

Cultivated land change in the Belt and Road Initiative region

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Abstract: The Belt and Road Initiative (BRI)—a development strategy proposed by China — provides unprecedented opportunities for multi-dimensional communication and cooperation across Asia, Africa and Europe. In this study, we analyse the spatio-temporal changes in cultivated land in the BRI countries (64 in total) to better understand the land use status of China along with its periphery for targeting specific collaboration. We apply FAO statistics and GlobeLand30 (the world's finest land cover data at a 30-m resolution), and develop three indicator groups (namely quantity, conversion, and utilization degree) for the analysis. The results show that cultivated land area in the BRI region increased 3.73×10^4 km² between 2000 and 2010. The increased cultivated land was mainly found in Central and Eastern Europe and Southeast Asia, while the decreased cultivated land was mostly concentrated in China. Russia ranks first with an increase of 1.59×10^4 km² cultivated land area, followed by Hungary (0.66×10^4 km²) and India (0.57×10^4 km²). China decreased 1.95×10^4 km² cultivated land area, followed by Bangladesh (-0.22×10^4 km²) and Thailand (-0.22×10^4 km²). Cultivated land was mainly transferred to/from forest, grassland, artificial surfaces and bare land, and transfer types in different regions have different characteristics: while large amount of cultivated land in China was converted to artificial surfaces, considerable forest was converted to cultivated land in Southeast Asia. The increase of multi-cropping index dominated the region except the Central and Eastern Europe, while the increase of fragmentation index was prevailing in the region except for a few South Asian countries. Our results indicate that the negative consequence of cultivated land loss in China might be underestimated by the domestic-focused studies, as none of its close neighbours experienced such obvious cultivated land losses. Nevertheless, the increased cultivated land area in Southeast Asia and the extensive cultivated land use in Ukraine and Russia imply that the regional food production would be greatly improved if China's "Go Out policy" would help those countries to intensify their cultivated land use.

Keywords: spatio-temporal change; land conversion, intensification; multi-cropping; fragmentation; GlobeLand30

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1 Introduction

Historically, China established connections with the world through two geographic Silk Roads. One was a terrestrial Silk Road, which extends along West and Central Asia and finally into Europe, forming the Eurasian integration; while the other was a maritime Silk Road, which connects China to the rest part of Asia as well as to the African continent (Chen *et al.*, 2015). These connections symbolized multi-dimensional communication and cooperation between the East and the West for centuries. In face of the weak recovery of the global economy, China proposes the “Belt and Road Initiative” (BRI) in the early 2010s to revive the Silk Road Spirit (He *et al.*, 2016), aiming to bring “peace and cooperation, openness and inclusiveness, mutual learning and mutual benefit” among all the Belt and Road countries (Gong *et al.*, 2015; Li *et al.*, 2015; Zou *et al.*, 2015).

Many studies have been carried out since the implementation of BRI (Liu *et al.*, 2016), focusing on the investment of energy (Duan *et al.*, 2017), manufacturing (Cheng *et al.*, 2016), water resource (Li *et al.*, 2017), agricultural trade (Gong *et al.*, 2015; Li *et al.*, 2015; He *et al.*, 2016), financial cooperation (Huang, 2016), telecoupling prosperity and ecological sustainability (Yang *et al.*, 2016). However, agricultural land use activities (Foley, 2005) – the foundation of agricultural trade and economic cooperation – have received less attention yet. As a vital resource for food supplies (Foley *et al.*, 2011; Zhao, 2012), it is of great significance to understand the spatio-temporal dynamics of cultivated land and agricultural practices in the BRI countries so as to ensure both domestic and cross-national food security (He *et al.*, 2016). Moreover, understanding the status of cultivated land use in the BRI countries would help China to promote its “Go Out policy” on one hand, and to target specific collaboration for satisfying its global resource demand on the other hand (Wu *et al.*, 2017).

Cultivated land change has been observed in many BRI countries, such as China (Liu *et al.*, 2014), India (Meiyappan *et al.*, 2017), Uzbekistan (Dubovky *et al.*, 2013), and Bangladesh (Islam *et al.*, 2016), for supporting domestic policy-making, yet analyses across countries are rare. Previous global- or continental-level observations of land cover change were primarily based on either statistical data (Ramankutty *et al.*, 2008) or land cover products (Fritz *et al.*, 2015). However, these mostly used land cover dataset are at a relatively coarse spatial resolution, e.g. 300 m or 1 km (Grekousis *et al.*, 2015), resulting in the low cartographic accuracy in the area of fragmentized agricultural landscape and the insufficient details in describing agricultural land use activities. Furthermore, there are multi-faceted characteristics of cultivated land change, e.g. quantity of land cover (He *et al.*, 2017), landscape pattern (Yan *et al.*, 2016), as well as land use intensity (Gray *et al.*, 2014). Previous analyses tend to focus on one aspect while leaving the rest unassessed. As a result, a more inclusive and detailed analysis of cultivated land change across countries within the BRI is imperative for comparison and subsequently for collaboration.

The latest 30 m global land cover data product (GlobeLand30) are recently available (Chen *et al.*, 2014; Chen *et al.*, 2015), which provides the cultivated land maps in 2000 and 2010 with an overall accuracy of 92.82% and 93.13% respectively (Cao *et al.*, 2016). GlobeLand30 shows great potential in characterizing land cover change for a relatively large geographical coverage, given its high spatial resolution and dual observations within a decade (Zhang *et al.*, 2015; Kühling *et al.*, 2015). Consequently, we select GlobeLand30 in addition to FAO statistics for the current study. We develop three indicator groups namely

quantity, conversion, and utilization degree, to capture the changing characteristics of cultivated land use pattern in the BRI countries. Based on the core results, we further discuss how China could better implement its “Go Out policy” to meet its global demand for resource collaboration, through the cross-national collaboration on cultivated land use.

2 Material and methods

2.1 Study area

The BRI is an open concept without any fixed area extent, and its coverage is still expanding. Following previous analyses, e.g. Gong *et al.* (2015) and Zou *et al.* (2015), we focus on 64 countries from seven geographical zones, including 2 in East Asia, 5 in Central Asia, 11 in Southeast Asia, 7 in South Asia, 20 in Central and Eastern Europe, 19 in West Asia and 1 in North Africa (Table S1 from the Online Supplementary Material).

Both of the “Belt” and “Road” start from China, while the “Silk Road Economic Belt” ends at Europe via Central Asia and West Asia, and the “21st Century Maritime Silk Road” ends at Europe via Southeast Asia, South Asia and North Africa. We therefore use “the Belt” to simplify the “Silk Road Economic Belt”, and use “the Road” to represent the “21st Century Maritime Silk Road” (Figure 1). A map distinguishing the “Belt” and “Road” countries is presented in Figure 1. The selected countries are further linked to the seven geographical zones, as presented in Table S1.

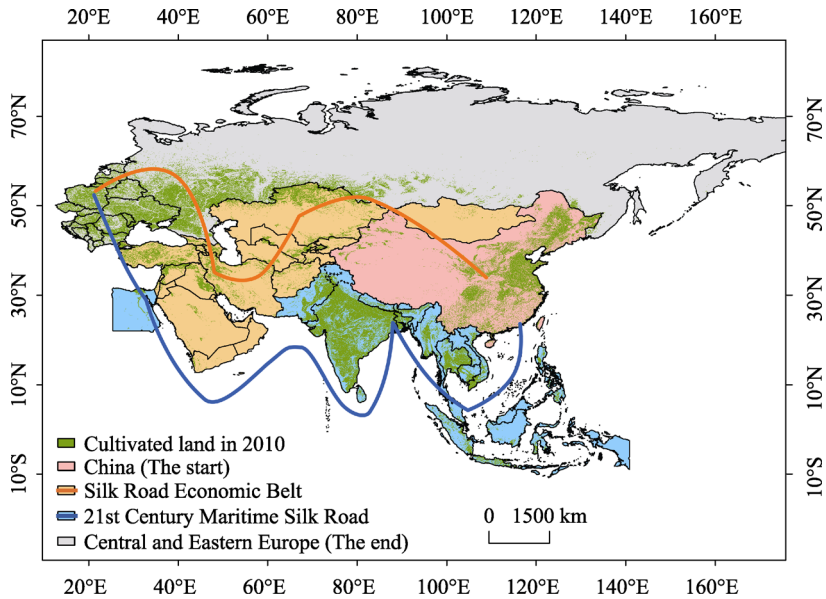


Figure 1 An overview of the Belt and Road Initiative

Due to a higher proportion of developing country in the BRI, agriculture plays an important role in the region’s socio-economic development. For example, the agriculture-accounted national economy (in share) is higher than the global average level (FAOSTAT). However, there are clear disparities in population, resource abundance, technology advancement, labor productivity and agricultural investment among individual countries (Li *et al.*, 2016). Therefore, it would have great implications to focus on the agricul-

ture-related issue in the BRI, especially for the purposes of collaboration.

