RICE AREA AND PROBABLE TRANSPLANTING DATES TRENDS MAPPING THROUGH A REMOTE SENSING BASED MODEL

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ABSTRACT

Egypt faces a great challenge. Fixed water resources and increasing water demands. Rice is the main water–consuming crop planted in Egypt Delta. Thus mapping of where and when rice is planted is important. The planting occurs over a wide spatial and temporal span. Thus, rice mapping with traditional methods is doubtful. Elshorbagy (2013) developed a model for rice mapping utilizing MODIS (MOD09A1, MOD09Q1) products where the dynamics of Land Surface Water Index (LSWI), Normalized Difference Vegetation Index (NDVI) and Enhanced Vegetation Index (EVI) throughout the rice-planting season were combined with an arable mapping module for rice area mapping. In the present study, ten years of historical multi-temporal MODIS imagery (2002-2011) were analyzed applying the developed model. For each main irrigation directorate an inventory of where and when rice was planted in the target period was mapped. The date intervals of maximum rice transplanting were identified. The most critical imagery dates for the model to well function were pinpointed. South-North rice transplanting lag trend was correctly mapped. The algorithm results were compared against the rice areas annual reports. There was good agreement between the estimated areas from the algorithm and the reports. Inter annual variation in rice areas was successfully mapped. In addition, the rice area and probable transplanting dates conforms to local planting practices. The findings of this study indicate that the algorithm can be used for rice areas and transplanting dates trends mapping on a timely and frequent manner.

KEYWORDS: Rice, Mapping, MODIS, Vegetation Indices, Transplanting dates, Trends

INTRODUCTION

The agriculture sector is the main water consumer in Egypt. The amount used by the agriculture sector represents 83 % of the available (CAPMAS, 2013). Building an inventory of where and when rice was planted will help in better water resources management as rice is the main water–consuming crop planted in Egypt delta. Mapping rice with traditional methods on a large area scale is doubtful. Mapping rice in Egypt is a challenge as the planting occurs within the heterogeneous agriculture environment. This challenge is further complicated as the planting spans a wide spatial and temporal window. Since the seventies, many studies had shown that remote sensing is an ideal tool for vegetation mapping. Satellite imagery differs in their spatial, spectral and temporal resolutions. The vegetation spectral and temporal characteristics can be used in vegetation mapping (Xie, 2008). Thus satellite imagery provides a valuable data source for rice inventory mapping. The main rice-differentiating feature is that rice is planted in flooded soil. Thus, a moisture sensitive index like the LSWI will temporarily exceeds or approaches a greenness sensitive index like the NDVI or the EVI, signaling the rice transplanting. Elshorbagy (2013) developed a remote sensing based model for rice mapping. The model consists of two modules. The first is for studying the dynamics of the LSWI, NDVI, and EVI throughout the rice-planting season utilizing the MODIS (MOD09A1) product and the second is an arable mapping module utilizing the MODIS (MOD09Q1) product. Although accurate and timely information is needed for decision-making, updated information about the vegetation area and rice fields in Egypt is problematic. In order to study rice mapping trends in Egypt the usage of historical satellite imagery seems the merely choice. In this study, ten years of historical MODIS (MOD09A1, MOD09Q1) products covering Egypt delta were analyzed utilizing the developed model.

Study Area

The Egypt delta lies in the northern part of Egypt bounded in the north by the Mediterranean Sea, in the south with the Egyptian capital Cairo, in the east with the eastern desert, in the west with the western desert. It covers about 30,000 Km^2. It covers the area south-north from 30˚ 4' N to 31˚ 36' N and east-west from 32˚ 12' E to 29˚ 25' E. Fig 1 shows the Delta region with the main governorates in planting rice boundaries highlighted.

