SOIL EROSION AND SAND MOVEMENT IN THE SOUTHERN PART OF HUNGARY[1]

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INTRODUCTION

In Hungary there are wind-blown sand areas of considerable size. These occupy nearly 20 % of the total surface of the country. One of the largest areas covered by blown sand is situated in the southern part of Hungary, between the Danube and Tisza rivers, and is named the Danube-Tisza Interfluve. The area of this land is approximately 804.000 ha. As wind erosion and the sand movement diminish the safety of agricultural activity, the effect of these processes has been investigated by different methods since the beginning of the 20th century. J. CHOLNOKY achieved remarkable results in his investigation and produced a genetic classification of the relief forms of blown sand. In the thirties the investigation of blown sand regions was given a great impulse by the work of L. KÁDÁR. Since 1950, large scale research work has been carried out in the blown sand regions of Hungary. Valuable works considerably enriching the store of information on Hungarian sand blown territories have been published by Z. BORSY, B. BULLA, M. ERDÉLYI, F. FRANYÓ, L. GÓCZÁN, L. JAKUCS, L. KÁDÁR, S. MAROSI, I. MIHÁLTZ, B. MOLNÁR, M. PÉCSI, J. SÜMEGHY. Remote sensing methods, especially airborne photographs, were used by Z. BORSY (1975) and by L. JAKUCS (1988). This latter detailed examination and analysis is the base for our study, in which we would like to add some new and practical information to, especially for agricultural landowners. A LANDSAT TM image was used, which was recorded on 3rd August 1985.

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RESULTS

1.1. GEOMORPHOLOGICAL CHARACTERIZATION OF THE AREA

Because of the financial limitations of the Department of Physical Geography only one, old LANDSAT TM imagecould be used. With the help of this image it was not possible to give an excellent description of the sand movement in the investigated area. Therefore, the aim of this study was to localize both cultivated and uncultivated areas which are endangered by wind erosion. The basis of this study is the detailed knowledge about the geomorphological, agricultural and meteorological conditions of the investigated area. The test site is situated near Kiskunmajsa on the Danube-Tisza Interfluve, at the border of Csongrád County (Fig. 1).

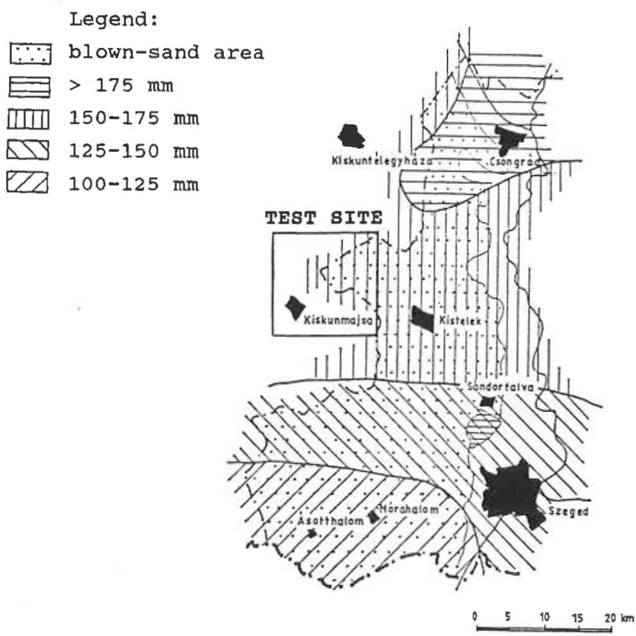


Figure 1 Location of the test site and the annual soil moisture deficit in Csongrád County (L. JAKUCS 1988.)

The sand covered areas of the county endangered by wind erosion can be investigated from the western border of the alluvial flood plain of the Tisza river. This area, which can be well characterized by geomorphological properties, is part of a homogeneous sand area on the Danube-Tisza Interfluve.

As shown in Fig. 2, the sand blown area of Csongrád County is the residue of the large alluvial fan of the Danube river, mainly formed during the Pleistocene, in spite of the fact that river sediments, either on the surface or in the near subsurface layers have not been found. The reason for this is the change in the river bed. The river left its enormous alluvial fan in the mid- Pleistocene and the bed shifted westward into the present Danube-valley with a N-S direction. In this way, the sand and sandy clay masses of the alluvial fan were eroded, transported and accumulated by wind from the last interglacial. Mainly in the Riss-Wurm interglacial and in the dry periods of Holocene, the wind transported and accumulated the loose river sediment of the alluvial fan and at the same time, it classified the sediment according to its grain size and mineral composition. In utilising airborne photographs (L. JAKUCS 1988) it may be suggested that the narrow, long straight NW-SE depressions are not the remnants of former branches of the river bed. According to the investigation of the borehole cores, the river sediment is lying at a deeper level under the surface. These valleys are so narrow (20-60 m) that they do not reach the lower limit of the width of the bed of the Danube river.

