A review: monitoring of rice production by using applications of remote sensing

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Abstract. Rice is the most significant main food for above three billion people all over the world. Rice paddy lands numerated almost 11.5% of the World’s cultivable field region. Thus, using rice region mapping and forecasting is so essential for food security, where requests mostly invade production. One of the monitoring applications is remote sensing, which is the science of hiving information regarding the earth's surface without physical contact, is becoming progressively significant in majority of strands these days. Newly, rice monitoring applications are detecting by various methods via remote sensing. Surveys about satellite images have displayed that rice lands crop several brightness forms at various plant development phases, permitting lands to be categorized. Howsoever, there is a demand for major survey into realization the interplays amongst electromagnetic waves and rice lands via the expansion of a methodical sample. This study explains extension theoretical patterns that able to inspect with field measurements to provide accurate explanation of remote sensing data and rice development monitoring by using the revolve detection manner. Not a lot is known concerning how electromagnetic waves interact rice lands and how rice crops distribute waves back to the satellite. Although rice lands able to be divided using the backscattering extent and also the rice development can be monitored, a plenary research of the theoretical scattering method is desperate to avouch accurate application of remote sensing data. This paper begins to peruse the communication amongst microwave backscatter signatures and rice development and to monitor rice development by using satellite images. At the end, it is used to results by using multi-temporal RADARSAT imagery have authenticated that the backscatter can make a good segregation for rice planting phases.

1. Introduction

From the past to the present, human existences have been using the five senses such as sight, smell, sound, taste and touch to comprehend the world. Howbeit, massive progress in science and technology have permit to learn much more than five senses could ever tell concerning the world, via the expansion of various tools and techniques. One of the key technologies that has extremely improved perception and understanding of the world in which human live in is remote sensing. Remote sensing is the science of exploration information about the earth's surface by discovering and measuring the radiation, particles and fields joined with it (Salviet al., 2003).

Generally, remote sensing can be divided into two groups: passive sensing and active sensing. Passive remote sensing figures out electromagnetic waves from the sun that have been reflected off the surface of the earth whilst active remote sensing hires a radar system, usually took away on an airplane.
or a satellite which transmits electromagnetic waves at the object and analyzes waves that are reflected back to the radar. The process in which the electromagnetic waves from the radar interact with the earth's surface and are transmitted in all routes is called scattering. The scattered waves that trip back to the antenna in the backscattering process are called the backscattered waves (Chen and Zebker, 2000). The time lag between transmitting the beat of electromagnetic radiation and recording the returned signal after it has been scattered back from a scatterer let the distance of the scatterer and the radar system to be calculated [1]. These backscattering returns measured by the radar are also impressed by the objects and therefore have information on the objects (A.B. Saiful, 2004).

The returns can be changed into an image from which lot of information about the objects can be insulated. Remote sensing applications too widely, and are used in regions such as military strategic planning, weather forecasting, fossil fuel exploration, urban scheming, natural disaster monitoring and even in off-world explorations of other asteroids. However, this study is centralized on continuous survey in Malaysia for the application of remote sensing in monitoring rice crops in Malaysia. In Malaysia, the same as most Asian countries, where rice is the main food, and the manufacture of rice has become a great part of the economy. Notwithstanding the great worldwide cultivated rice region and developing rice crop in plenty of countries, the complete requests mostly invade the yield. Moreover, the worldwide rice utilization is planned to be~873 million tones in 2030 (Berardino et al. (2002)).

A tender balance stands amongst the manufacture of rice and the needs of users. This is acute that rice resources can be extends to hold an ever more growing world population (Berrettiet al. (2001)). There is hence a need for an impressive means by which rice manufacture can be scouted as well as forestalled with advisable precision, validity and cost effectiveness. Here is a rising quantity of cosmopolitan benefit in the zone of performing space-borne radars and sensors in the remote sensing of rice lands in wish that it will change common field -by using monitoring systems. As regards, rice yields are chiefly civilized in tropical weather where rain is heavy and cloudiness is aggregate all over the year. Thus, the basic compression of such survey operations is in utilization of microwave remote sensing, whereas microwaves may transude via clouds and has every climate abilities (Berardino et al. (2002)).

The use of Synthetic Aperture Radar in differentiation between various agronomical product types is represented in different researches [2-4]. The precision of grouping belongs to the delicacy of the used backscattering ratios to the diversities of the biomorphological construction of the vegetables, so to the several interplay conduct among electromagnetic wave and construction of canopy [5]. Multi temporal lone modulation, lone polarization data collected with successive skyways able to amend the precision as they are impressed by the queer changes induced in backscattering by the development term of a given vegetable[6-8].

