APPLYING COMPUTER SUPPORTED MEDIA IN LAND-USE MANAGEMENT FOR GETTING SUSTAINABILITY ON LOCAL LEVEL

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***Abstract**: The world we are living in at the present time offers people digital information readily accessible with just a click away. Modern technologies are used for exploring our planet, navigation or verifying geospatial positions. Users deal with digital images, but behind them there are mathematical models that can be employed to create and combine others. These mathematical models are the key to understanding and protecting the environment and by this to assure sustainability of our human society. Humanity has a vast amount of available data that can aid in achieving proper land utilization and sustainable land-use management. For the present paperwork, there were used digital photographs for interpretation with the aid of specific models, and analyzed and drawn conclusions. The focus lies on the Normalized Difference Vegetation Index (NDVI) from the visible and near-infrared spectrum. Through more detailed analyses, the quantity of color for each channel can be established and therefore the health status of the vegetation. Based on this information, the pollution degree of analyzed soil can be emphasized and finally land-use management strategies can be adopted to achieve sustainability on a local level.*

***Keywords:** land-use management; computer supported media; soil pollution; light reflection and health status of the vegetation; sustainability*

1. Introduction

From the beginning it is to be pointed out that assuring sustainability on a local level means among other aspects also efficient land-use planning and management, which relates to good soil quality because of the small pollution degree [1]. A proper land use planning, beside land administration and management, is a foremost condition for assuring an appropriate economic development thus human prosperity [2].

A proper land use planning, beside land administration and management, is a foremost condition for assuring an appropriate economic development thus human prosperity. This is becoming more relevant than ever in regard of assuring the sustainability of our human society on a regional level, where the needs of land property clarifications are sometimes shutting-down the efforts of shaping a sustainable region [2], [3]. Finally, the health status of the vegetation which grows on this soil is in a satisfactory range, which can be emphasized by different radiation spectra.

The spectrum of electromagnetic radiation is divided into several domains, from low to high frequencies, including radio radiation, microwaves, infrared radiation, visible light, ultraviolet radiation, X-rays, and gamma radiation. Electromagnetic radiation, depending on the frequency, can experience phenomena such as interference, reflection, refraction, diffraction and absorption. [4]

Light is a form of electromagnetic radiation perceptible to the human eye, situated between the infrared and ultraviolet spectrum, with wavelengths between 400 and 700nm. The primary properties of visible light include intensity, direction of propagation, frequency or wavelength spectrum, and polarization, and its speed in a vacuum of 299,792,458 meters per second is one of the fundamental constants of nature, being similar for all types of electromagnetic radiation. [5], [4]

The fact that we perceive plants as green is due to the main pigment involved in the process of photosynthesis, known as chlorophyll. Chlorophyll is the pigment responsible for absorbing light during photosynthesis, and it is more efficient at absorbing blue and red light from the solar spectrum. [6]

Healthy plants absorb light in the visible spectrum and actively reflect radiation in the near infrared (NIR) spectrum (Fig. 1). This behavior is due to the presence of chlorophyll in plants, which absorbs light in the visible spectrum and changes its reflectance level in the NIR spectrum. Solar energy is absorbed, reflected or remitted by vegetation, depending on the amount of chlorophyll. Terrestrial and aerial cameras, as well as cameras mounted on satellites collect information on the energy reflected or remitted by vegetation. [7]

Fig. 1. Light reflected by plants [8]

In case of healthy vegetation, chlorophyll absorbs almost all red and blue light in the visible spectrum and converts it into energy, while most of the NIR is reflected. In case of stressed vegetation, plants reflect more red and blue light from the visible spectrum, generating less energy, and less NIR is reflected. [7]

The radiation reflected as a wavelength function is referred to as the spectral signature of a surface. Vegetation exhibits a notably high reflectance in the near-infrared (NIR) range and a low reflectance in the visible red range. The spectral signature of green plants is particularly distinctive. Chlorophyll in a growing plant absorbs visible light, especially red light, for photosynthesis, while near-infrared light is efficiently reflected since it is not utilized by the plant. Active radiation in case of photosynthesis ranges between 400 and 700nm, whereas green leaves reflect NIR light between 700 and 1100nm. This reflective property helps plants to avoid excessive heating and minimize water loss through evaporation. Consequently, reflectance from vegetation in the NIR and visible ranges of the spectrum varies significantly. The extent of this variation indicates the proportion of an area covered by actively growing green leaves, known as the leaf area index. [9], [10]