The thickness of the transported and accumulated blown sand ranges from 10 to 30 m in the western part of Csongrád County. The most characteristic landforms are windrifts, residual ridges, sand hills as well as sand dunes. From the airborne photographs, the long straight valleys can be studied especially well, as opposed to the accumulated positive sand blown landforms. In these valleys, which are parallel to the most characteristic wind direction (NW), there are small lakes or sometimes smaller streams. On the bottom of these valleys, silty-sodic sediments are being formed containing dolomite silt and clay (or limestone), which can be explained as a soluted and later precipitated sediment of the infiltrating groundwater. As a

Legend:

- fixed, loessilty sand
- semifixed blown sand
- unfixed blown sand (late holocene)
- caustic sludge sand, dolomitic silt
- loessy sand, infusive loess, loess silt
- sediment on flood plain
- lake
- stream, channel
- important bank
- inactive steep river-side
- active river-side
- narrow, shallow valley
- small sodic basins
- sand blown form
- elongated dune with thin loess cover
- dune on river-side
- windrift, residual ridges
- 52/D/a code of the used airborne photographs

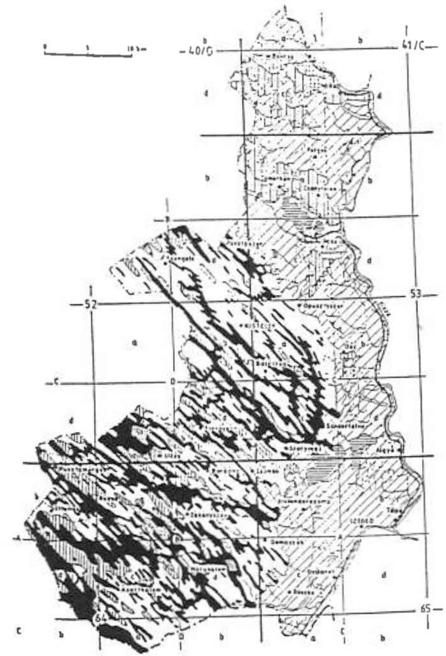


Figure 2 Geomorphologic map of Csongrád County based on airborne photographs (L. JAKUCS 1988)

result of strong acidic processes the most significant components are Na salts and Ca- and Mg-carbonates.

1.2. CLIMATICAL CONDITIONS OF THE WIND EROSION

1.2.1. PRECIPITATION

Precipitation is the basis for the development of groundwater. Consequently, sand movement (which occurs only on dry sand surfaces) is related to dry periods. According to the long term precipitation measurements (from 1901) it may be said that the whole area of the county can be characterized as a droughty land. The average annual precipitation for this area is lower than 550 mm . Typically, very strong droughts can form at the beginning of spring (as in 1993), in midsummer (as in 1992), at the end of summer as well as in the early months of autumn. The probability of the droughty periods is high in March, July, August, September and in October. The probability of 10 days or longer droughty period is 10 % in July and 13 % in August.

1.2.2. TEMPERATURE AND WIND

The investigated area has a continental climate and may be characterized as a sand steppe with a warm and hot summer. The average monthly mean temperature is higher than 22°C. There is a long warm Autumn, the daily mean temperature usually falling below 10°C after 25th October and the first autumnal frost occurs at the beginning of November. The properties of the autumnal period show a strong sub-mediterranean climatic effect.

In connection with the above mentioned facts, the values of the potential and the real evapotranspiration show significant differences so that the land has a high soil moisture deficit from May to September. The soil moisture deficit is 10 mm in May, 22 mm in June, but its average value reaches 47 mm in July and 48 mm in August. Consequently the soil surface totally dries up during this period, the grains of the upper sandy soils losing their water content which is necessary for bonding. In this way, wind erosion can remove, blow out, transfer and accumulate the sand.

In summer and after the growing season, the effect of the wind erosion depends only on the direction and on the velocity of the actual wind. The prevailing winds during the year are from the north-west and south east. However, the strongest winds blow from the NW and the strong winds (stronger than 5° on Beaufort Scale) occur from July to September (to coincide with the drought period with its associated strong a soil moisture deficit) with the greatest frequency (Fig. 3). Therefore we can say that wind erosion is closely connected with the activity of NW winds.