Premier researches [6-9] manipulated on microwave satellite images of rice lands have bared that rice lands including rice crops of changing ages will produce differing types on the images, as shown in Figure 1. These researches have shown that as the rice crops flourish, the rice lands will show up as brighter and brighter splotches on the image because of an increase in the severity of the backscattered waves (Berrettiet al. (2001)).

One way of expressing the severity of the backscattered waves is the backscattering ratio. A higher backscattering ratio will indicate a higher severity of the backscattered waves. Figure 2 displays the collation results of the age of the rice crops for rice land in Sungai Burung, Selangor with its comparable backscattering ratio. As the rice products flourish, the backscattering ratio will gain till it attains its maximum whenever rice crops are approximately 60 to 100 days old, belonging to the rice crop diversity. After that, it begins to reduce slowly till the crops are harvested. By using this information, the age of the rice crops of each rice land can be distinguished from satellite images, so the aforesaid studies have tried to use these data to classify the rice lands based on their age and growth step. Therefore, these primary researches have shown that remote sensing data can be used in monitoring of rice crops.
researches [10] have shown that such data can even be used for turnover prediction objects so that the total revenue of rice lands in a particular area can be estimated [8].

Though a significant extent of survey is performed in the application of satellite images for grouping and monitoring of rice production, little is known about the factual interplays of electromagnetic waves with rice hovels. To be able to better known such interactions, methodical models that can help to describe how electromagnetic waves are scattered off rice crops need to be expanded [10]. Of course, suchlike models must be accredited by measurement data.

These methodical models will avouch an accurate discerning and application of remote sensing data also cater a remedy from which physical parameters of rice hovels able to be regained from radar data via inversion algorithms. Furthermore, the research of such models will demonstrate to be necessary in future absorbency of radar images for rice yield monitoring.

The aims of this research are to peruse the communication among microwave backscatter signatures and rice development and to do rice growth monitoring using satellite images (Berardino et al., 2002).

This review paper states that, the introduction consists of brief description of rice vegetable morphology and rice tillage workouts in Malaysia. Then defines the extension of a scientific model that make to better understand the scattering phenomenon captive in the remote sensing of rice lands. Finally, the common manners in which satellite images are processed and rice lands are sorted are described.

![Figure 1. A Microwave Remote Sensing Image Acquired on the 20th of September, 2004, Showing Rice Lands at Sungai Burung, Selangor, (A.B. Saiful, 2000)](image)

2. Remote sensing in rice-based agriculture
To know the base of physiology of rice is significant to use the remote sensing applications and success in rice relay on agronomical systems.
Figure 2: Plot of backscattering coefficient vs. Plant Age for Rice Lands in Sungai Burung.

The information able to show a serious pattern for planning phases of a remote sensing project as well as in the final phases of analysis. The amplifying revolution of rice may be divided into two phases by regard to the maximum corrosion of remote sensing data: herbal and gamic.

Herbal phase consists of the part of the development revolution where the vegetable develops and grows beginning after seeding and finishing since herbs begin to increase. This phase is defined with a stable rise in vegetable height and biomass. The increasing phase begins whenever the herb pauses developing longer and finally after puberty and consists of panicle and grain extension (Ribbes and Toan, 1999). This can be advantageous several times to further gap the reproductive phase into two groups: Gamic pre-heading and gamic post heading. Gamic pre-heading means interval from panicle primordia initiation to heading and post-heading relates to interval relay on heading to puberty.

RADARSAT satellite works at a modulation of 5.3 GHz and uses HH polarized waves, it means that the radar conveys also receives waves that have electric lands that are horizontally oriented. RADARSAT works in several manners, each with a various image resolution.

From methodical study, the angle selected was fit as larger angle would reason more attenuation to the wave as it passes via the crop layer and smaller angle would cater shorter route for the wave to interact with the rice crops.

The satellite crosses with the same precise spot point every 24 days, therefore the images were taken on 4 detach opportunities with 24 day timeouts” August 27, September 20, October 14 and November 6 of 2004, which hurled by 4 land travels (Lanari et al., 2004).

Tow fundamental unities of remote-sensing based rice crop estimation system: (1) Maps cape-rice, and (2) ORYZA2000 (Diagram. 1). Maps cape-rice is connector from satellite seated perception data into SAR crops includes as rice region approximates begin of season (SOS), phonological farm location, and leaf area index (LAI). System can adapt SAR crops, to wit LAI and SOS into ORYZA2000 until produce crop approximates. Joint with rice region crop, the approximated crop then may be transformed into production approximates for chosen geographical region.
Diagram 1. Rice crop and manufacture approximation system requiring MAPS cap-Rice for SAR crops production and ORYZA 2000 version planned to join with remote sensing crops. (Bouman B.A.M. et al. 2001. ORYZA2000)

3. Development of a theoretical model
Scattering models can commonly be categorized into two basic groups: surface scattering models, in which scattering happens between the boundaries of two media (Figure 3) and volume scattering models, in which scattering happens along of the in homogeneities in the average (Figure 4).