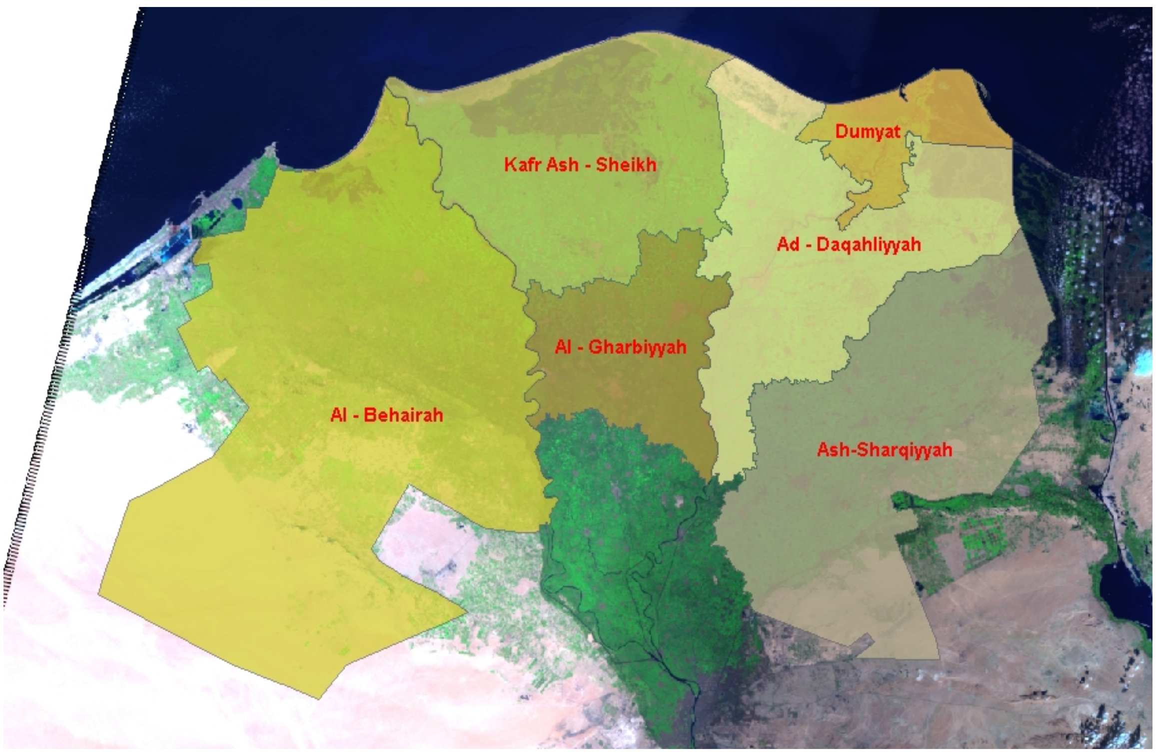


Fig 1: Delta region and Rice planting governorates

Data Used

The MODIS Terra/Aqua Surface Reflectance 8-Day L3 Global 500 m (MOD09A1) and 250m (MOD09Q1) products were used. For each pixel, the best observation value in the 8-day record is selected based on high observation coverage, low view angle, absence of clouds or cloud shadow, and aerosol loading. The tile of the two MODIS products used, that cover the delta region is h20v5. According to the rice mapping calendar in Egypt, images from 15-April to 9-November covers the rice-planting season. The imagery dates in the interval 15-April to 9-November in the years from 2002 until 2011 were downloaded from http://reverb.echo.nasa.gov/reverb/. The main irrigation directorate boundaries shape file was obtained from the Egyptian ministry of water resources and irrigation.

Data processing

After downloading the images it was clipped to extract the delta area. Lakes and Deseret area was masked out utilizing shape files obtained from the Egyptian ministry of water resources and irrigation. The images were projected to UTM Zone 36 with WGS84 datum to match the available shape file projection. The images were checked for clouds or poor quality and then masked out. The three vegetation indices LSWI, NDVI and EVI were calculated as shown in Equations (1), (2), and (3) respectively for all processed images.

$$\mathbf{LSWI = (NIR- SWIR) / (NIR+ SWIR)} \qquad (1)$$

$$\mathbf{NDVI = (NIR- Red) / (NIR + Red)} \qquad (2)$$

$$\mathbf{EVI = 2.5*(NIR - RED/ (NIR + 6 * RED -7.5* BLUE + 10000))} \qquad (3)$$

Where

NIR = the near infra-red band (841-876 nm)

Red=the red band (620-670 nm)

Blue= the blue band (459-479 nm)

SWIR=the short wave infra-red band (1628-1652 nm)

Rice mapping Model

For a complete description of the rice mapping model refer to Elshorbagy (2013). The flowchart shown in Figure 2 summarizes the steps for the arable mapping module while the flowchart shown in Figure 3 summarizes the steps for the rice mapping algorithm.