The differentiation of surfaces according to light reflection is of great importance (Fig. 2) [11]:

- Important indicator in remote sensing work in agriculture: evaluating the amount of NIF light reflected compared to the red in the visible spectrum
- Differentiation of arid soil from that covered by vegetation or forests
- Identifies plants that are sick or affected by different pests
- Differentiation of harvests and harvest phases
- Efficiency

Fig. 2. Differentiation of surfaces according to light reflection [11]

2. Materials and Methods

Computer devices rely upon digital imaging software. Computer supported media refers to using media applications running on computers to integrate, assess, process and convert image data and extract useful information. Due to the technological advance in the field of computers and their increasing performance, media is now commonplace as users can obtain reliable information about objects or phenomena, for a better understanding of the world we are living in and the environment. [6]

The use of an Infrared (IR) camera presents a great advantage in terms of "seeing" in a larger light band, because of the receiving of more information about the surrounding world. From a physical point of view, "seeing" means intercepting and interpreting an electromagnetic wave. A photograph captures a band of wavelengths that materialize in color the light emitted from certain surfaces. There are satellites that collect multispectral data, but access to these images can be expensive and not available to everyone. An affordable alternative is to use a photo sensor to capture a longer wavelength with a lower frequency. Possible applications of using photo sensors could be monitoring the absorption or emission of light in the infrared spectrum. [6]

There are many applications where infrared photo sensors are used, including agriculture, forestry and environmental protection.

The Normalized Difference Vegetation Index (NDVI) is a graphical indicator that can be used in the analysis of remote sensing observations, often from a space platform, to evaluate the content of green vegetation within the studied area. Specifically, NDVI is a dimensionless indicator used to express plant health based on the reflection of light by plants, at different frequencies (some where they can be absorbed, while others are reflected – Fig. 3). [7], [6]

Fig. 3. Incident and reflected solar radiation [12]

NDVI is based on the normalized difference between the spectral information in the red and near-infrared bands of the electromagnetic spectrum. It is a measure of vegetation health, with higher values indicating greater coverage of healthy vegetation. [7], [6]