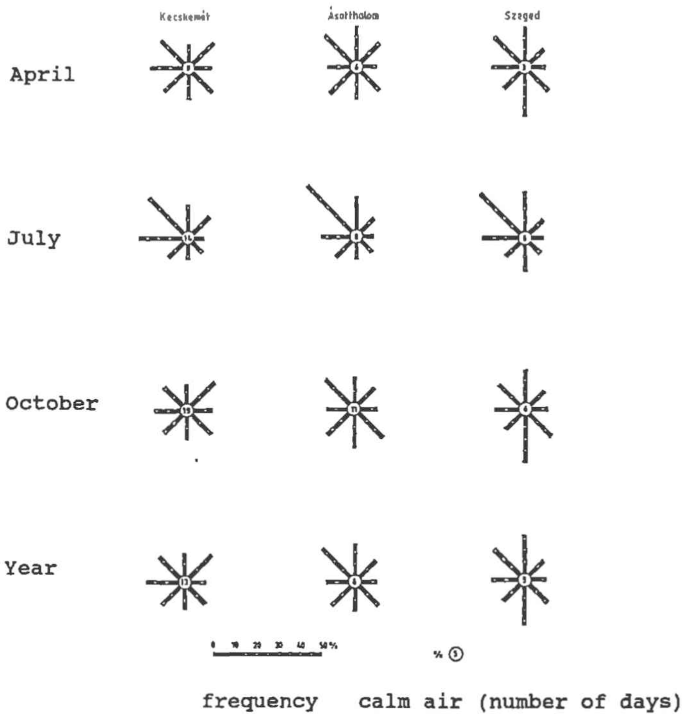


Figure 3 Direction of the most frequent winds in Csongrád County (L. JAKUCS 1988)

1.3. REMOTE SENSING METHOD

Because of the resolution of the LANDSAT TM (30 m), the smaller sandforms can not be investigated in greater detail. Therefore on the basis of the above mentioned geomorphological and climatological information, were the effects of wind erosion systematically looked for. The recording date is favourable for the examination because after the harvest of autumn wheat, on one part of the test area there is no plant cover. Due to the high temperature and low precipitation these large parcels of land lose their soil moisture content rapidly. On the neighbouring parcels, there are maize and sunflower fields and on these fields the effect of wind erosion is different.

A special area was chosen where the differences can be well characterized. This area is situated near Kiskunmajsa, eastward from the village (Fig. 1). The nearly square shaped area is surrounded by dry land (after the harvest of wheat and ploughing) on both the northern and eastern side. According to the NDVI (Fig. 4), it can be deduced that there are significant and sharp differences in plant cover. The northern neighbouring ploughed land borders the maize field along a 2 km long belt. This land is wide enough therefore for narrow wind channels to form along it. Unfortunately the ploughed land is very dry and hot. This can be seen on the thermal band image (TM Band 6) and by the image of Soil Wetness Index:

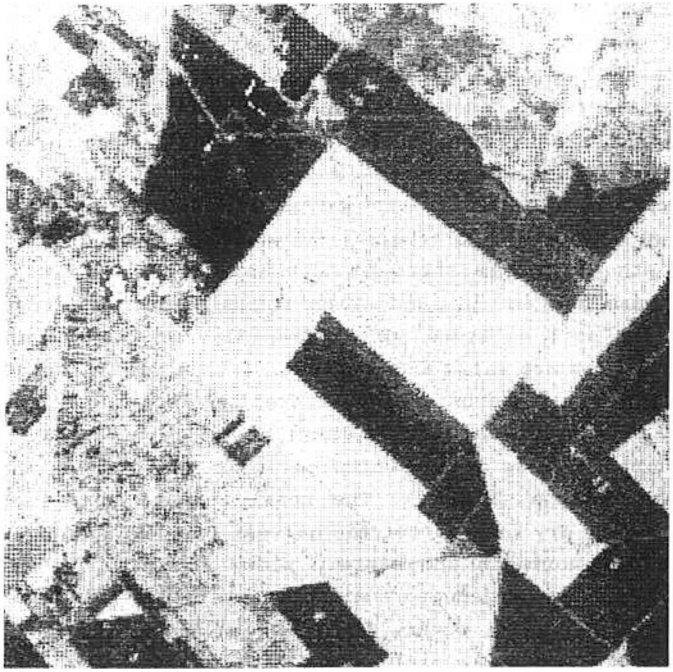
$$SWI = 0.3406(TM4)-0.7112(TM5)-0.4572(TM7)$$

BANNINGER 1986, CRIST 1983).

On the plant covered land, the effect of wind erosion can also be seen. According to the investigation of the LANDSAT TM bands and colour composite images it can be deduced that:

1. the accumulation of blown sand may be the reason for the different development of plants in maize fields. The accumulated sediment was removed from the dry plough lands.