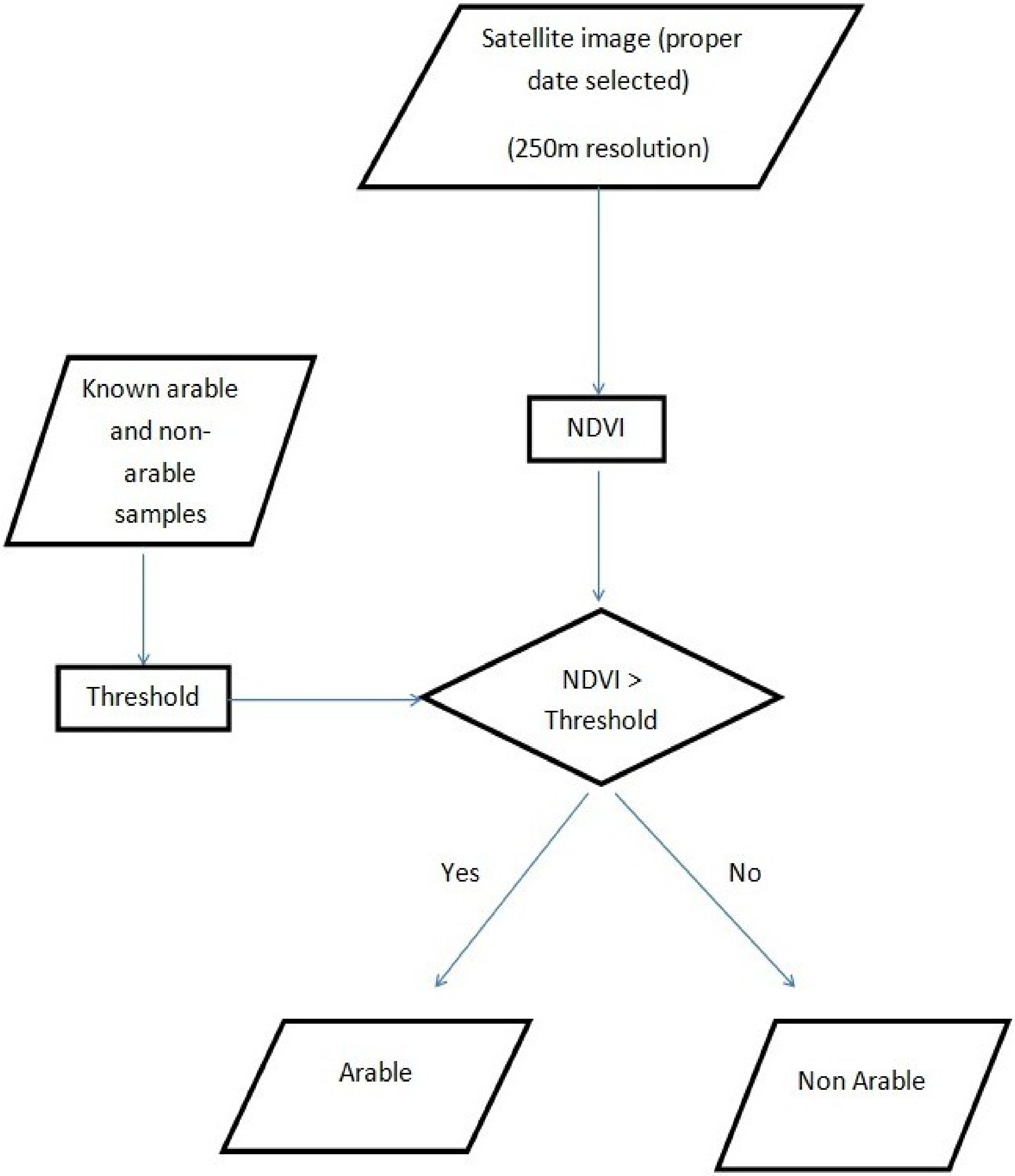


Fig 2: Flow chart showing arable land mapping module (Adapted from Elshorbagy, 2013)