2.2 Data and application

The essential land cover data of the analysis, i.e. GlobeLand30, is obtained from <http://www.globeland30.com>. As the finest global land cover dataset at a 30m spatial resolution, GlobeLand30 was produced by using a plenty of medium-high spatial resolution remotely sensed images, including Landsat TM/ETM+ and HJ-1 (Chen *et al.*, 2014; Chen *et al.*, 2015). GlobeLand30 provides two land cover maps of 2000 and 2010 respectively, which were subjected to 10 land cover classes, namely cultivated land, grasslands, forest, shrub land, wetland, water bodies, artificial surfaces, tundra, bare land, and permanent snow and ice. In addition to the global level overall accuracy, the overall accuracy of cultivated land maps in the study area over the study period ranges from 93.63% to 98.90% (Cao *et al.*, 2016). The statistical data, i.e. the country-level harvested area, is acquired from the FAOSTAT (<http://www.fao.org/faostat/en/#home>).

Three groups of indicators were conceptualized to explore the spatio-temporal changes in cultivated land in the BRI between 2000 and 2010. The first group is related to quantity, including the changes in total cultivated land area (ΔCA) and the area changing rate (R_{CA}). ΔCA and R_{CA} are calculated at the national level:

$$\Delta CA = CA_{2010} - CA_{2000} \quad (1)$$

$$R_{CA} = \frac{\Delta CA}{CA_{2000}} \times 100\% \quad (2)$$

where CA_{2010} is the total cultivated land area in 2010, CA_{2000} is the total cultivated land area in 2000.

The second group describes the cultivated land conversions among other land cover classes with the manifestations of the country-level land conversion matrixes, including: (i) the share of cultivated land converted from other land cover classes, and (ii) the share of cultivated land converted to other land cover classes. They are calculated as:

$$Share_IN_m = \frac{IN_m}{CA_{2010}} \times 100\% \quad (3)$$

where IN_m is the gross cultivated land area converted from land cover class m in a location between 2000 and 2010.

$$Share_OUT_n = \frac{OUT_n}{CA_{2000}} \times 100\% \quad (4)$$

where OUT_n is the gross cultivated land area converted to land cover class n in a location between 2000 and 2010.

In the third group, two indicators including multi-cropping index (MCI) and fragmentation index (FI) are adopted for measuring the utilization degree. MCI is an output-oriented measurement of land use intensity (Erb *et al.*, 2013), which has been widely used in agricultural intensification assessments (Wu *et al.*, 2018; Yu *et al.*, 2018). It is calculated as:

$$MCI_{it} = \frac{HA_{it}}{CA_{it}} \quad (5)$$

where HA means harvested area and CA means cultivated land area, respectively. i repre-

sents country and t represents time stage.

Although the HA applied in this study is acquired from FAOSTAT, while the CA is aggregated from GlobeLand30, we believe such an inter-dataset application is validated. Because GlobeLand30 has been intensively validated by data producers (Cao *et al.*, 2016) as well as by data users (Lu *et al.*, 2016; Lu *et al.*, 2017). To better illustrate the consistency, a comparison between GlobeLand30 and FAOSTAT is presented in Figure S1 (from the Online Supplementary Material).

FI reflects the connectivity of land use patterns (Forman *et al.*, 1995), which could potentially affect the intensity and efficiency of agricultural production (Coppedge *et al.*, 2001; Yu *et al.*, 2018). It is computed as:

$$FI_{jt} = \frac{NP_{jt}}{CA_{jt}} \times 100\% \quad (6)$$

where NP means the number of cultivated land patches, which is calculated by FRAGSTATS at both country- and county-level. j represents county. When computing the country-level FI , i will be adopted for replacing j .

3 Results

3.1 Spatio-temporal changes in cultivated land area

The cultivated land area in the BRI increased $3.73 \times 10^4 \text{ km}^2$ (ca. +0.39%) between 2000 and 2010 (see details from Table S2 from the Online Supplementary Material). Cultivated land mainly distributed in the eastern part of East Asia, South Asia, Southeast Asia, northern part of Central Asia and West Asia, and southwest of Central and Eastern Europe (Figure 2a, upper part). Cultivated land in northeast India, south Kazakhstan, the Nile Delta in Egypt and the central part of Vietnam increased obviously. By contrast, cultivated land along the Yangtze River Delta in China decreased obviously. Cultivated land change in these hotspots – including southwest Iran and southwest Russia – are highlighted in Figure 2b-2h (lower part). These highlighted patterns generally represent the characteristics of cultivated land change at the geographical zone level.

At the geographical zone level, Central and Eastern Europe had the largest net change area in cultivated land ($2.86 \times 10^4 \text{ km}^2$), followed by East Asia ($-1.98 \times 10^4 \text{ km}^2$) and then Southeast Asia ($1.05 \times 10^4 \text{ km}^2$), while Central Asia had the smallest net change area in cultivated land between 2000 and 2010 (Table S2). In terms of the changing rate, North Africa had the largest growth rate (ca. +8.75%), followed by Southeast Asia (+1.11%) and Central and Eastern Europe (+1.02 %). East Asia was the only region where cultivated land decreased (ca. -0.96%), while the net cultivated land loss in China largely contributed to this decrease.

At the country level, a total of 38 countries had increased cultivated land area, while the rest (25 countries) decreased. The higher increase rates were found in Bhutan (+20.25%), Brunei (+15.83%), Laos (+12.24%), among others. By contrast, the higher decrease rates were found in Israel (-18.92%), Jordan (-11.18 %), and Lebanon (-7.31%) (Table S2). These countries have a small amount of cultivated land, so a small amount of change in area results in relatively high rate of change.

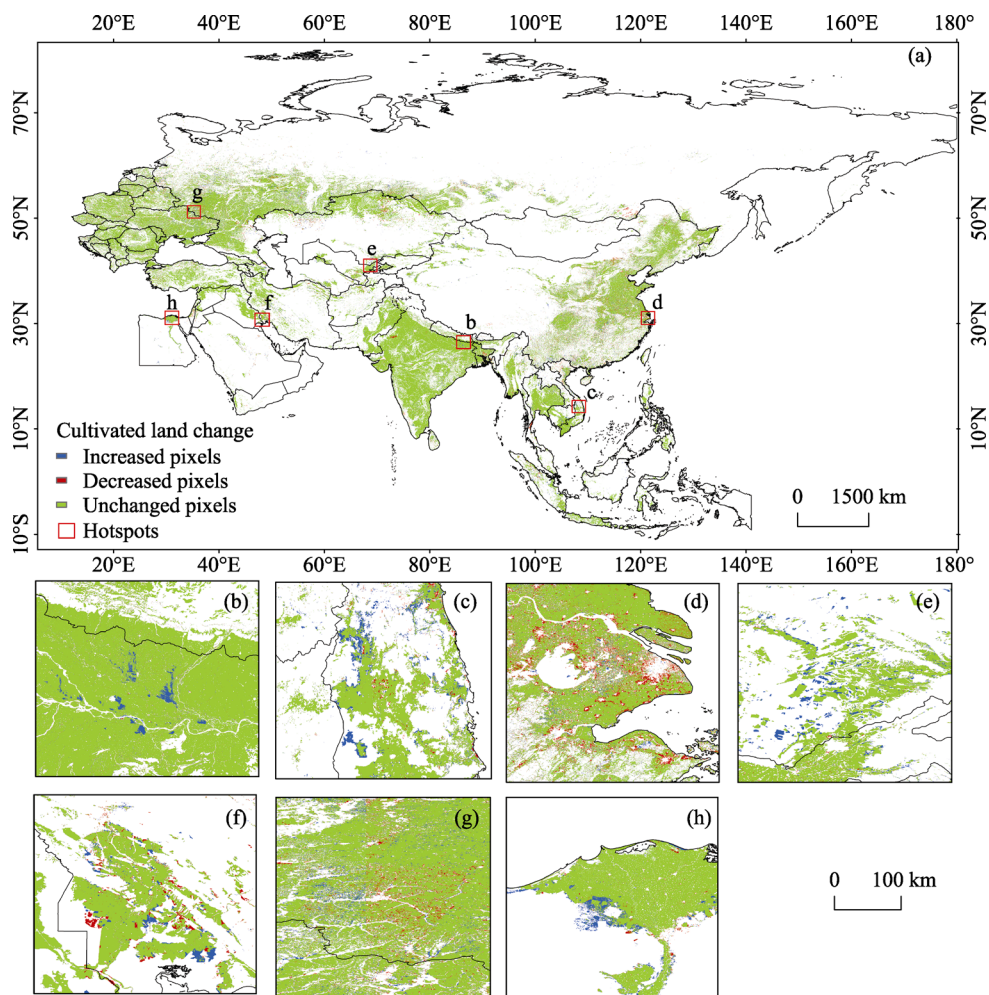


Figure 2 Cultivated land change in the BRI between 2000 and 2010 (a) and the identified seven hotspots representing the characteristics of cultivated land change at the seven geographical zones, including: northeast India from South Asia (b), central part of Vietnam from Southeast Asia (c), Yangtze River Delta in China from East Asia (d), south Kazakhstan from Central Asia (e), southwest Iran from West Asia (f), southwest Russia from Central and Eastern Europe (g) and Nile Delta in Egypt from North Africa (h). Detailed elaboration of the seven geographical zones can be found in Section 2.1 and Table S1. A unified legend is provided in the upper figure (a).

