MANAGMENT OF RAINFED AREAS USING REMOTE SENSING TECHNOLOGY

GESTION DES ZONES PLUVIALES EN UTILISANT LA TECHNOLOGIE DE TELEDETECTION

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ABSTRACT

One of the basic requirements of every country's sustainable development is providing food security. Since about 1/3 of Iran's cultivated areas is under rain fed cultivation, appropriate management of rain fed areas assumes great importance in sustainable development and ensuring the required food supply. Limitation of resources, particularly of water, either from rainfall or from river flow and groundwater are the major constraints in pursuing the vocation of agriculture in a sustainable manner. Therefore, identifying areas for rainfed agriculture irrigated agriculture using the limited fresh water resources according to the land potential and taking into consideration the other factors, particularly the climate, should be of first priority with a view to attaining self-sufficiency in food production. So far, this task has been carried out unscientifically based on the existing methods in agricultural areas, however, now there is a need for revision using new techniques.

Key words: *Rainfed area management, Remote sensing, Nova 18 satellite, NVDI, VCI.*

RESUME ET CONCLUSIONS

L'un des éléments fondamentaux du développement durable de chaque pays est d'assurer la sécurité alimentaire. Depuis environ 1 / 3 des surfaces cultivées de l'Iran a consacré à la pluie culture nourris, ce type de culture a une grande importance dans le développement durable et l'approvisionnement alimentaire nécessaire et la gestion appropriée des zones pluviales sont des questions inévitables. Limiter les éléments de la production de produits agricoles comme les conditions climatiques et de l'eau et des ressources du sol ont plus d'effet sur la culture pluviale, donc de séparer les zones agricoles à des zones aptes à pluviale et d'irrigation et d'identifier le potentiel des zones climatiques »serait nécessaire. Jusqu'à

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présent, cette tâche a été effectuée non scientifique sur la base des méthodes existantes dans les zones agricoles, cependant, il ya maintenant un besoin de révision en utilisant de nouvelles techniques.

La technologie de la télédétection est l'une des techniques les plus importantes. Caractéristiques uniques des données de télédétection ont abouti à ses applications multiples comme un instrument approprié en matière d'observation, d'évaluation, de contrôle, de supervision et de gestion des ressources en eau et le sol et la végétation. Examen des terres agricoles et les zones cultivées à l'aide des données de télédétection et l'identification des zones aptes à l'agriculture feront appliquer une gestion optimale de l'agriculture possible. Ainsi, les données acquises à partir de photos satellite et les indices de dérivés sont considérés comme des outils permettant d'identifier le potentiel de la culture de la pluie domaines. Parmi les indices de dérivés de photos satellite, les indices contenant plus d'informations sur l'état de la végétation ont plus d'importance depuis la végétation a une relation étroite avec des conditions d'humidité du sol et la révision de son statut entraîne une méthode efficace dans l'identification et la séparation des domaines. Dans cet article, en utilisant l'indice état de la végétation dérivés à partir de photos satellite nova 18 ans dans l'année agricole 2008, les régions du pays ont été séparés pour les zones appropriées et inappropriées pour la culture de la pluie. En outre, la comparaison de la quantité d'eau consommée pour la production de blé de cette année avec la quantité d'eau renouvelable ont montré qu'environ 8% de renouvelables en eau est utilisée pour la production de blé à partir de laquelle seulement 1,5% est attribuée à la pluie de blé nourris. Par conséquent, en accordant une attention à la pluie la culture et l'augmentation de la production des zones de culture pluviale a une grande importance.

Mots clés : *Gestion des zones pluviales, télédétection, Satellite Nova 18, NVDI, VCI.*

(Traduction française telle que fournie par les auteurs)

1. INTRODUCTION

Our country, Iran, with the area of about 165 million hectares (Mha) climatically classified as mostly arid and semi-arid and has limited water resources. Iran's whole areas which is suitable for agriculture are 37 Mha of which, 18 Mha has been allocated to agriculture: 7.8 Mha to irrigated, 6 Mha to rain fed, and 4.5 Mha to fallow land use.

Iran's renewable water is 131 billion cubic meters (bcm) and the consumption is 97.4 bcm from which, 87.7 bcm (about 90%) is consumed in agriculture and the rest for drinking and industry sections. Of the 97.4 bcm of the country's drinking water need, 65 bcm is withdrawn from groundwater resources, i.e., wells, aqueducts, and springs. In other words, 68% to 70% of the country's water consumption comes from groundwater resources.

According to the definition of water crisis index by UN Commission on Sustainable Development Foundation, when the amount of water withdrawal by a country is above 40% of its total renewable water resources, the country is faced with severe water crisis. Since in Iran 74% of the total renewable water resources is used, at present therefore, we encounter extreme water crisis. In spite of this critical situation and severe water limitation, the productivity of water utilization in agriculture sector is very due to just about 32% efficiency of irrigation, which is the main water consumer. Where as in most countries which are similar to Iran from the climate, social and economic points of view, irrigation efficiency is higher. According to reports of FAO in 2000, irrigation efficiency in India has been about 54%, in Syria about 45%, and in Turkey 40%. The low efficiency of irrigation and the limitation of water resources has focused the attention to rain fed areas more than in the past. Figure 1 presents the situation of agricultural lands in Iran and it is seen that rain fed cultivation covers nearly one third of agricultural lands.