Primary, widely used surface scattering sample is the Kirchhoff sample [11] which is suitable to surfaces where the medium horizontal girth is large compared to the wavelength of the electromagnetic wave. Thus, the electromagnetic waves trespassing on a local region are supposed to be reflecting off a tipped infinite glace plane.

However, when the medium horizontal girth of the surface is shorter than the wavelength of the electromagnetic waves, the small disturbance model [12] is used.

On the other side, mass scattering and can be modeled using two various approaches. One of them is to use the wave method [13] which is relying on Maxwell's wave equations. This approach first assumes that the inhomogeneous average is homogenous with a mean permittivity (that is an intrinsic exclusivity of the average). An undulating permittivity is thereby added to the formulation to take into account the inhomogeneities, hence producing an ongoing random average model.

This pattern, howsoever, it has a majority of formulation and calculation.
The other approach is not as intricate as the wave method and is named the intensity approach [13]. In this approach, the glittering transfer opinion [14] is wont to explain the alteration in severity of electromagnetic waves because of scattering and imbitions as it trips via an inhomogeneous average. The lower average is modeled as a history host average implanted with distinct scatters that have senses and dispensation explained with statistical functions.

The interactions between the electromagnetic waves and the average are explained with phase matrices that are combined into the glittering transfer equations.

The glittering transfer equation is specified by:
\[
\cos \theta \frac{dt}{dz} = -k e I + \int P I d\Omega
\]  

(1)

To describe it, \( I \) is stokes vector explains severity of wave, whenever \( k e \) and \( P \) are overthrow matrix and phase matrix of average, severally.

Scattering and imbibitions losses of gravity along diffusion orientation are derived into account with overthrow matrix. Depending on scattered severities, the phase matrix \( P \), to event severities on module mass of scatters [9].

After resolving for severity of backscattered waves in glittering shift equation, also backscattering ratio can be captured applying this equation:

\[
\sigma_{pq} = \frac{4\pi \cos \theta_s I_{ip}}{I_{iq}}
\]

Wherever \( p \) and \( q \) show event and backscattered polarizations severally and may be \( v \) or \( h \). \( \theta_s \) is angle of scattered land by honor to simple of average. \( I_{sp} \) is severity of the backscattered waves, whenever \( I_{iq} \) is the severity of incident wave.

Conventionally, models that use the severity approach is supported the presumptions that the divide scatters are autonomous of one another and that their factors are incoherent. It means that the waves that are scattered off a scatter do not affect waves that are scattered off another scatter.

This keeps right for media which have scatters that are thin and outlying from one another. Howsoever, based on an electrically thick average, wherever medium distance among scatters is shorter than wavelength of electromagnetic wave, these presumptions are any more precise since waves scattered from any scatter will interact by waves scattered from scatters. Besides, scatters are within the near land of one another. Hence, the near land agents need to be taken into account, as conflicted to contractual models where only the far field agents are considered.

One of the techniques used to develop the glittering transfer outlook to infold thick media is named the thick medium pause and domain correction outlook (DM-PACT) [15]. In a primary research [16], it has already been displayed that domain corrections need to be done on the phase matrices of thick media to take into account the near land agents of the scattered lands. The DM-PACT near employs antenna lineup method to make formulate a phase correction period to take into account clinging effects of the scatters, furthermore the domain corrections.

Table 1 represent the various changes in the model applied for the various development phases of the rice crops corresponding to its age and also date of RADARSAT image possession. This theory is wont to specific model the phase matrix of media by orbicular scatters includes snow and ice [17]. The DM-PACT besides is extended to enfold media by cylindrical, disk-shaped and needle-shaped scatters [18] therefore it may be wont to formulate phase matrix of media by non-orbicular scatters such as forests [19].
Table 1. Using Various Models for the Various Development Phases of Rice Vegetables Corresponding to Herb Age and Date of RADARSAT Image Attainment