3.2 Conversions between cultivated land and other land use types

Between 2000 and 2010, 96.50% of the cultivated land in the BRI remained unchanged. Nevertheless, there were still notable conversions between cultivated land, forest, grassland, bare land and artificial surfaces, with apparent regional disparities. Regarding the increased cultivated land, 3.57% of the cultivated land in Southeast Asia was converted from forest; 1.03% and 10.26% of the cultivated land in West Asia and North Africa, respectively, were converted from bare land; and 1.76% of the cultivated land in Central and Eastern Europe was converted from grassland. Regarding the decreased cultivated land, 3.51% and 1.44% of the cultivated land in Central Asia and West Asia were converted to grassland; 1.76% of the cultivated land in East Asia was converted to artificial surfaces (Table S3).

New cultivated land converted from grassland and bare land was concentrated in “the

Belt”, i.e. in the Central Asia and West Asia. Figure 3 shows that there were 15.05%, 11.83% and 3.85% of cultivated land converted from grassland in Armenia, Azerbaijan and Kazakhstan respectively. In the United Arab Emirates and Oman, there were 10.11% and 9.59% of cultivated land converted from bare land, respectively. On the other hand, new cultivated land converted from forest is concentrated in “the Road” countries, i.e. in the Southeast and South Asia. For example, forest in Bhutan and Laos were transferred to cultivated land at a share of 25.80% and 12.90%, respectively, markedly higher than other land cover classes. Cultivated land converted to artificial surfaces were concentrated in China and some countries in “the Road”, e.g. Bangladesh and Singapore. The shares of these conventions were 4.13%, 3.14% and 1.77%, in Bangladesh, Singapore and China, respectively. At the same time, cultivated land converted to grassland was concentrated in some countries of Central and Eastern Europe and in “the Belt”. For example, cultivated land in Russia and Israel were transferred to grassland at a share of 2.05% and 14.16%, respectively, markedly higher than other land cover classes (Figure 3).

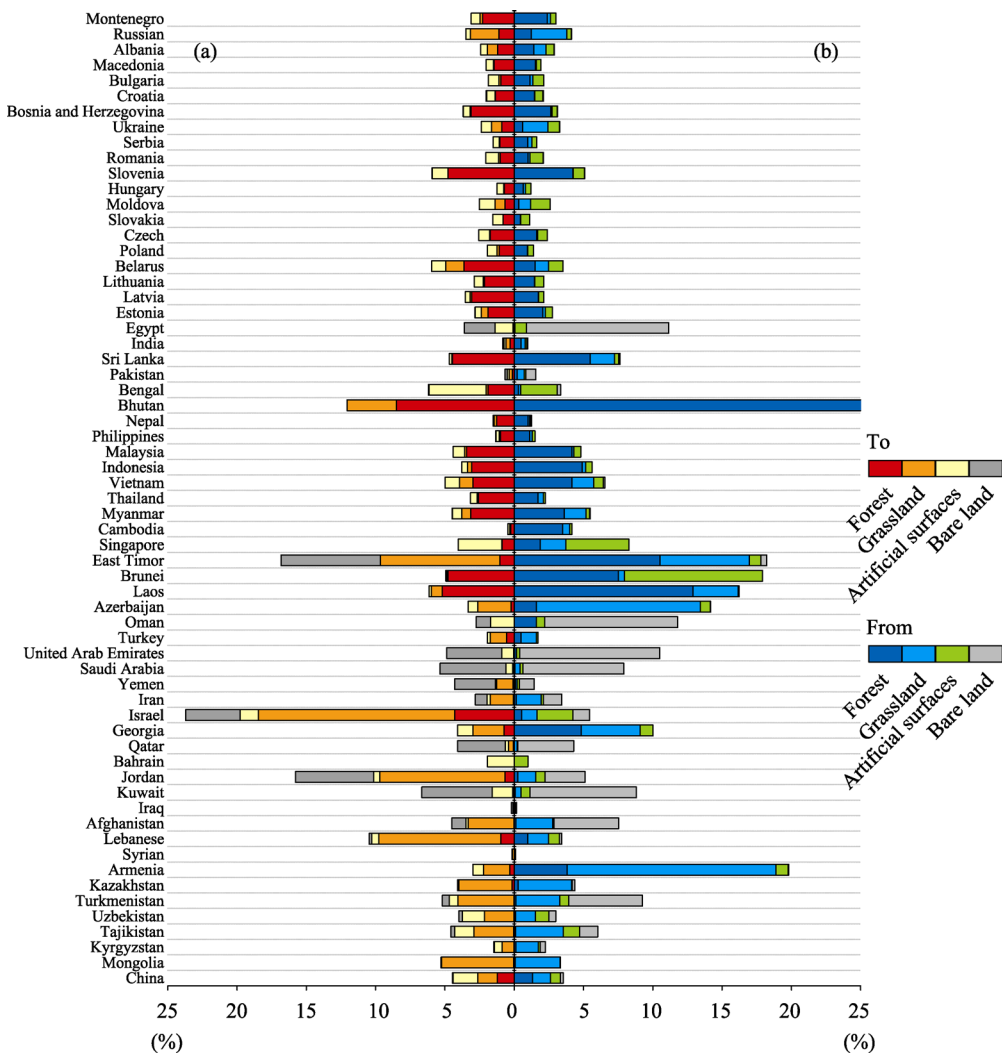


Figure 3 The share of cultivated land converted to other land cover classes in BRI countries (a), and the share of other land cover classes converted to cultivated land in the BRI countries (b) between 2000 and 2010

3.3 Spatio-temporal changes in cultivated land utilization degree

3.3.1 Multi-cropping index

The MCI was 0.82 in the BRI in 2010, with an increase of 0.03 (+4.27%) between 2000 and 2010. A few Southeast Asian countries, such as Malaysia, the Philippines and Brunei had a MCI higher than 2.00. Most countries in the BRI had a MCI between 1.00–2.00. While the lowest MCI (i.e. lower than 1.00) were mainly found in Central and Eastern Europe, West Asia, and Central Asia (Figure 4).

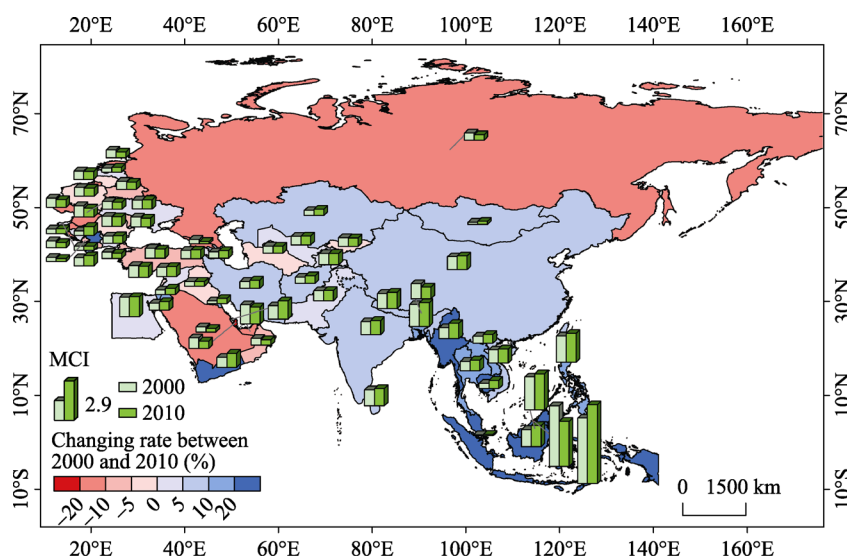


Figure 4 Spatial distribution of multi-cropping index and its changing rate in the BRI countries between 2000 and 2010. The number, i.e. 2.9 in the legend, means the length of the presented bar equalizes to this specific value.