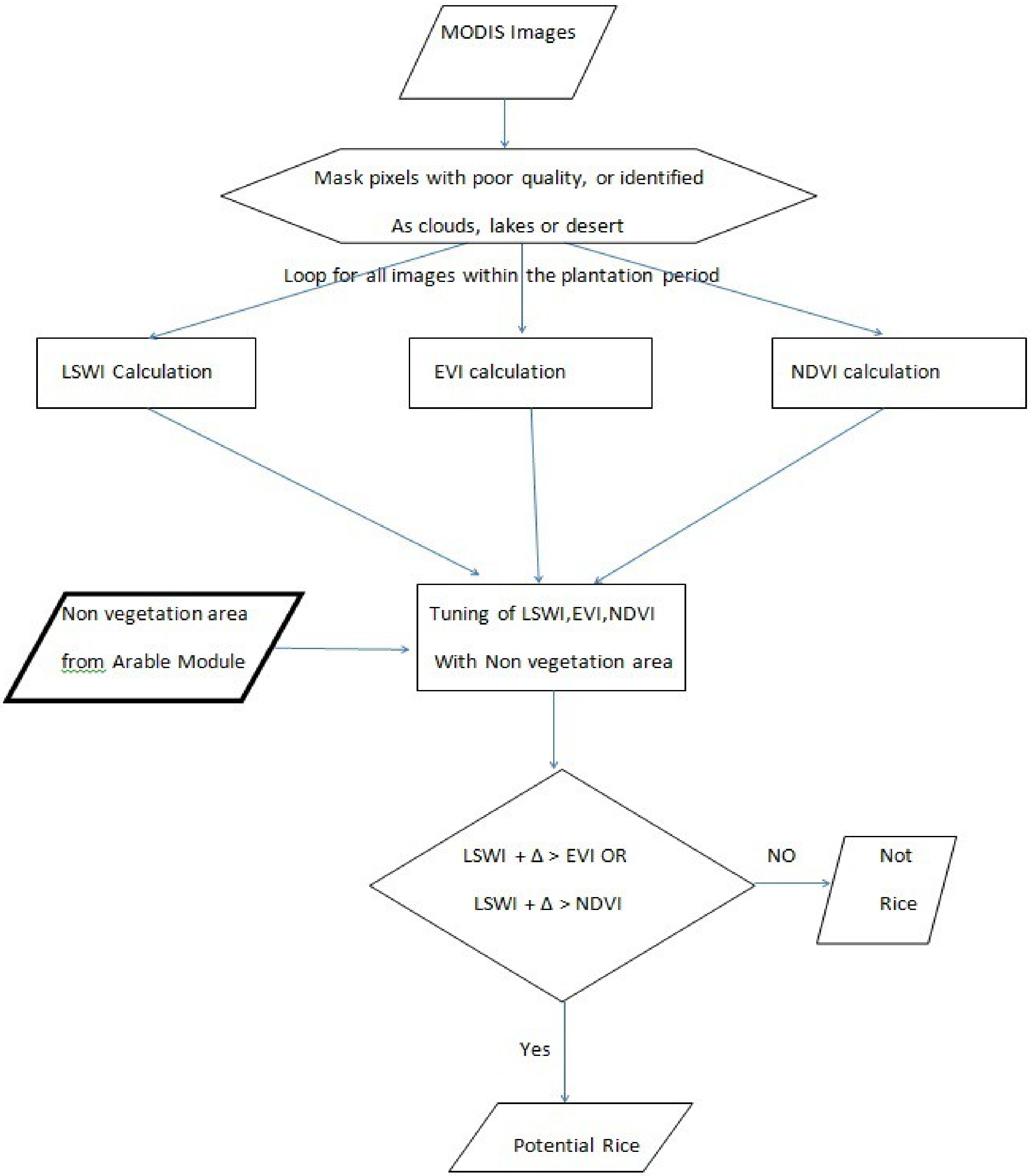


Fig 3: Flow chart showing the rice mapping algorithm (Adapted from Elshorbagy, 2013)

Results and Discussions

After running the model following the procedure outlined in Figures 2, 3 for the years (2002 to 2011) the rice areas and probable transplanting dates were determined. The main irrigation directorate shape file was used to map the rice area and probable transplanting dates within each directorate command area. Figures 4, 5, and 6 show the spatial distribution and probable transplanting dates in 2003, 2006 and 2008 respectively. While Table 1and 2 summarizes the results of running the model for 2006. It can be seen that the northern part of the delta use to transplant rice earlier than the southern part. It was found that the rice area was maximum in year 2008 with about 2.2 million feddan (880,000 hectare). In order to find dates with maximum transplanting, the average of each date window of the ten years period was calculated the results is presented in Table 3 and figure 7.

