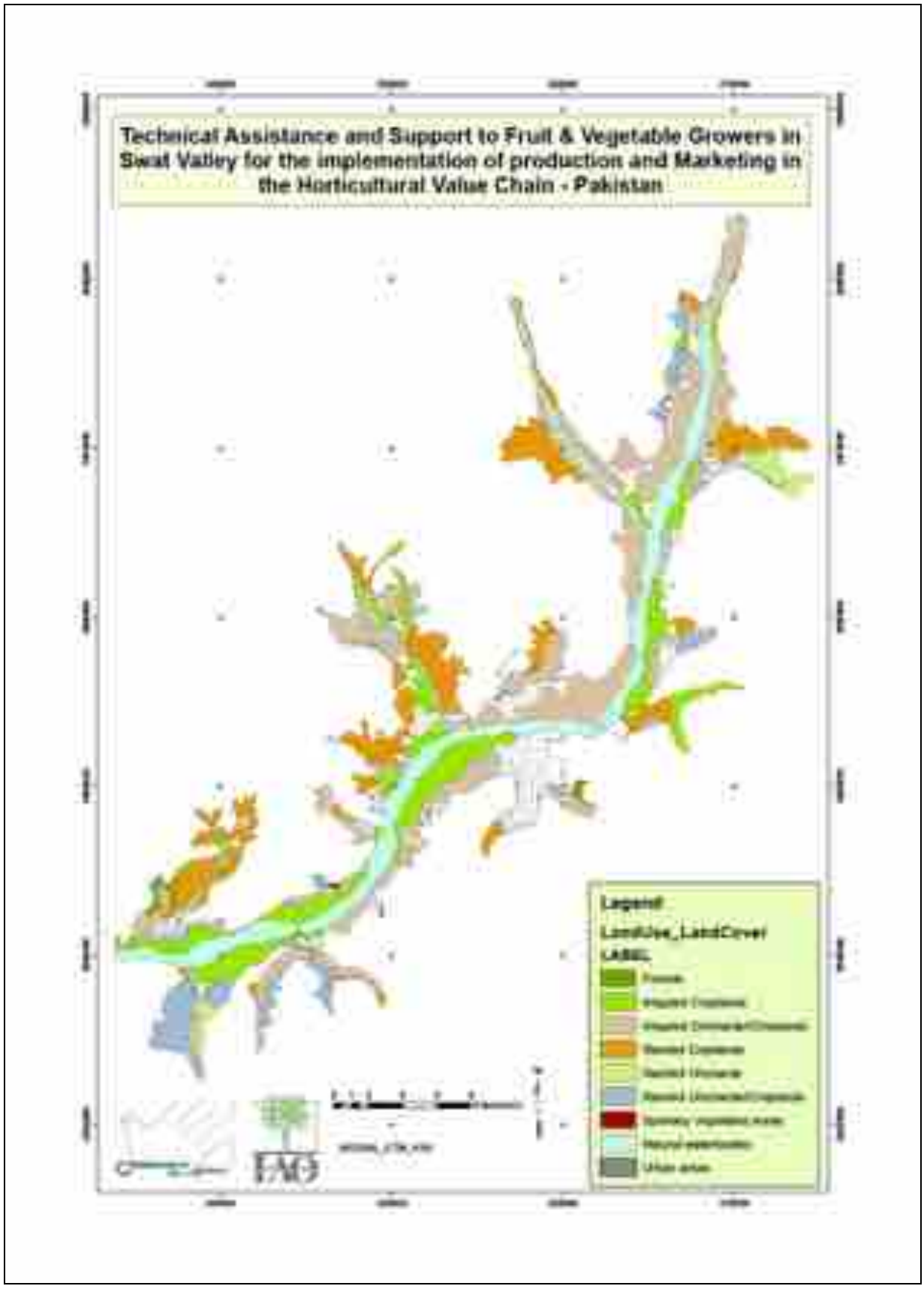
ANNEX 1 – Suitability maps

7. Plum

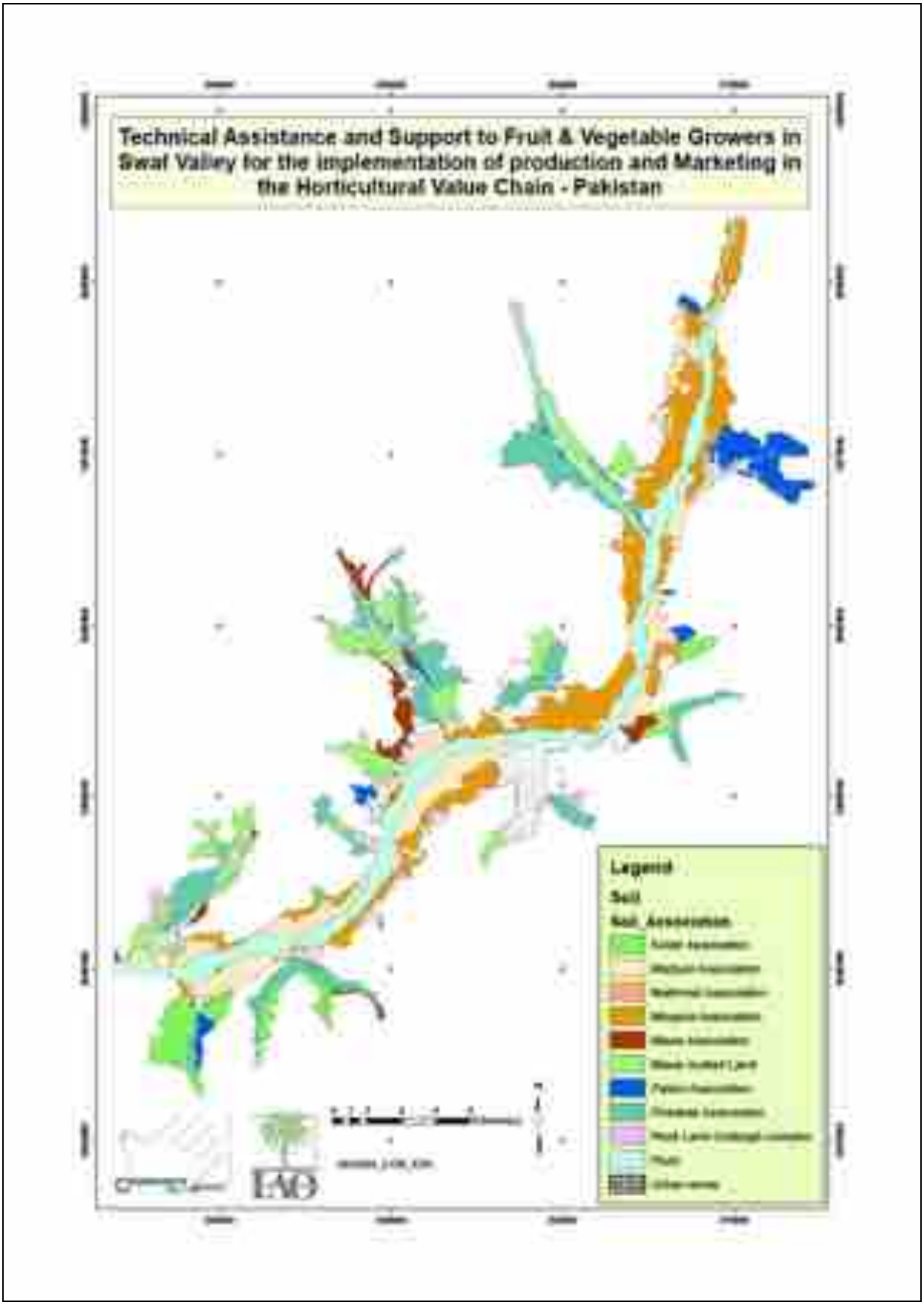


ANNEX 2 – Land unit map

ANNEX 3 – Land use - cover map



ANNEX 4 – Soil map



ANNEX 5 – Network analysis