The MCI in the southeast of the BRI presented a higher growth rate than it in the north-west of the BRI between 2000 and 2010 (Figure 4), while the growth rate in Southeast Asia was 20.40%, much higher than the rate in West Asia, which was 2.21%. Only Central and Eastern Europe showed a negative growth, which was –13.44%. Specifically, almost all countries in “the Road” region experienced an increase in MCI. For example, Indonesia increased 24.42%, followed by Laos (+23.36%) and Thailand (+15.37%). These countries are clustered in Southeast Asia. Conversely, the MCI change in “the Belt” region displayed a markedly variation. For example, Israel and Kazakhstan increased 21.05% and 22.71%, respectively; whereas Oman and Turkey decreased 19.38% and 9.60% respectively. These countries are clustered in West Asia (Figure 4). China’s MCI increased 6.01%, ranking 29th among the BRI countries (Table S4 from the Online Supplementary Material).

3.3.2 Fragmentation index

The countries in East Asia, Southeast Asia, south of West Asia and some small countries in the south of Central and Eastern Europe had a relatively higher FI, such as China, Philippines, Oman, United Arab Emirates and Albania. On the other hand, the countries in South Asia, Central Asia, West Asia, such as India, Pakistan, Turkmenistan, Iraq and Syria had a relatively lower FI (see details from Figure S2 from the Online Supplementary Material).

The FI within counties had larger spatial differences. For example, we find more fragmented cultivated land in south China (Figure S3).

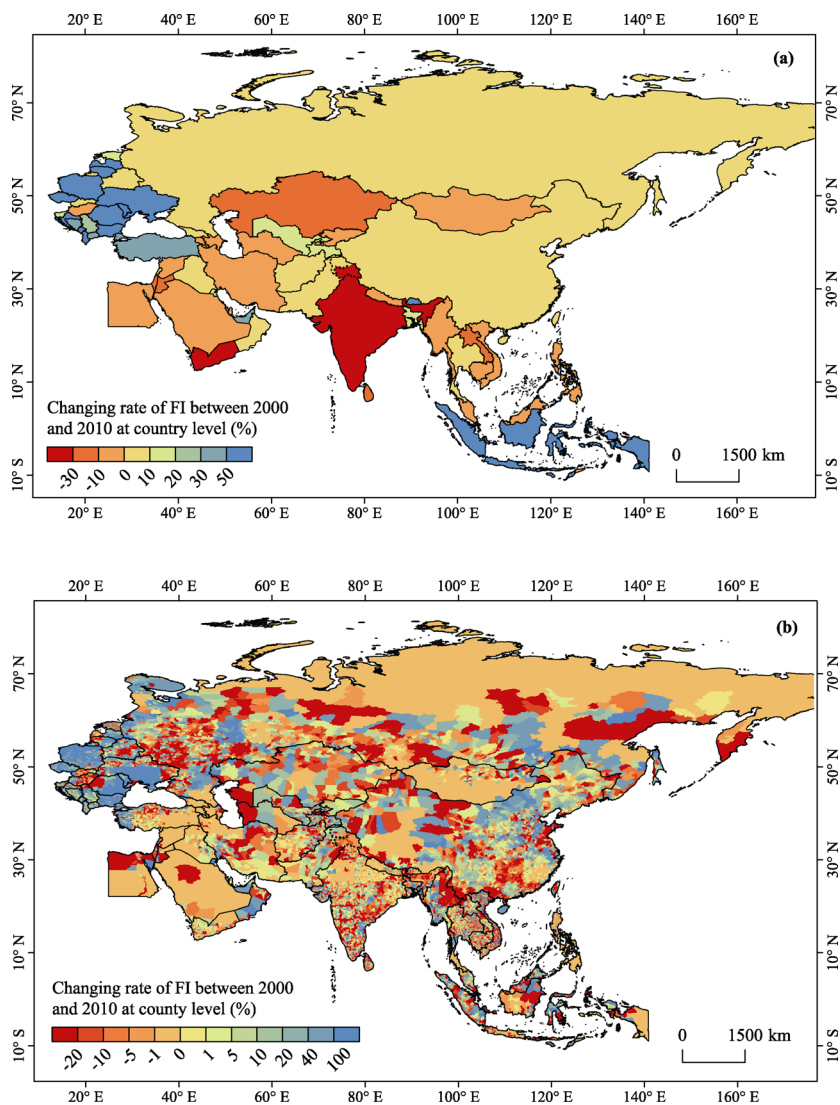


Figure 5 Changing rate of cultivated land fragmentation index in the BRI countries between 2000 and 2010 at country level (a) and county level (b)

The overall FI in the BRI countries increased 6.51% between 2000 and 2010. It shows a more obvious increase in the Central and Eastern Europe (+23.41%), yet in the Central Asia, South Asia, a decreased trend in FI was found, with a rate of -14.28% and -16.67% respectively (see Table S4 and Figure 5a). At the country scale, half of “the Belt” countries, including Israel, Kazakhstan, Saudi Arabia, had experienced a decrease in the cultivated land FI. The rates were -21.72%, -17.35% and -1.40% respectively. The same trend has been observed in two thirds of “the Road” countries, such as the Philippines (-8.32%), Myanmar (-8.26%), Vietnam (-7.46%). Coincidentally, the countries which located at the start and end of “the Belt” and “the Road”, including China, Russia, Belarus, Ukraine, had an increased FI

since 2000. In particular, China's FI increased 2.17% between 2000 and 2010, ranking 33rd among the BRI countries (Table S4). The changes within countries were varied as well. For example, in China, cultivated land became more fragmented in the Yangtze River Delta and Beijing-Tianjin-Hebei Region, but concentrated in parts of south China (Figure 5b).

4 Discussion

Between 2000 and 2010, net cultivated land decrease had only been observed in East Asia, where China had contributed to 98.98% of this net loss. The shrink of cultivated land in China was closely related to its urban expansion. It is reported that the newly expanded urban area between 2000 and 2010 was $3.76 \times 10^4 \text{ km}^2$ (Liu *et al.*, 2014), as twice as the amount in the previous decade (Wang *et al.*, 2012; Du *et al.*, 2014). Our results show that $3.62 \times 10^4 \text{ km}^2$ artificial land had been converted from cultivated land, which is close to the previous observations. In addition to urbanization, our study shows that $2.50 \times 10^4 \text{ km}^2$ cultivated land had been converted to forest, which accounts for the second source of cultivated land loss. However, Liu *et al.* (2014) showed that only $0.24 \times 10^4 \text{ km}^2$ cultivated land had been converted to forest. It is documented that the national level afforestation policy, known as "Green for Grain Project" that started from 1999, had afforested $9.27 \times 10^4 \text{ km}^2$ from cultivated land (Wu *et al.*, 2009). It indicates that more uncertainty exists when we observe the conversions between cultivated land and forest, although our result stands in the middle. In addition to the cross-study comparison, our analysis provides opportunities for inter-country comparison as well. Although it has been acknowledged that cultivated land loss in China is noticeable and would bring adverse consequences on food security and environmental sustainability (Wu *et al.*, 2014), the inter-country comparison suggests that such an issue is more severe than what we used to think, as none of its close neighbors experienced such obvious cultivated land losses. Therefore, it is hoped to stimulate stricter cultivated land protection policy in China.

Small and scattered land patches would probably result in landscape fragmentation. Consequently, the cultivated land FI as measured in our study might potentially relate to the field size of cropland as measured by Fritz *et al.* (2015). Four regions with relatively high FI are selected and compared with their field size, correspondingly. We could see a trend that locations with a higher FI are likely to have a smaller field size, which supports our hypothesis (Figure 6). However, such a qualitative comparison only stands at the visualization level, because the concepts, data, and methods are totally different from each other. Although Fritz *et al.* (2015) developed the world's first field size map that provides a potential for renovating the traditional agricultural land system studies, the results were largely relied on a crowdsourced campaign, which inevitably resulted in a coarse interpretation and limited reliability. Future studies in mapping global field size are anticipated to integrate various data and approaches to improve the accuracy and usability. The cultivated land FI derived from GlobeLand30 would be one of the potential contributors for this interest.