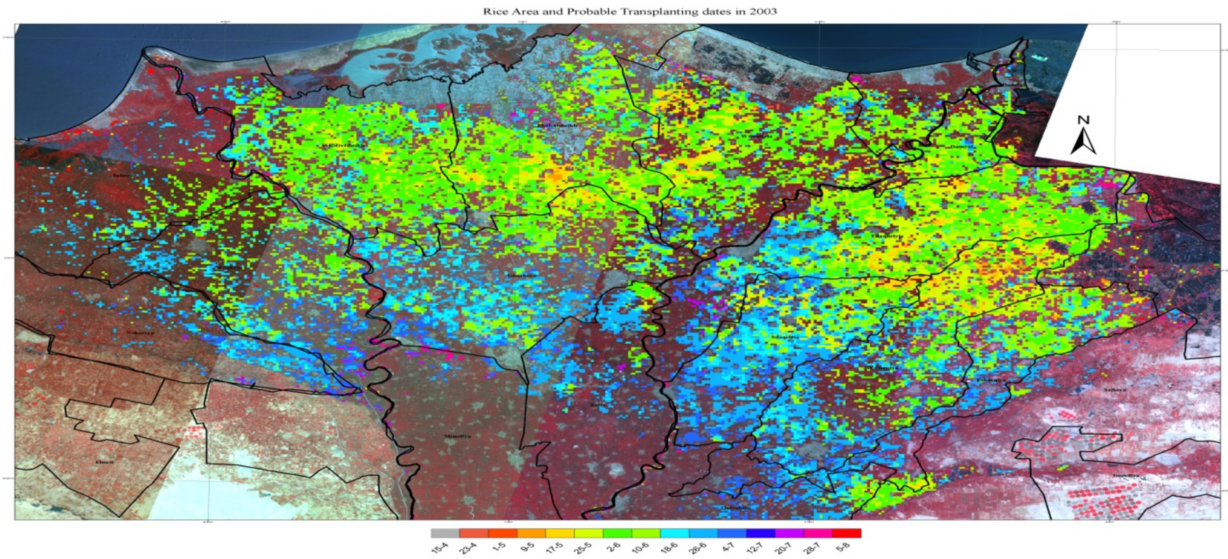


Fig4: Rice Area and Probable Transplanting dates in 2003

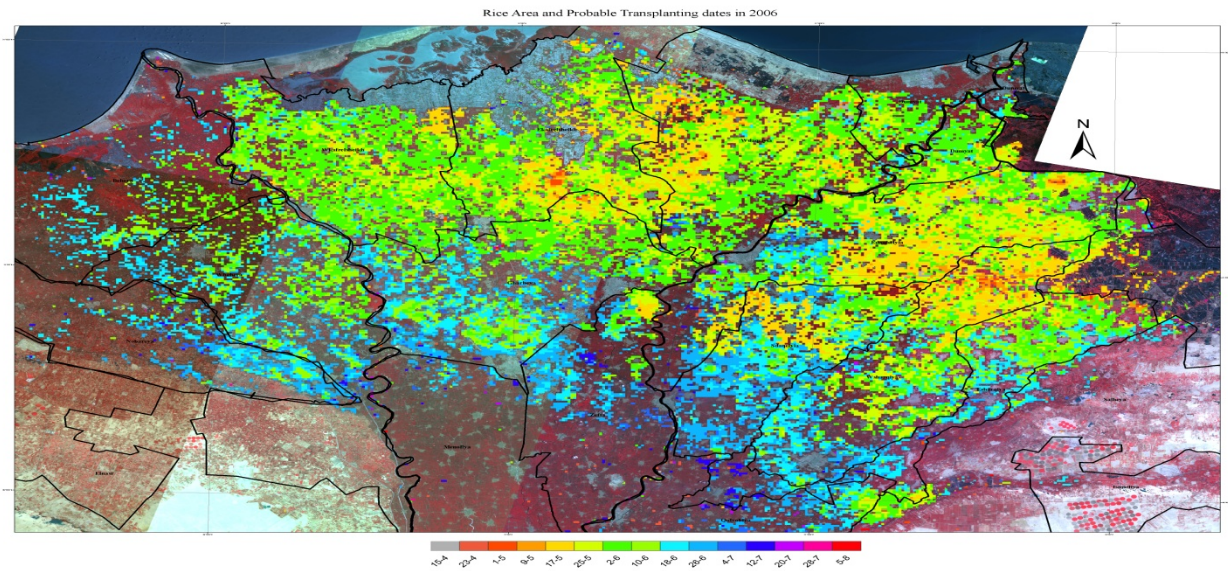


Fig5: Rice Area and Probable Transplanting dates in 2006

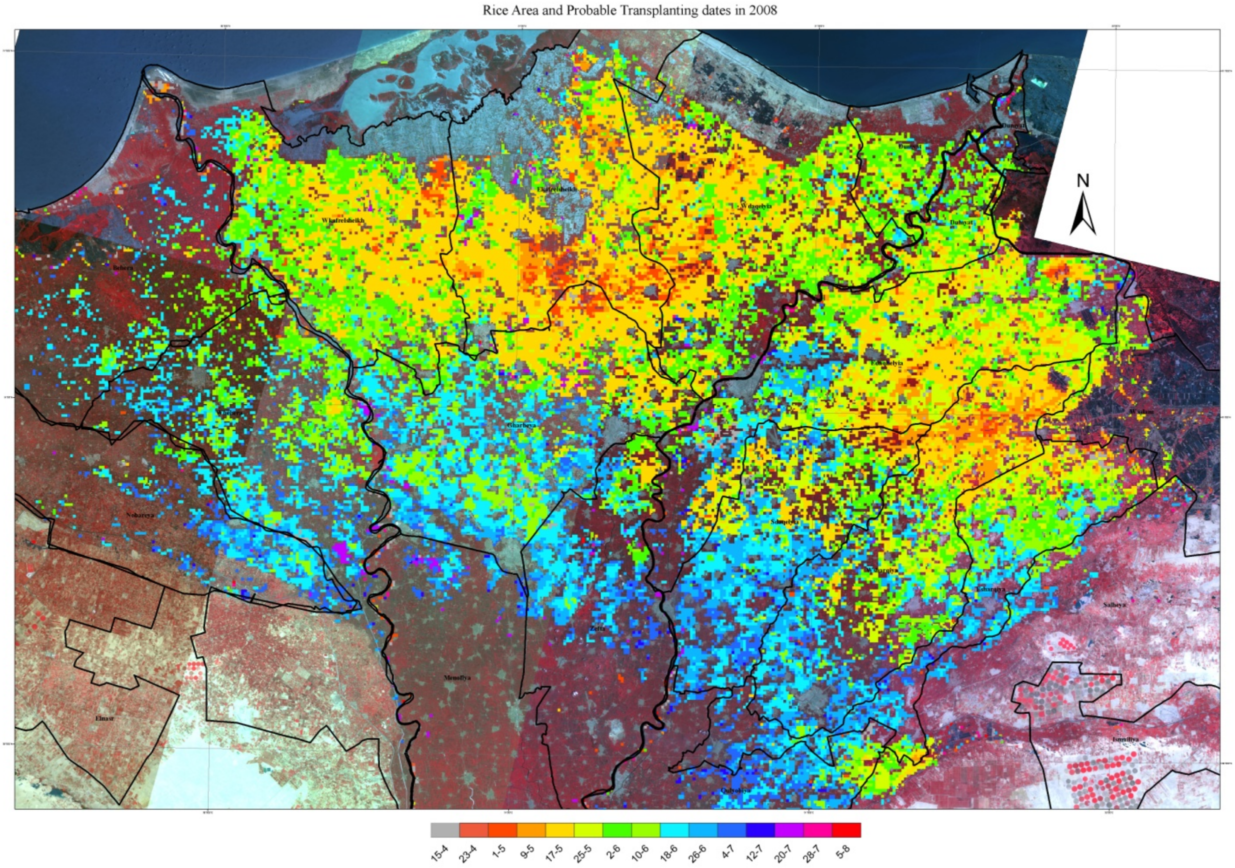


Fig6: Rice Area and Probable Transplanting dates in 2008

Table 1. Rice areas(feddans) and Transplanting dates in 2006(Mid and East Directorates)

Date	Zefta	Dumyat	East_daqehleya	East_Kafr Elsheikh	East_sharqeya	Gharbeya	Menofiya
15/04/2006	252	441	2267	2998	101	1247	252
23/04/2006	479	101	680	831	542	403	642
01/05/2006	63	302	907	1234	856	302	252
09/05/2006	50	239	4484	1663	1990	554	0
17/05/2006	2368	2834	51552	31211	4824	7217	88
25/05/2006	3073	13527	79866	49172	10958	17193	63
02/06/2006	6562	43655	71302	65999	26929	58442	831
10/06/2006	3350	9837	13716	15656	20593	36954	605
18/06/2006	10996	7545	17167	3199	32105	39461	1751
26/06/2006	21739	504	17079	1852	12986	33680	3187
04/07/2006	2834	252	882	403	202	1914	668
12/07/2006	2318	101	680	516	3426	869	1108
20/07/2006	76	50	441	164	176	151	731
28/07/2006	252	0	0	25	0	25	441
05/08/2006	38	239	25	0	0	101	265
13/08/2006	0	0	0	0	0	0	0
21/08/2006	0	0	0	0	0	0	0
29/08/2006	0	0	0	0	0	0	0
Total	54160	79388	261024	174897	115687	198388	10177
Rounded	54200	79400	261000	174900	115700	198400	10200

Table 2. Rice areas(feddans) and Transplanting dates in 2006(Mid and West Directorates)

Date	South_Daqehelya	West_Behera	West_Daqeleya	West_KafrElsehikh	West_sharqeya	Zefta	Totals(all directorates)