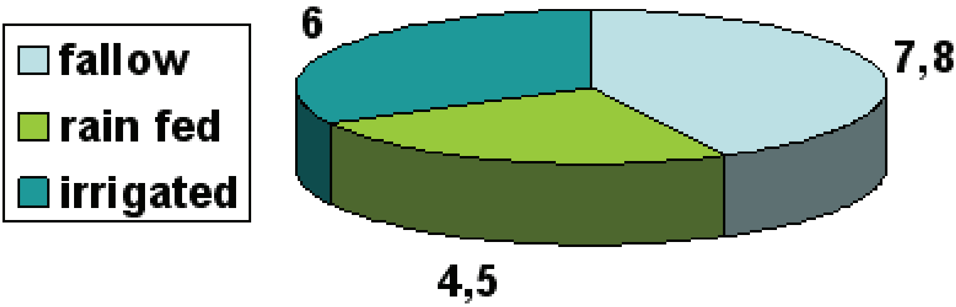

Fig. 1. Distribution of agricultural lands in Iran (Schéma de la forme de terres agricoles en Iran)

Due to its dependence on uncertain precipitation, rain fed cultivation is regarded as the most vulnerable agricultural endeavour. Concurrent factors such as climate, limitation in other water resources, finite land resources, growing demand for water from other sectors, etc., make agriculture in rainfed areas highly risk-prone. Considering these factors, appropriate management on these areas is important to enhance their yield potential. Thus, it is necessary to separate agricultural regions to areas fit for rain fed and irrigated cultivation based on climate and potential of the land.

Monitoring agricultural lands in terms of their vegetation status is useful to recognize regions fit for rain fed cultivation. Constant examination of vegetation status requires collecting the information of cultivated areas that is time consuming and expensive. Therefore, attention is to be given to the methods, which could provide information from vast areas easily and within a short time. The data obtained through satellite imageries satisfy this requirement.

The following issues related to agriculture can be studied by using satellite images:

- Examination of vegetation and its annual comparison for reviewing the amount of increase or decrease
- Recognition and distinction of plant species
- Calculation of the areas under cultivation of agricultural crops
- Identification of the regions which have been damaged by plant pests
- Identification of the lands which their use has changed from agriculture to other uses
- The trend of controlling saline lands

- To identify the lands apt for the cultivation of agricultural crops
- Recognition of irrigation and drainage trend in vast areas
- To control soil erosion
- To help optimal management of lands, to manage irrigation and drainage macro-plans
- To manage macro-projects of irrigation and evaluate their operation
- To examine the effects of climate change on agriculture section and regions' water

2. MATERIALS AND METHODS

For the purpose of examining vegetation status of lands, Nova 18 satellite images from April to August in 2008 (month-wise) have been used (Specifications given in Table 1).

Table 1. Specifications of the used images (Caractéristiques des images utilisées)

Row	AD year	Solar year	Passing time in GMT	Passing time in Iran	Days of a year
1	2008/4/24	1387/1/16	9:30	13:00	94
2	2008/5/5	1387/2/15	9:09	12:39	125
3	2008/5/25	1387/3/4	10:18	13:48	148
4	2008/7/8	1387/4/18	9:45	13:15	189
5	2008/8/3	1387/5/13	9:37	13:07	209

At first, the photos are processed and necessary corrections including radiometric, geometric, and atmospheric corrections are applied on them; then they are interpreted by using the relationship under satellite indexes. The software used in this phase is ENVI 4.7.

Satellite indexes are very efficient for monitoring agricultural lands and drought status in vast areas. From among satellite indexes, the indexes which obtain the information from vegetation status are more significant since vegetation has close relation with soils moisture condition and the examination of its status is an efficient method in monitoring drought.

3. SATELLITE INDEXES

3.1 Normal Difference Vegetation Index

Normal Difference Vegetation Index (NDVI) which is calculated by using relation (1) is the most common parameter for examining vegetation status. This index is determined by using bands 1 and 2 of evaluating Nova satellite AVHRR which states their reflection or albedo.

$$NDVI = \frac{\rho_2 - \rho_1}{\rho_2 + \rho_1} \qquad (1)$$

In this relation,

NDVI is Normal Difference Vegetation Index

ρ_2, ρ_1 are reflection of bands 1 and 2 evaluating AVHRR.

3.2 Vegetation Condition Index

Vegetation status is reviewed relative to a long-term statistical period by using Vegetation Condition Index (VCI) which is presented through relation 2. Since this index has a close relation with soils moisture condition, it indicates the regions with sufficient amount of water for agriculture and in other words, it shows the potential for rain fed cultivation.

$$VCI = \frac{100 \times (NDVI_i - NDVI_{\min})}{NDVI_{\max} - NDVI_{\min}} \qquad (2)$$

In relation (2),

VCI is Vegetation Condition Index

$NVDI_i$, the rate of Normal Difference Vegetation Index in each pixel of satellite photo

$NVDI_{min}$, the least rate of Normal Difference Vegetation Index in statistical period under consideration

$NVDI_{max}$, the most rate of Normal Difference Vegetation Index in statistical period under consideration

VCI less than 50 is indicator of arid and inappropriate regions for rain fed cultivation and VCI above 50 is fit lands for rain fed cultivation.