Cultivated land fragmentation is not efficient for commercial agriculture, as the costs for production, including labor, machinery, and management would increase dramatically due to the scattered land patches (Lu *et al.*, 2011). However, it shows potential advantages for smallholder agriculture, as it enables diversified planting of crops with limited investment,

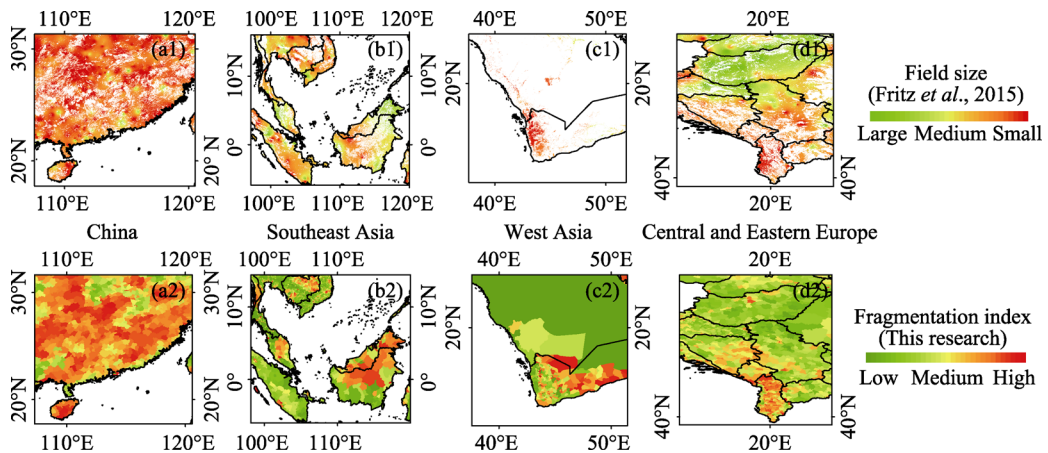


Figure 6 Comparison between fragmentation index and field size in hotspots from China (a, 1 and 2), Southeast Asia (b, 1 and 2), West Asia (c, 1 and 2), Central and Eastern Europe (d, 1 and 2)

which would reduce the risk of agricultural production in turn. The BRI is dominated by developing countries, and there used to be prevailing smallholder agriculture (Loayza *et al.*, 2010). Our analysis shows that the FI in many countries decreased, particularly in Southeast Asia. Those regions are likely experiencing drastic agriculture transformation, as shown by the less fragmented landscape. Large-scale land acquisition – the buying or leasing of large pieces of land for commercial agriculture – has been emerging as a global phenomenon since the 2000s, and has been intensively documented in Southeast Asia (Arezki *et al.*, 2011; Chen *et al.*, 2017). This transformation is partly reflected by our result as it captures the changes in cultivated land concentration in Laos and Vietnam. However, in contrast to Southeast Asia, FI has increased in some parts of China, Central and Eastern Europe, and West Asia. Noticeable cultivated land loss is also observed in these regions, e.g. to artificial land, grassland, and bare land, respectively. This implies that urbanization (Liu *et al.*, 2009; Liu *et al.*, 2014), land abandonment (Estel *et al.*, 2015; Meyfroidt *et al.*, 2016) and social conflicts (Yang *et al.*, 2009) played an even more important role in landscape change than agriculture transformation. The fragmented land tenure (i.e. use right) originated from the Household Responsibility System policy underlines the cultivated land fragmentation in China (Li *et al.*, 2003). Although China hopes to promote agricultural modernization through consolidating the land use right (Yu *et al.*, 2013), cultivated land loss due to urbanization has driven the landscape even more fragmented, which would pose negative effects on realizing this goal.

Agricultural cooperation is anticipated between China and the BRI countries through cultivated land use activities. One alternative is to optimize the use of cultivated land resource. Our study shows a prevailing conversion between cultivated land and grassland in Russia, Kazakhstan and Ukraine, confirming that cultivated land abandonment has substantially happened in Central and Eastern Europe (Meyfroidt *et al.*, 2016). On the other hand, this region would have large amount of potential cropland resources, as confirmed by Lambin *et al.* (2013) and Eitelberg *et al.* (2015). It is reported that China has invested 3.00×10^4 km² abandoned cultivated land in Ukraine. The “win-win” consequence is emerging through such cooperation: the agricultural investment from China provides necessary financial and tech-

nical assistance to Ukraine, while the food produced in Ukraine contributes to Chinese food security in turn (Ba, 2013). Russia had the world's largest chernozem (Li *et al.*, 2015), and Kazakhstan had abundant grassland resources (Zhang *et al.*, 2015), however, both of these countries are lack of population and their MCI are relatively low. As Ukraine is becoming China's largest overseas agricultural production base, similar model could be duplicated to these countries.

Another alternative is to share the advanced experience in cultivated land management. Our study shows that cultivated land area in Israel also decreased a lot (ca. -18.92%), but with an increase in MCI (ca. $+21.05\%$) and a decrease in fragmentation (ca. -21.72%). As Israel is famous for its irrigation technology (Tal *et al.*, 2016), the forementioned result suggests that agricultural production is not only determined by cultivated land quantity, which could also be improved by advanced agricultural technologies (Wu *et al.*, 2014). Israel's agricultural practices shed light on cultivated land management in China, especially for its vast western regions where agricultural productivity is relatively low due to the arid climate (similar to Israel). On the other hand, China's agricultural achievements, especially in its main breadbaskets (e.g. Northeast China, North China, and Lower Yangtze Plains), are worthy for improving cultivated land management in its adjacent Southeast Asia and South Asian countries, where cultivated land has increased significantly after the global food crisis in 2008 (Hong *et al.*, 2008, Sudaryanto *et al.*, 2009), yet the crop yield gap (Neumann *et al.*, 2010) and the cropping intensity gap, e.g. due to the relative low MCI against a relative high MCI potential (Wu *et al.*, 2018), are still largely existing. The optimized use of cultivated land resource and the sharing of advanced cultivated land management would sustain the China's agriculture "Go Out", and would eventually contribute to the sustainable agricultural development within the BRI.

It needs to be noted that this study cannot extend to a long period given that the GlobeLand30 contains only two land cover maps of 2000 and 2010. An amount of comparative studies show that GlobeLand30 has a higher accuracy than other global land cover datasets such as UMD-GLC, GlobCover2009, BU-MODIS, ESACCI (Liu *et al.*, 2015; Lu *et al.*, 2016; Chen *et al.*, 2017). The different data sources, definitions, classification schemes and methods, bring much inconsistency between these global land cover datasets, in particular in those regions with fragmented landscapes and small sizes of cultivated land (Cao *et al.*, 2016). It is thus not reasonable to combine these datasets for change studies as the heterogeneity of these datasets is far bigger than the changes of the real world. Extending the mapping period of GlobeLand30 or developing the latest global land cover map at GlobeLand30 or even higher resolution is of great importance for future global-scale land cover change analysis.

5 Conclusions

Between 2000 and 2010, cultivated land area in the BRI increased $3.73 \times 10^4 \text{ km}^2$. Russia ranks first with an increase of $1.59 \times 10^4 \text{ km}^2$ cultivated land area, which is followed by Hungary ($0.66 \times 10^4 \text{ km}^2$) and India ($0.57 \times 10^4 \text{ km}^2$). China ranks first with a decrease of $1.95 \times 10^4 \text{ km}^2$ cultivated land area, following by Bangladesh ($-0.22 \times 10^4 \text{ km}^2$) and Thailand ($-0.22 \times 10^4 \text{ km}^2$). In total, there are 25 countries having cultivated land area decreased,

comparing to 38 countries which have cultivated land area increased. Our analysis reveals that the total cultivated land area in the BRI increased slightly, which is the results of a noticeable cultivated land area loss in China in combination of an overall cultivated land increase in the other BRI countries. This implies that the negative consequence of cultivated land loss in China might be underestimated by the domestic-focused studies, as none of its close neighbors experienced such obvious cultivated land losses. Moreover, the land change matrix indicates that the cultivated land loss in China is mainly associated with the increases in artificial land, while the cultivated land increases in Southeast Asia and Central and Eastern Europe are mainly converted from forest and grassland. It implies that these regions – which experienced cultivated land increase – would have huge potential to increase food production, despite the cultivated lands are largely fragmented and extensively managed there. Given the challenges brought by cultivated land loss in China, not only a more rigorous domestic policy is needed to prevent further cultivated land loss due to urbanization, but also effective international collaborations are anticipated to optimize the use of cultivated land resources at the regional level. A potential solution would be strengthening the financial and technical assistance between China and the countries in Central and Eastern Europe and Southeast Asia to improve their food production through a more intensified cultivated land use management.