$$NDVI = \frac{(NIR - Red)}{(NIR + Red)}$$

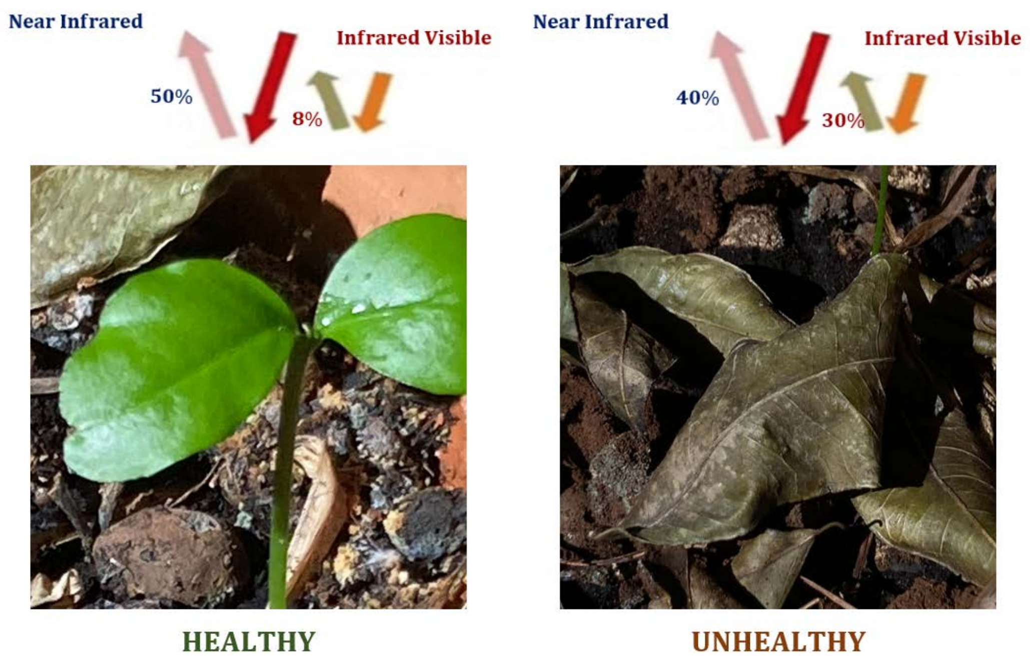

Fig. 4. Connection between solar radiation and vegetation health status

NDVI represents a ratio between data from different spectral bands and helps compensate the illumination differences for a singular image or for multiple images (due to moment of the day, season when the photos are taken etc.) – Table 1. Using NDVI, significant ecological changes in the vegetation layer can be identified. [11]

Table 1. NDVI values and their meaning [11]

NDVI Values	**Meaning**
	arid areas, bare soil, rocks, sand, snow
	water
	vegetation

Media applications such as Photoshop allow the analysis of NIR data in order to assess the vegetation health status, by measuring the amount of reflected NIR light compared to visible light.

The first stage in the analysis refers to the separation of the channels, by converting the image to RGB mode and using the channel mixer to isolate the NIR and red channels. To isolate the channels, it is necessary to duplicate the image, by creating two duplicate layers for the NIR and red channels, keeping one for the original image. Channel isolation consists of removing unwanted channels to separate the NIR and red channels on different layers. At this point, the NDVI values can be calculated by adding and subtracting the pixel values between the NIR and red layers (Fig. 5). [7], [13]

Fig. 5. NDVI values calculation

3. Results and Discussion

The infrared filter for the NIR camera is designed to completely transmit light in the range of 760nm - 860nm (infrared spectrum).

Infrared light begins in the high red area of the visible spectrum at approximately 750nm and passes beyond 1000nm, not being visible to the naked eye. Infrared photography offers very interesting, sometimes amazing and creative results, because the object in a scene reflects infrared light differently from normal light. This technique is often used both in engineering (for example to detect vegetation distribution and health – Fig. 6) and in other fields such as medicine or investigations and forensics. [6]

Fig. 6. Enhancing spectral data in a digital photograph

This way, details of the electromagnetic radiation can be observed (Fig. 7). In Infrared, organic elements emit light (healthy vegetation can be seen light in color), in contrast to inorganic elements.

Fig. 7. Details of the electromagnetic radiation – urban landscape

4. Conclusions

From presented methodology became obvious that for assuring minimum environmental impacts by low soil pollution an appropriate land use planning on a local and regional level is necessary to be considered. The advantages of a proper land use planning connected to land administration and management must be used by the local decision makers to finally take best decisions for assuring the most appropriate urban development.

Unlike the human eye, which can only perceive visible light, certain photo sensors are capable of detecting objects (including vegetation) that emit and absorb light in the infrared spectrum. This capability is particularly useful in analyzing two critical plant processes –

photosynthesis and transpiration – which influence how plants interact with near-infrared (NIR) light:

- Photosynthesis: During photosynthesis, plants absorb visible light and reflect a portion of NIR light. The amount of NIR reflected can reveal how effectively plants are utilizing light for photosynthesis, providing insights into their health and metabolic activity.
- Transpiration: Transpiration involves the evaporation of water from plants through their stomata. This process releases water vapor, which interacts with NIR light. By analyzing the NIR light absorbed by this vapor, it is possible to estimate the water lost through transpiration. Significant deviations in transpiration levels can signal water stress or other plant health issues.

Measuring the amount of NIR light reflected or absorbed by plants provides valuable insights into their health and physiological condition. This data can be used to monitor plant health, assess their water and nutrient requirements, and implement measures to optimize growth and development. It serves as a critical first step in evaluating, quantifying, and monitoring vegetation health.

In the context of climate change, repeated assessments of vegetation health are increasingly important. Such evaluations offer scientists essential data that can complement information from other environmental fields, supporting the development of adaptive strategies for environmental protection.

By integrating traditional land surveying techniques with modern technologies like remote sensing and photogrammetry, surveyors can create detailed topographic maps. These maps are vital tools for informed land use planning and vegetation management, ultimately contributing to sustainable development at the local level.

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