| Date       | Test Field | Age (days) | Growth Stage     | Model       | Scatterers               |
|------------|------------|------------|------------------|-------------|--------------------------|
| 20/09/2004 | 1          | 27         | Early vegetative | Single layer| needless                 |
|            | 4          | 26         | Early vegetative | Single layer| needless                 |
|            | 5          | 29         | Early vegetative | Single layer| needless                 |
|            | 6          | 21         | Early vegetative | Single layer| needless                 |
| 14/10/2004 | 1          | 51         | Late vegetative  | Double layer| needless, stem cylinders|
|            | 4          | 50         | Late vegetative  | Double layer| needless, stem cylinders|
|            | 5          | 53         | Late vegetative  | Double layer| needless, stem cylinders|
|            | 6          | 45         | Late vegetative  | Double layer| needless, stem cylinders|
| 06/11/2004 | 1          | 75         | Early reproductive| Double layer| needless, stem cylinders, grain cylinders |
|            | 4          | 74         | Early reproductive| Double layer| needless, stem cylinders, grain cylinders |
|            | 5          | 77         | Early reproductive| Double layer| needless, stem cylinders, grain cylinders |
|            | 6          | 69         | Early reproductive| Double layer| needless, stem cylinders, grain cylinders |

The cylindrical scatters are used to show trunks, whenever the disk- shaped and needle-shaped scatters is used to show the leaves. In the expansion of a scientific model of rice crops, both the glittering transfer theory and DM-PACT for cylindrical and needle- shaped scatters are applied. Rice hovel is patterned as either an alone layer or multilayer thick divide casual average, contingent on its development phase, upon a slick water surface.

In its primary herbal phase, corresponding to the RADARSAT image captured on 20th September, model of rice includes a lone layer of needle- shaped scatters, in attention to identical direction dispensation of the rice leaves.

Due to lower contributions of rice plants, consisting of the stalks, are submerged. Just leaves are upper surface. Microwaves at C- band modulation are unable to transpire into the water, so it is displayed in Figure 5(a) (26, 28).

Regarding to the image captured on the 14 October, rice vegetables are now in their late vegetative phase, and canopy is modeled as a double-layer average.

Over layer includes needle shaped leaves, whenever lower layer is a composition of needle shaped leaves and cylindrical stalks as described in Figure5 (b).
Pending the genital phase, teeny cylinders are added to over layer of model to analogize rice grains [Figure 5(c)] (32, 33).

This corresponds to RADARSAT image accumulated on November 6.

RADARSAT image captured on 27 August won’t be consisted of in this research as seeds have just been transmitted and just source of backscattering is soil.

Trial lands 2 and 3 as well as are eliminated because of skimp data set like a result of high rainfall and sectional demolition of rice lands severally.

The theoretical method is wont to calculate HH polarized backscattering ratio of rice canopies, at a modulation of 5.3 GHz and at an incident angle of 39 to adjust of Fine Mode 2 of RADARSAT [12-13].

To attain it, parameters of the measured ground fact such as the herb geometry and total are combined into the scientific model equations for imitation [14-15].

**Figure 5.** Alteration in the Model applied for the Calculation of Backscattering Ratios of Rice Lands in the (a) Early Vegetative phase, (b) Late Vegetative phase and (c) Reproductive phase, (Shewalkar, P.; Khobragade, A.; Jajuwalr, K.2002)

There is so a low reduce in the backscattering ratio as the yields travel into the genital phase and grains start to appearance.

It could be because of reducing in compression of the rice hovel as shorter vegetables and stalks die out [21].

These trends agree by those that are presented in moving researches [9].

4. **Image processing and classification of rice lands**

Radar images are compounded of extremely pixels. Every pixel in the radar image shows the radar backscatter for that zone on the ground. Bright aspects mean that a large deduction of the radar energy was reflected back to the radar which show high backscatter whenever dark aspects mention that very little energy was reflected which show low backscatter [19].

In radar image analysis, the brighter the pixels on the image, the unsmoothed the surface entity imaged. Vegetation is generally mildly unsmooth on the scale of most radar wavelengths and manifests as grey or light grey in a radar image [22]. Moreover, the brightness of the image is tender to the water content. Rice land with high water content shows bright pixel. Anyway, there is exclusion
to water body, which will reflect entering energy around from the radar and therefore, describing dark pixels on the image. Since mapping any part of the surface of the earth it is larger than a few square miles, a map plan is needed because of the basic problem of the earth's surface entity orbicular whenever the surface of a map is flat and oblong (Xie, Y.; Sha, Z.; Yu, M. 2008).

A map plan is a system of alterations that empowers places on the orbicular earth to be displayed systematically on a flat map [23].

Every plan protects some attributes of the mapped zone, such as similar show areas or shapes, and protection of correct bearings. So, the multi-temporal RADARSAT images needed on the 27 August, 20 September, 14 October and 7 November 2004 are geometrically corrected pending preprocessing therefore that it adapts to its corresponding map plan and arrangement.