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References

- Arezki R, Deininger K, Selod H, 2011. What drives the global “land rush”? Policy Research Working Paper – World Bank, (5864). doi: 10.5089/9781463923334.001.
- Ba S, 2013. Ukraine will become China’s largest overseas farm, provides 3 million hectares of farmland. *People’s Daily*, <http://politics.people.com.cn/n/2013/0923/c70731-22997138.html>. (in Chinese)
- Cao X, Chen X, Zhang W *et al.*, 2016. Global cultivated land mapping at 30 m spatial resolution. *Science China Earth Sciences*, 46(11): 1426–1435. (in Chinese)
- Chen J, Chen J, Liao A P *et al.*, 2014. Concepts and key techniques for 30 m global land cover mapping. *Acta Geodaetica et Cartographica Sinica*, 43(6): 551–557. (in Chinese)
- Chen J, Chen J, Liao A P *et al.*, 2015. Global land cover mapping at 30 m resolution: A POK-based operational approach. *ISPRS Journal of Photogrammetry and Remote Sensing*, 103: 7–27.
- Chen W, Wu X, 2015. Import demand changes of the countries along the Maritime Silk Route and the response strategy of China. *International Economics and Trade Research*, 31(4): 87–100. (in Chinese)
- Chen X, Lin Y, Zhang M *et al.*, 2017. Assessment of the cropland classifications in four global land cover datasets: A case study of Shaanxi Province, China. *Journal of Integrative Agriculture*, 16(2): 298–311.
- Chen Y, Li X, Wang L *et al.*, 2017. Is China different from other investors in global land acquisition? Some observations from existing deals in China’s going global strategy. *Land Use Policy*, 60: 362–372.
- Cheng L K, Fleisher B M, Huang K X *et al.*, 2016. Three questions on China’s “Belt and Road Initiative”. *China Economic Review*, 40: 309–313.
- Coppedge B R, Engle D M, Fuhlendorf S D *et al.*, 2001. Landscape cover type and pattern dynamics in fragmented southern Great Plains grasslands, USA. *Landscape Ecology*, 16: 677–690.
- Du S, Shi P, Rompaey A. 2014. The relationship between urban sprawl and farmland displacement in the Pearl River Delta, China. *Land*, 3(1): 34–51.
- Duan F, Ji Q, Liu B *et al.*, 2017. Energy investment risk assessment for nations along China’s Belt & Road Initia-

- tive. *Journal of Cleaner Production*, 170: 535–547.
- Dubovyyk O, Menz G, Conrad C *et al.*, 2013. Spatio-temporal analyses of cropland degradation in the irrigated lowlands of Uzbekistan using remote-sensing and logistic regression modeling. *Environmental Monitoring and Assessment*, 185(6): 4775–4790.
- Eitelberg D A, van Vliet J, Verburg P H, 2015. A review of global potentially available cropland estimates and their consequences for model-based assessments. *Global Change Biology*, 21(3): 1236–1248.
- Erb K H, Haberl H, Jepsen M R *et al.*, 2013. A conceptual framework for analyzing and measuring land-use intensity. *Current Opinion in Environmental Sustainability*, 5: 464–470.
- Estel S, Kuemmerle T, Alcántara C *et al.*, 2015. Mapping farmland abandonment and recultivation across Europe using MODIS NDVI time series. *Remote Sensing of Environment*, 163: 312–325.
- Fritz S, See L, McCallum I *et al.*, 2015. Mapping global cropland and field size. *Global Change Biology*, 21(5): 1980–1992.
- Foley J A, 2005. Global consequences of land use. *Science*, 309(5734): 570–574.
- Foley J A, Ramankutty N, Brauman K A *et al.*, 2011. Solutions for a cultivated planet. *Nature*, 478(7369): 337–342.
- Forman R T T, 1995. Some general principles of landscape and regional ecology. *Landscape Ecology*, 10: 133–142.
- Gong B, Song Z, Liu W, 2015. Commodity structure of trade between China and countries in the Belt and Road Initiative area. *Progress in Geography*, 30(5): 571–580. (in Chinese)
- Gray J, Friedl M, Frohling S *et al.*, 2014. Mapping Asian cropping intensity with MODIS. *IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing*, 7(8): 3373–3379.
- Grekousis G, Mountrakis G, Kavouras M, 2015. An overview of 21 global and 43 regional land-cover mapping products. *International Journal of Remote Sensing*, 36(21): 5309–5335.
- He M, Huang Z, Zhang N, 2016. An empirical research on agricultural trade between China and “The Belt and Road” countries: Competitiveness and complementarity. *Modern Economy*, 7: 1671–1686.
- He Y, Lee E, Warner T A, 2017. A time series of annual land use and land cover maps of China from 1982 to 2013 generated using AVHRR GIMMS NDVI3g data. *Remote Sensing of Environment*, 199: 201–217.
- Hong K, 2008. The impact of global food crisis on Southeast Asian countries and China’s countermeasures. *Southeast Asian Studies*, (6): 31–35, 84. (in Chinese)
- Huang Y, 2016. Understanding China’s Belt & Road Initiative: Motivation, framework and assessment. *China Economic Review*, 40: 314–321.
- Islam M, Miah M, Inoue Y, 2016. Analysis of land use and land cover changes in the coastal area of Bangladesh using Landsat imagery. *Land Degradation & Development*, 27(4): 899–909.
- Kühling I, Broll G, Trautz D, 2016. Spatio-temporal analysis of agricultural land-use intensity across the western Siberian grain belt. *Science of the Total Environment*, 544: 271–280.
- Lambin E F, Gibbs H K, Ferreira L *et al.*, 2013. Estimating the world’s potentially available cropland using a bottom-up approach. *Global Environmental Change*, 23(5): 892–901.
- Li F, Dong S, Yuan L *et al.*, 2016. Study on agriculture patterns and strategy of the Belt and Road. *Bulletin of Chinese Academy of Sciences*, 31(6): 678–688. (in Chinese)
- Li J, Mancini M, Su B *et al.*, 2017. Monitoring water resources and water use from earth observation in the Belt and Road Countries. *Bulletin of the Chinese Academy of Sciences*, 32(Suppl.1): 62–73.
- Li X, Wang X, 2003. Changes in agricultural land use in China: 1981–2000. *Asian Geographer*, 22(1/2): 27–42.
- Liu J, Kuang W, Zhang Z *et al.*, 2014. Spatiotemporal characteristics, patterns and causes of land use changes in China since the late 1980s. *Acta Geographica Sinica*, 69(1): 3–14. (in Chinese)
- Liu J, Peng S, Chen J *et al.*, 2015. Knowledge based quality checking method and engineering practice of GlobeLand30 cropland data. *Bulletin of Surveying and Mapping*, (4): 42–48. (in Chinese)
- Liu J, Zhang Z, Xu X *et al.*, 2009. Spatial patterns and driving forces of land use change in China in the early 21st century. *Acta Geographica Sinica*, 64(12): 1411–1420. (in Chinese)
- Liu W, Dunford M, 2016. Inclusive globalization: Unpacking China’s Belt and Road Initiative. *Area Development and Policy*, 1(3): 323–340.
- Loayza N V, Raddatz C, 2010. The composition of growth matters for poverty alleviation. *Journal of Development Economics*, 93: 137–151.

- Lu M, Wu W, Zhang L *et al.*, 2016. A comparative analysis of five global cropland datasets in China. *Science China Earth Sciences*, 59(12): 2307–2317.
- Lu M, Wu W, You L *et al.*, 2017. A synergy cropland of China by fusing multiple existing maps and statistics. *Sensors*, 17(1613): 1–16.
- Lu X, Huang X, Zhong T *et al.*, 2011. A review of farmland fragmentation in China. *Journal of Natural Resources*, 26(3): 530–540. (in Chinese)
- Meiyappan P, Roy P, Sharma Y *et al.*, 2017. Dynamics and determinants of land change in India: Integrating satellite data with village socioeconomics. *Reg. Environ. Change*, 17(3): 753–766.
- Meyfroidt P, Schierhorn F, Prishchepov A *et al.*, 2016. Drivers, constraints and trade-offs associated with recultivating abandoned cropland in Russia, Ukraine and Kazakhstan. *Global Environmental Change*, 37: 1–15.
- Neumann K, Verburg P H, Stehfest E *et al.*, 2010. The yield gap of global grain production: A spatial analysis. *Agricultural Systems*, 103(5): 316–326.
- Ramankutty N, Evan A T, Monfreda C *et al.*, 2008. Farming the planet: 1. Geographic distribution of global agricultural lands in the year 2000. *Global Biogeochemical Cycles*, (22): GB1003. doi: 10.1029/2007GB002952.
- Sudaryanto T, 2009. Policy response to the impact of global food crisis in Indonesia. *Extension Bulletin – Food & Fertilizer Technology Center*, (624): 1–10.
- Tal A, 2016. Rethinking the sustainability of Israel's irrigation practices in the drylands. *Water Research*, 90: 387–394.
- Wang L, Li C, Ying Q *et al.*, 2012. China's urban expansion from 1990 to 2010 determined with satellite remote sensing. *Chinese Science Bulletin*, 57(22): 2802–2812.
- Wu F, Zhang H, 2017. China's Global Quest for Resources: Energy, Food and Water. Oxon, New York: Routledge, 5–6.
- Wu L, Liu Q, Li L, 2009. A review of the progress of the national Green for Grain Project. *Forestry Economics*, 9: 21–37. doi: 10.13843/j.cnki.lyjj.2009.09.007. (in Chinese)
- Wu W, Verburg P H, Tang H, 2014. Climate change and the food production system: Impacts and adaptation in China. *Reg. Environ. Change*, 14(1): 1–5.
- Wu W, Yu Q, Verburg P H *et al.*, 2014. How could agricultural land systems contribute to raise food production under global change. *Journal of Integrative Agriculture*, 13(7): 1432–1442.
- Wu W, Yu Q, You L *et al.*, 2018. Global cropping intensity gaps: Increasing food production without cropland expansion. *Land Use Policy*, 76: 515–525.
- Yan L, Roy D P, 2016. Conterminous United States crop field size quantification from multi-temporal Landsat data. *Remote Sensing of Environment*, 172: 67–86.
- Yang D, Cai J, Hull V *et al.*, 2016. New road for telecoupling global prosperity and ecological sustainability. *Ecosystem Health and Sustainability*, 2(10): e01242.
- Yang J, Sun J. 2009. Probing into the food security issues in the Arabian countries. *West Asia and Africa*, (11): 33–40. (in Chinese)
- Yu Q, Hu Q, van Vliet J *et al.*, 2018. GlobeLand30 shows little cropland area loss but greater fragmentation in China. *International Journal of Applied Earth Observation and Geoinformation*, 66: 37–45.
- Yu Q, van Vliet J, Verburg P H *et al.*, 2018. Harvested area gaps in China between 1981 and 2010: Effects of climatic and land management factors. *Environmental Research Letters*, 13: 044006.
- Yu Q, Wu W, Verburg P H *et al.*, 2013. A survey-based exploration of land-system dynamics in an agricultural region of northeast China. *Agricultural Systems*, 121: 106–116.
- Zhang Y, Chen J, Chen L *et al.*, 2015. Characteristics of land cover change in Siberia based on GlobeLand30, 2000–2010. *Progress in Geography*, 34(10): 1324–1333. (in Chinese)
- Zhang Y, Yang G, Yang Y, 2015. The Belt and Road strategy: To strengthen China and Central Asian agricultural cooperation opportunities. *Transnational Business*, (1): 31–43. (in Chinese)
- Zhao W, 2012. Arable land change dynamics and their driving forces for the major countries of the world. *Acta Ecologica Sinica*, 32(20): 6452–6462. (in Chinese)
- Zou J, Liu C, Yin G *et al.*, 2015. Spatial patterns and economic effects of China's trade with countries along the Belt and Road. *Progress in Geography*, 34(5): 598–605. (in Chinese)