15/04/2006	164	945	4912	970	327	252	26790
23/04/2006	13	227	668	516	151	479	8401
01/05/2006	0	139	1839	265	806	63	9220
09/05/2006	1763	50	3212	0	5806	50	22634
17/05/2006	16928	88	39385	7847	32445	2368	209547
25/05/2006	22508	856	50406	31375	42345	3073	334303
02/06/2006	15983	18414	85245	96908	38466	6562	567353
10/06/2006	8300	36350	17973	43643	12280	3350	243416
18/06/2006	31425	36577	5932	11499	36388	10996	290056
26/06/2006	45544	20026	2670	3287	22823	21739	234574
04/07/2006	1965	1045	705	151	479	2834	19157
12/07/2006	403	1020	202	151	479	2318	16084
20/07/2006	25	504	50	139	365	76	5114
28/07/2006	25	327	0	101	0	252	1801
05/08/2006	0	340	38	13	0	38	1713
13/08/2006	0	0	0	0	0	0	0
21/08/2006	0	0	0	0	0	0	0
29/08/2006	0	0	0	0	0	0	0
Total	145022	116241	213200	196750	193161	54160	1986647
Rounded	**145000**	**116200**	**213200**	**196800**	**193200**	**54200**	**1986600**

In order to find dates with maximum transplanting, the average of each date window of the ten years period was calculated the results are presented in Figure 7 and Table 3. As illustrated in Figure 7 and Table 3it is found that the date window with maximum rice transplanting occurring is from 2 June to 10 June totaling more than 450,000 feddans on average. While the dates window from mid May to early June accounts for another 450,000 feddan mostly occurring in the delta northern part. While the dates window from mid June to early July contributes with about 700,000 feddan mainly in mid and southern delta