2. Because of the sand movement and wind erosion caused by the early spring winds, plant growing was unequal at the beginning of the growing period. These long narrow strips can be seen in the maize field (Fig. 5).

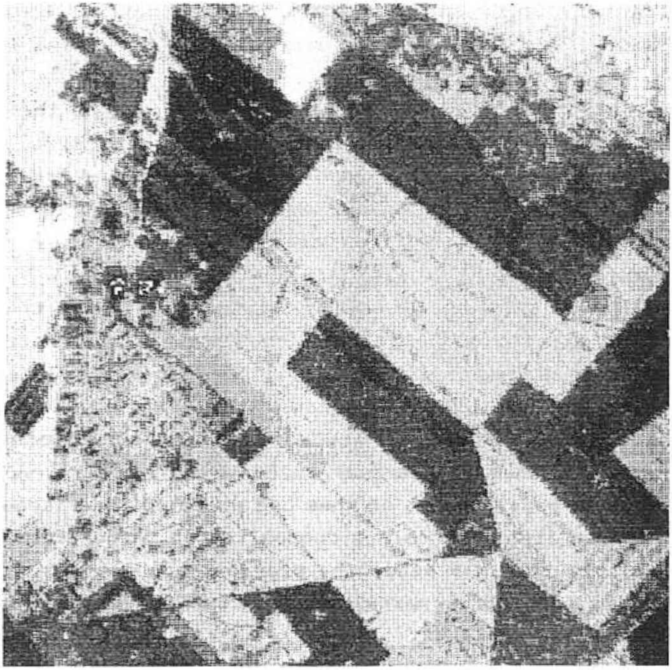


0 1 2 3 km

black = low vegetation index
grey = medium vegetation index
white = high vegetation index

NDVI ranges from 0.00 to 0.69

Figure 4 NDVI on the test site



0 1 2 3 km

black = low soil wetness index
grey = medium soil wetness index
white = high soil wetness index

Figure 5 Soil wetness index on the test site

3. A very important factor is that the direction of the parcel side is the same as the direction of the prevailing NW wind.

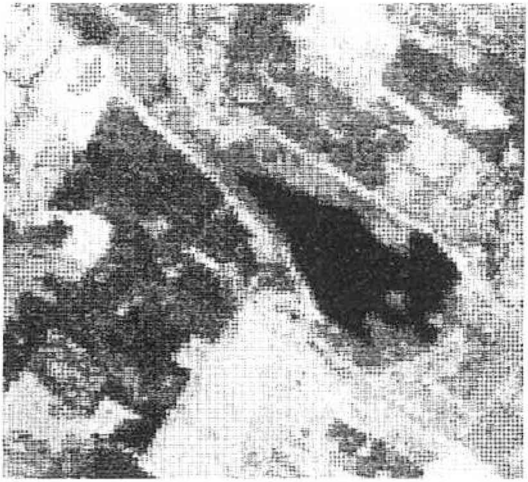
4. The effect of wind erosion is very strong on the narrow ploughed land which occurs within the maize field (Fig. 4). The NW wind from the northern ploughed land deposits its transported sand content in the maize fields (sand accumulation). This narrow ploughed land may be described as an artificial wind channel through which the wind accelerates again.

Proof for the previous effect of wind erosion is the shape and the distribution of the lakes on the Danube-Tisza Interfluve. In the deeper valleys, smaller or larger elongated lakes were formed from infiltrating groundwater and precipitation. Using airborne photographs L. JAKUCS (1988) investigated the distribution of these lakes and proved that they were once much bigger, but at present part of them had dried up. One larger lake can be seen on different colour composites or bands (for example in Fig. 6, LANDSAT TM 5 Band. The previous homogeneous lake has been divided into three parts and at present, the area between them is covered by plants.

CONCLUSION

With the help of LANDSAT TM bands, we can investigate the most important reasons for wind erosion, for example surface temperature (Band 6), the condition of vegetation (NDVI) and soil moisture (SWI). The larger accumulated and eroded resultant forms can be characterized on ploughed lands or on plant covered land according to the different level of plant development (especially on the monoculture land). There are sharp differences in the forms on ploughed land which is where erosion occurs and between the forms on plant covered land, which is where accumulation occurs. With a change in land use or after the growing season the places of erosion and accumulation may change. For example, the plant covered area may preserve the previous forms and effects of wind erosion in the different development of plants.

The effect of wind erosion which occurred during the growing season or during a longer period can be measured with the help



0 1 km

black = lake

Figure 6 Lake on the test site divided into three different parts due to the drought (LANDSAT TM 5 Band) of the above mentioned images and geographical methods. The investigation of this LANDSAT TM image forms the basis of a later project in which it will be compared with present conditions.

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