Supplementary Material

Cultivated land change in the Belt and Road Initiative region

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Table S1 Countries in the “Belt and Road Initiative” (BRI) region

BRI	Geographical zone	Countries
China (the start) the Belt	East Asia	China
	East Asia	Mongolia
	Central Asia	Kazakhstan, Turkmenistan, Tajikistan, Uzbekistan, Kyrgyzstan
	West Asia	Armenia, Syrian, Lebanese, Afghanistan, Iraq, Kuwait, Jordan, Bahrain, Qatar, Georgia, Israel, Iran, Yemen, Saudi Arabia, United Arab Emirates, Turkey, Oman, Azerbaijan
the Road	Southeast Asia	Brunei, East Timor, Laos, Singapore, Cambodia, Myanmar, Thailand, Indonesia, Malaysia, Vietnam, Philippines
	South Asia	Maldives, Sri Lanka, Pakistan, India, Bangladesh, Nepal, Bhutan
	North Africa	Egypt
Central and Eastern Europe (the end)	Central and Eastern Europe	Estonia, Latvia, Lithuania, Belarus, Poland, Czech, Slovakia, Moldova, Hungary, Slovenia, Romania, Serbia, Ukraine, Bosnia and Herzegovina, Croatia, Bulgaria, Macedonia, Albania, Russia, Montenegro

Table S2 Cultivated land area change (10⁴ km²) and changing rate (%) of seven geographical zones and each country in the BRI region between 2000 and 2010

Geographical zone	Country	Area change	Area changing rate
East Asia	China	−1.95	−0.95
	Mongolia	−0.03	−2.00
	Subtotal	−1.98	−0.96
Central Asia	Kazakhstan	0.17	0.40
	Turkmenistan	0.17	4.87
	Tajikistan	0.02	1.86
	Uzbekistan	−0.06	−0.89
	Kyrgyzstan	0.02	0.92
	Subtotal	0.31	0.55
West Asia	Armenia	0.0001	0.02
	Syrian	−0.003	−0.04
	Lebanese	−0.02	−7.31
	Afghanistan	0.21	3.57
	Iraq	−0.001	−0.01
	Kuwait	0.001	2.39
	Jordan	−0.05	−11.18

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Geographical zone	Country	Area change	Area changing rate
	Bahrain	-0.00003	-0.96
	Qatar	0.00005	0.35
	Georgia	-0.01	-0.58
	Israel	-0.12	-18.92
	Iran	0.32	1.40
	Yemen	-0.04	-3.16
	Saudi Arabia	0.08	2.97
	United Arab Emirates	0.01	6.44
	Turkey	-0.04	-0.15
	Oman	0.02	10.50
	Azerbaijan	0.10	3.20
	Subtotal	0.44	0.52
Southeast Asia	Brunei	0.0006	15.83
	East Timor	0.0007	1.78
	Laos	0.24	12.24
	Singapore	0.0006	5.07
	Cambodia	0.28	4.78
	Myanmar	0.10	0.64
	Thailand	-0.22	-0.82
	Indonesia	0.42	1.67
	Malaysia	0.01	0.49
	Vietnam	0.21	1.68
	Philippines	0.003	0.05
	Subtotal	1.05	1.11
South Asia	Maldives	0.00	0.00
	Sri Lanka	0.06	3.28
	Pakistan	0.27	1.01
	India	0.57	0.29
	Bangladesh	-0.22	-2.53
	Nepal	-0.01	-0.25
	Bhutan	0.02	20.25
	Subtotal	0.69	0.29
North Africa	Egypt	0.35	8.75
	Subtotal	0.35	8.75
Central and Eastern Europe	Estonia	0.003	0.18
	Latvia	-0.03	-1.03
	Lithuania	-0.02	-0.47
	Belarus	-0.18	1.72
	Poland	-0.08	-0.39

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Geographical zone	Country	Area change	Area changing rate
	Czech	−0.003	−0.06
	Slovakia	−0.01	−0.42
	Moldova	0.003	0.12
	Hungary	0.66	11.69
	Slovenia	−0.004	−0.59
	Romania	0.39	2.98
	Serbia	0.01	0.13
	Ukraine	0.50	1.25
	Bosnia and Herzegovina	−0.01	−0.45
	Croatia	0.01	0.58
	Bulgaria	0.02	0.35
	Macedonia	−0.001	−0.15
	Albania	0.004	0.55
	Russia	1.59	1.02
	Montenegro	−0.0004	−0.15
	Subtotal	2.86	1.02
The BRI region	Total	3.73	0.39

Table S3 Share (%) of cultivated land converted into other land cover types, and other land cover types converted into cultivated land in the BRI region between 2000 and 2010

Geographical zone	Country	Cultivated land converted OUT				Cultivated land converted IN			
		(to) forest	(to) grass-land	(to) artificial surfaces	(to) bare land	(from) forest	(from) grass-land	(from) artificial surfaces	(from) bare land
East Asia	China	1.22	1.41	1.77	0.04	1.33	1.28	0.72	0.20
	Mongolia	0.04	5.21	0.02	0.01	0.08	3.22	0.01	0.04
	Subtotal	1.22	1.43	1.76	0.04	1.32	1.30	0.72	0.20
Central Asia	Kazakhstan	0.15	3.83	0.09	0.02	0.30	3.85	0.03	0.19
	Turkmenistan	0.02	4.05	0.61	0.50	0.13	3.16	0.65	5.32
	Tajikistan	0.04	2.86	1.40	0.28	0.10	3.44	1.18	1.31
	Uzbekistan	0.01	2.12	1.61	0.24	0.10	1.44	0.96	0.50
	Kyrgyzstan	0.01	0.85	0.56	0.05	0.13	1.62	0.13	0.37
	Subtotal	0.12	3.51	0.36	0.08	0.25	3.42	0.22	0.58
West Asia	Armenia	0.31	1.91	0.76	0.00	3.83	15.05	0.87	0.07
	Syrian	0.00	0.12	0.02	0.00	0.07	0.02	0.01	0.00
	Lebanese	0.97	8.80	0.51	0.19	0.97	1.50	0.80	0.16
	Afghanistan	0.01	3.31	0.16	1.03	0.11	2.66	0.10	4.66
	Iraq	0.02	0.05	0.02	0.11	0.01	0.03	0.02	0.10
	Kuwait	0.01	0.09	1.48	5.08	0.09	0.41	0.63	7.69
	Jordan	0.66	9.03	0.44	5.65	0.27	1.28	0.67	2.89
	Bahrain	0.00	0.00	1.93	0.00	0.00	0.00	0.99	0.00