4. CONCLUSIONS AND DISCUSSION

Maps obtained by the determination of VCI from April to August 2008 have been presented in Figure 2. As it is shown in the figure, lands suitable for rain fed cultivation are limited to west part of Iran and lands of Kermanshah, Kurdistan, and Lorestan provinces and north of Fars province are more appropriate than other provinces.

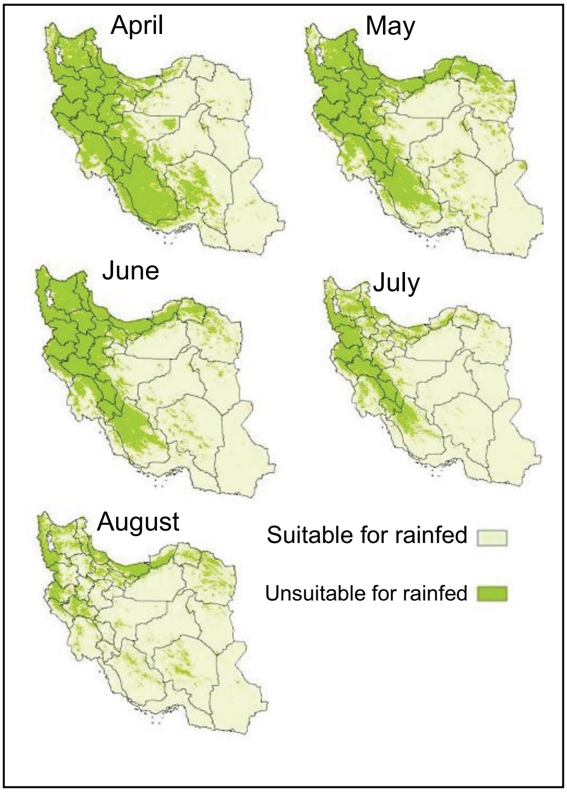

Fig. 2. Progeny of Vegetation Condition Index (Descendance de l'indice de la condition de vegetation)

Since cultivated area of most rain fed crops is devoted to wheat, the function of rain fed wheat has been reviewed. In agricultural year 2007-2008, the wheat production in the whole country was 7956648 tons from which 1456332.5 tons (18.3% of the whole crops) was from rainfed land. Considering the definition of virtual water (the amount of water that could be saved by not producing a given product), it is 1500 liters for each kilogram of wheat, 15,000 liters for each kilogram of meat, 125,000 liters for a ton of sugar, and 237,000 liters for each ton of steel. The water consumed for producing rain fed wheat in the agricultural year 2007-2008 was 2×10^{12} liters or 2 billion cubic meters; also, 9.7 billion cubic meters of water was consumed for the production of irrigated wheat. The comparison of the amount of consumed water for wheat production with the amount of renewable water in the country (131 billion cubic meters) shows that 8% of renewable water has been consumed for wheat production which is a considerable quantity.

Regarding the special climate conditions of the country and low possibility of increase in new water resources used for agriculture and the necessity of increasing agricultural production from limited resources, recognition and separation of areas fit for rain fed cultivation will lead to reform in the land allocated for irrigated and rainfed agriculture, which in turn will reduce the requirement of reservoir water for irrigation. It will also save water by 5% in the next 20 years.

Vegetation Condition Index has a close relation to soil moisture condition; thus, using this index to delineate lands suitable for irrigated and for rainfed agriculture will help I overall planning for the agricultural activities. This will go hand in hand with the long-term development strategies of the country's water resources, aiming to enhance exploitable surface water resources from 35% at present to 55% in next 20 years.

Also, another fundamental factor in determining efficient utilization of water for producing agricultural crops is water consumption efficiency index. This index is the indicator of the amount of production (operation) for each unit of water consumed, which is very low in Iran in comparison with other countries. According to the research, the medium water consumption efficiency of agricultural crops in Kerman, Hamadan, Moghan, Golestan, and Khuzestan is 1.2 kg/m^3 of water for irrigated lands, that is very low. Using appropriate scientific and technical methods for increasing agricultural water consumption efficiency is very important.

5. SUGGESTIONS

The results of this study can be used in compilation and performance of appropriate operational programs for creating the balance between water resources and consumption especially in ground waters with negative balance and applying the management of drought and flood, compatible with climate condition in line with policies of consumption model reform. The results of analysis on remote sensing data show agricultural lands' need to irrigation operation and in other words, the existence of water transmission and distribution system. Therefore, remote sensing technology would be really efficient in irrigation and drainage networks management and soil moisture status analysis. At the end, it is suggested that for achieving more accuracy in calculating satellite indexes, photos with more separating ability be used in local studies so that separation of apt areas for rain fed cultivation can be carried out with the most confidence.

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