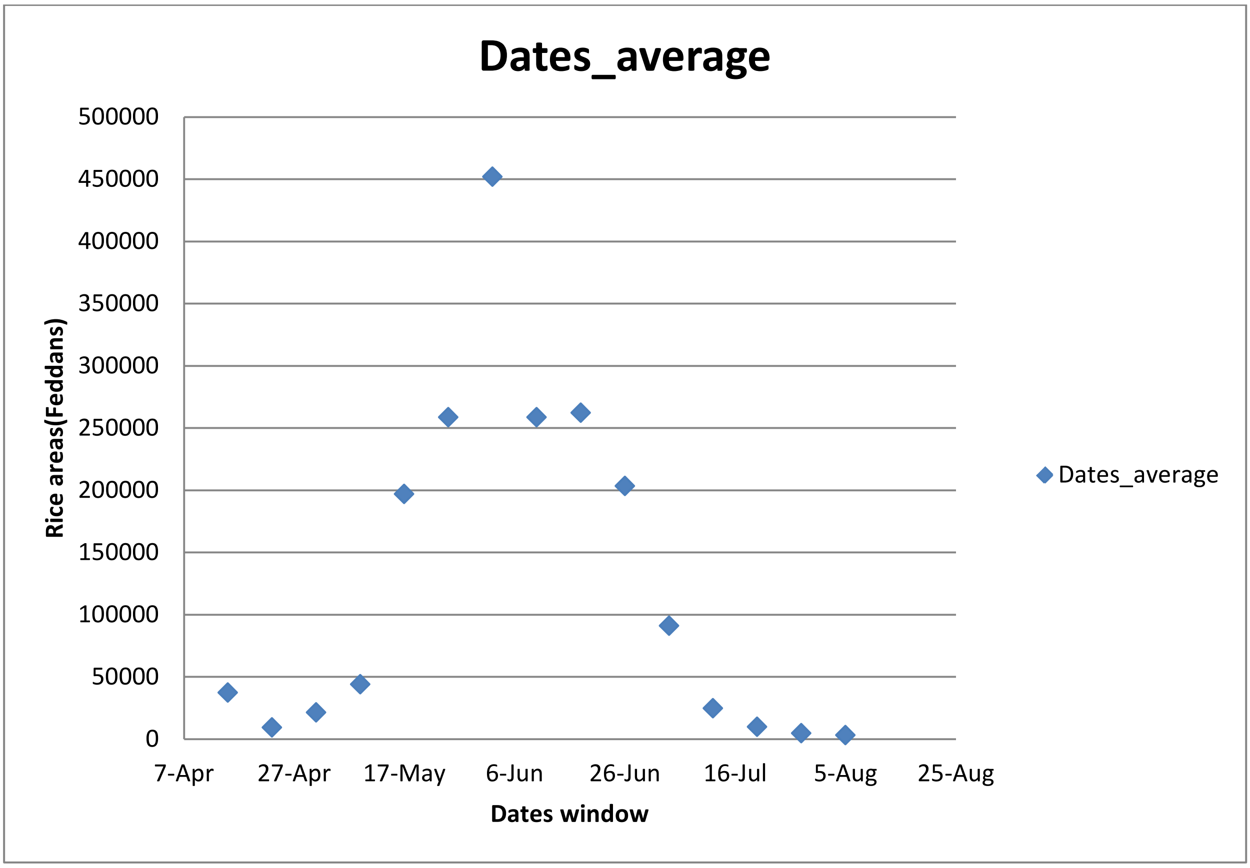
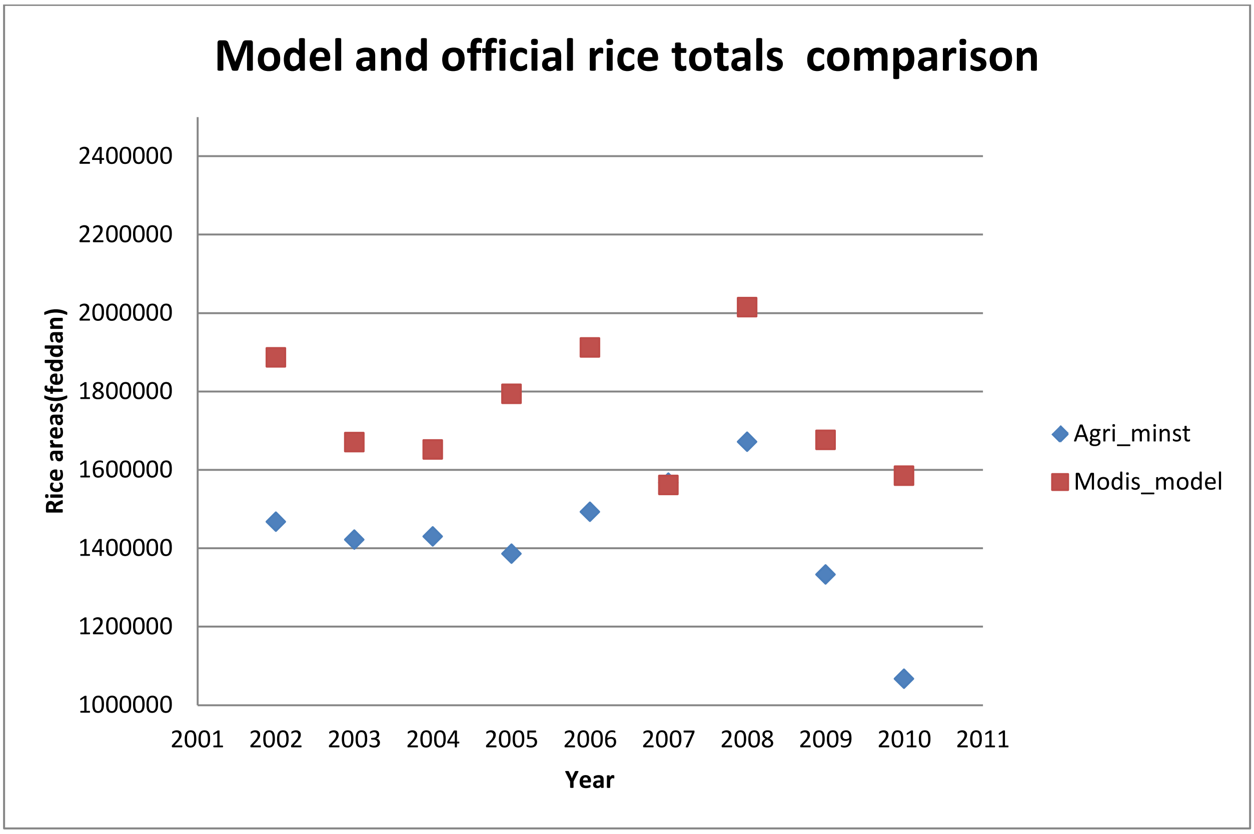