Consider this situation; the images are graduated to the plan attributes of Kertau 1984 (West Malaysia and Singapore). The data is consisted of the image header case, therewith making the geographical data handy to the image processing software named "PCI Geomatics" [14] Figure 7 represents the four satellite images that were captured.

As an explained in gray scale where brighter pixels display higher backscattering ratio values, as forenamed before. This is therefore pursued by a variation discovery method to define the variations between two serial images using the technique of "image ratioing" [16].

5. Collaboration among remote sensing-dependent on different methods

According to literature review, one object was detected that the collaboration among remote sensing and different modes could extensively be divided into two parts: collaboration among remote sensing related to models (i) parameters of meteorological; (ii) production development methods (Nuarsa, I.W.; Nishio, F.; Hongo, C, 2001).

Figure 6: represent the various changes in the model applied for the various development phases of rice production corresponding to its age, also date of RADARSAT image possession.

![Figure 6(a): Image Acquisition on 27 August 2004, (F.Ribbes, and L.T. Thuy, 2004)](image-url)
**Figure 6(b):** Image Acquisition on 20 September 2004, (F.Ribbes, and L.T. Thuy, 2004)

**Figure 6(c):** Image Acquisition on 14 October 2004, (F.Ribbes, and L.T. Thuy, 2004)
By the difference images between Figure 6(a), (b), (c) and (d), it is conceivable to categorize the rice lands into various sorts based on the providing scheme projected by the relevant authorities. When the Malaysian government offers a planting scheme to synchronize the agricultural operations interning the rice lands in a specific area, the rice lands can be divided conforming to any the farmers cohered to the projected scheme or were late [35].

As compare the diversity in backscattering ratio with the orientation of the graph in Figure 2, the rice lands are categorized as on scheme rice planting, both late and very late rice planting [33,34].

For instance, if the ratio of the backscattering severity on 20 September 2004 to that of 27 August 2004 of the rice land is so high, the rice land is in its vegetative phase and is divided as "On Scheme Rice Planting". Whenever although, the diversity between the backscattering ratios is too high between 20th September and 14th October, the rice land will be categorized as either "Late Rice Planting" or "So Late Rice Planting", relating to if the backscattering ratio gained or reduced between the first two images. This is found that the various planting schemes have propelled to the various propensity of backscatter ratio all over the planting age as they are specious severally by the irrigation project and rainy season [29].

Figure 7 presents the design of the radar backscattering ratio versus the inception dates of the radar images for the three groups of rice lands. That is outlandish nature of interplay between radar signals and the rice plant construction that permits for the obvious view of the various groups of rice lands using multi-temporal information [32]. Hence, that is conceivable to use the ratioing technique to know the various crop planting schemes [9].
Figure 7: The Backscattering Coefficients of the 3 Groups of Rice Fields Corresponding to the Data of Acquisition of the Satellite Images, (P.Saich, and M.Borgeaud, 2003)

Conforming to Rig not and Zy1 [20], there are two vantages of the image ratioing technique. First and foremost, the ratioing manner is autonomous the total severity values of the pixels. It shows the relevant change in pixel severity between the two images beneath comparison. Second, the ratioing manner can cancel off the calibration faults created during the processing of the radar naive data [35, 36].

By using this technique that is conceivable to sort the rice lands conforming to the upper classifies as represented in Figure 8.

It is considered that the plenty of the rice lands are arranged as "Late Rice Planting" (61.4%), confirmed by the "On Scheme Planting (33.5%) and so Late Rice Planting (5.1%) [27, 28].

Figure 8: Rice Lands Classified into 3 Different Categories, (P.Ferrazzoil, 2002)
6. Conclusion
Remote sensing has been greatly applied and useful to provide human to find more about universe, also to support human reclaim people lives, however, it is just in the final decade or so that research workers and engineers have started to identify the potential of remote sensing in rice monitoring applications. Study into the application of remote sensing in monitoring of rice production is as yet a comparatively new and stimulating strand of study, and it will keep on bringing profits to the world as a whole, exclusively in countries same Malaysia where rice is very significant to people daily lives. This study, scientific model has been expanded to explain the scattering of electromagnetic waves off rice herbs. In addition to that, the comparisons among the backscattering values taken from RADARSAT images by the valence computed by applying the scientific model represent undertaking results. Various planting phases are able to be detached applying the change discovery manner. Therefore, that is conceivable to cooperate in the monitoring of rice land. This manner is so effective to use and also it has more accuracy than other methods. Newly, a majority of countries use this method to monitor rice crops. Therefore, it became more popular after year 2000.

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