Fig 7: Rice area average for each date window in years (2002-2011)

Table 3: Rice areas (feddans) in the dates windows (years 2002-2011)

	2011	2010	2009	2008	2007	2006	2005	2004	2003	2002	**Average Rounded (feddan)**
15-Apr	20669	12154	39549	25556	41917	26790	65319	35695	10920	38819	**37300**
23-Apr	13956	23150	3640	4068	3035	8401	12583	8137	6247	0	**9300**
1-May	42383	41904	0	38290	48504	9220	8262	6172	2381	10832	**21400**
9-May	40116	146369	50645	81819	41136	22634	11424	55696	10038	12482	**43900**
17-May	175540	240985	268442	457522	315700	209547	126280	153133	54109	101177	**197000**
25-May	270722	341771	264953	253706	162605	334303	217532	0	174482	310447	**258700**
2-Jun	507979	309906	382417	301089	0	567353	624107	622809	363650	486705	**452000**
10-Jun	225115	187770	190528	244864	386195	243416	84413	0	390717	395944	**258600**
18-Jun	234259	104792	179633	310813	361194	290056	404546	433641	207847	229145	**262300**
26-Jun	177933	139392	226651	229221	184029	234574	102324	339832	310510	139177	**203400**
4-Jul	104729	27697	98344	106606	43844	19157	173965	42093	132527	149140	**91100**
12-Jul	41804	70684	21576	12205	21891	16084	3451	5920	0	12016	**24800**
20-Jul	3993	2658	4194	15139	3237	5114	8930	2569	17079	37697	**9900**
28-Jul	1914	3401	3615	4484	2229	1801	1499	11814	14787	3489	**4800**
5-Aug	2040	2972	5088	3224	2040	1712	3677	3274	3854	3010	**3200**

The comparison between the rice area totals in each year with the official totals from the ministry of agriculture annual reports is illustrated in Figure 8. Good agreement between the totals can be found and that inter annual variation in rice areas is correctly mapped. In addition, the findings conform to local rice transplanting practices.



Conclusions

This study findings show that the rice mapping model (Elshorbagy,2013) can be used for rice areas and probable transplanting dates trends mapping. An inventory of where and when rice was planted in the years 2002 to 2011 was build. The date window with max transplanting occurring on average in the ten years period was found to be in early June with an area of about 190,000 hectare. The delta south-north rice-transplanting lag was successfully mapped. The findings conform to local rice planting practices. The official rice totals is obtained from traditional methods which is problematic to map rice areas on large scale. However, the comparison between model outputs and official rice area totals showed a good agreement and that the inter annual area variation was successfully mapped.

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