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Geographical zone	Country	Cultivated land converted OUT				Cultivated land converted IN			
		(to) forest	(to) grass-land	(to) artificial surfaces	(to) bare land	(from) forest	(from) grass-land	(from) artificial surfaces	(from) bare land
	Qatar	0.05	0.35	0.25	3.43	0.02	0.20	0.04	4.05
	Georgia	0.73	2.24	1.13	0.00	4.84	4.25	0.92	0.00
	Israel	4.28	14.16	1.34	3.92	0.55	1.10	2.59	1.20
	Iran	0.06	1.67	0.22	0.85	0.14	1.80	0.16	1.34
	Yemen	0.10	1.17	0.08	2.93	0.10	0.11	0.15	1.08
	Saudi Arabia	0.01	0.09	0.50	4.75	0.06	0.36	0.23	7.26
	United Arab Emirates	0.04	0.00	0.85	3.98	0.14	0.02	0.24	10.11
	Turkey	0.55	1.17	0.20	0.00	0.49	1.12	0.11	0.00
	Oman	0.00	0.00	1.69	1.06	1.60	0.00	0.60	9.59
	Azerbaijan	0.22	2.40	0.70	0.00	1.61	11.83	0.71	0.02
	Subtotal	0.28	1.44	0.24	0.59	0.43	1.74	0.18	1.03
Southeast Asia	Brunei	4.78	0.06	0.09	0.00	7.52	0.45	9.95	0.00
	East Timor	1.05	8.61	0.00	7.17	10.52	6.46	0.82	0.43
	Laos	5.20	0.78	0.17	0.00	12.90	3.26	0.05	0.01
	Singapore	0.86	0.04	3.14	0.00	7.52	0.45	9.95	0.00
	Cambodia	0.24	0.06	0.16	0.00	3.50	0.51	0.17	0.00
	Myanmar	3.13	0.65	0.68	0.02	3.61	1.58	0.24	0.06
	Thailand	2.58	0.10	0.47	0.00	1.72	0.39	0.14	0.00
	Indonesia	3.07	0.29	0.42	0.00	4.89	0.27	0.46	0.00
	Malaysia	3.45	0.13	0.83	0.00	4.17	0.13	0.50	0.00
	Vietnam	2.96	0.97	1.04	0.01	4.18	1.56	0.70	0.10
	Philippines	0.98	0.11	0.22	0.02	1.12	0.18	0.19	0.01
	Subtotal	2.67	0.37	0.54	0.01	3.57	0.76	0.32	0.02
South Asia	Maldives	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Sri Lanka	4.46	0.03	0.18	0.00	5.48	1.76	0.32	0.09
	Pakistan	0.14	0.23	0.13	0.16	0.21	0.53	0.11	0.72
	India	0.30	0.29	0.16	0.09	0.49	0.31	0.11	0.08
	Bangladesh	1.89	0.13	4.13	0.05	0.30	0.15	2.64	0.25
	Nepal	1.26	0.19	0.05	0.01	0.99	0.12	0.05	0.08
	Bhutan	8.48	3.57	0.00	0.00	25.80	0.65	0.09	2.36
	Subtotal	0.39	0.27	0.30	0.09	0.51	0.33	0.20	0.16
North Africa	Egypt	0.07	0.02	1.29	2.21	0.03	0.01	0.84	10.26
	Subtotal	0.07	0.02	1.29	2.21	0.03	0.01	0.84	10.26
Central and Eastern Europe	Estonia	1.89	0.48	0.46	0.00	2.05	0.20	0.50	0.00
	Latvia	3.07	0.10	0.36	0.00	1.74	0.03	0.37	0.00
	Lithuania	2.15	0.08	0.67	0.00	1.45	0.03	0.65	0.00
	Belarus	3.62	1.32	1.01	0.00	1.50	0.97	1.06	0.00

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Geographical zone	Country	Cultivated land converted OUT				Cultivated land converted IN			
		(to) forest	(to) grass-land	(to) artificial surfaces	(to) bare land	(from) forest	(from) grass-land	(from) artificial surfaces	(from) bare land
	Poland	1.09	0.16	0.69	0.00	0.95	0.04	0.40	0.00
	Czech	1.74	0.05	0.77	0.00	1.62	0.08	0.69	0.00
	Slovakia	0.80	0.01	0.75	0.00	0.45	0.01	0.65	0.00
	Moldova	0.65	0.73	1.14	0.00	0.33	0.85	1.43	0.00
	Hungary	0.71	0.03	0.49	0.01	0.66	0.16	0.39	0.00
	Slovenia	4.76	0.02	1.13	0.01	4.23	0.03	0.81	0.01
	Romania	1.00	0.13	0.91	0.01	1.00	0.12	0.96	0.02
	Serbia	1.04	0.05	0.44	0.00	0.99	0.29	0.37	0.00
	Ukraine	0.89	0.74	0.74	0.00	0.61	1.83	0.84	0.01
	Bosnia and Herzegovina	3.11	0.06	0.50	0.01	2.65	0.07	0.39	0.01
	Croatia	1.35	0.02	0.61	0.04	1.47	0.02	0.58	0.04
	Bulgaria	0.97	0.13	0.75	0.01	1.13	0.22	0.78	0.01
	Macedonia	1.45	0.05	0.53	0.00	1.54	0.05	0.35	0.00
	Albania	1.20	0.73	0.48	0.01	1.42	0.86	0.58	0.03
	Russia	1.10	2.05	0.34	0.00	1.23	2.57	0.32	0.02
	Montenegro	2.28	0.19	0.64	0.00	2.38	0.23	0.40	0.00
	Subtotal	1.22	1.33	0.52	0.00	1.13	1.76	0.50	0.01
The Belt region	Subtotal	0.21	2.27	0.28	0.39	0.35	2.41	0.19	0.85
The Road region	Subtotal	1.04	0.30	0.38	0.09	1.38	0.45	0.25	0.25
The BRI region	Total	1.01	1.13	0.70	0.10	1.14	1.30	0.41	0.26

Table S4 Changing rate (%) in multi-cropping index, and fragmentation index of seven geographical zones and each country in the BRI region between 2000 and 2010

Geographical zone	Country	MCI changing rate	FI changing rate
East Asia	China	6.01	2.17
	Mongolia	27.77	−2.82
	Subtotal	6.06	2.16
Central Asia	Kazakhstan	22.71	−17.35
	Turkmenistan	−2.76	−8.55
	Tajikistan	0.62	15.53
	Uzbekistan	1.45	14.44
	Kyrgyzstan	−3.21	−2.20
	Subtotal	14.72	−14.28
West Asia	Armenia	4.11	−0.34
	Syrian	6.40	−0.97
	Lebanese	−5.49	3.82
	Afghanistan	20.06	2.13

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Geographical zone	Country	MCI changing rate	FI changing rate
	Iraq	-1.76	0.95
	Kuwait	87.13	19.41
	Jordan	32.04	-21.81
	Bahrain	36.26	13.58
	Qatar	-29.94	0.00
	Georgia	-45.10	1.62
	Israel	21.05	-21.72
	Iran	18.88	-0.28
	Yemen	41.95	-49.59
	Saudi Arabia	-30.48	-1.40
	United Arab Emirates	-11.03	36.70
	Turkey	-9.60	34.67
	Oman	-19.38	3.42
	Azerbaijan	19.35	-1.89
	Subtotal	2.21	4.19
Southeast Asia	Brunei	-25.74	22.88
	East Timor	20.44	-1.78
	Laos	23.36	-16.52
	Singapore	49.09	-40.20
	Cambodia	54.40	-2.88
	Myanmar	39.15	-8.26
	Thailand	15.37	1.09
	Indonesia	24.42	52.22
	Malaysia	9.30	-6.67
	Vietnam	7.55	-7.46
	Philippines	9.39	-8.32
	Subtotal	20.40	10.47
South Asia	Maldives	0.00	0.00
	Sri Lanka	7.03	-12.32
	Pakistan	2.13	3.66
	India	8.82	-30.71
	Bangladesh	8.16	10.11
	Nepal	7.44	-0.57
	Bhutan	-22.18	129.89
	Subtotal	7.98	-16.67
North Africa	Egypt	2.35	-5.91
	Subtotal	2.35	-5.91
Central and Eastern Europe	Estonia	-24.44	9.85
	Latvia	16.04	58.77
	Lithuania	-6.02	69.96

(To be continued on the next page)

(Continued)

Geographical zone	Country	MCI changing rate	FI changing rate
	Belarus	-9.55	3.59
	Poland	-7.45	133.17
	Czech	-16.51	89.39
	Slovakia	-11.25	6.66
	Moldova	-11.01	75.19
	Hungary	-20.58	-9.42
	Slovenia	0.79	17.63
	Romania	-4.76	60.83
	Serbia	93.08	28.88
	Ukraine	3.38	77.19
	Bosnia and Herzegovina	2.53	38.88
	Croatia	-24.36	74.29
	Bulgaria	2.76	113.41
	Macedonia	-15.55	34.42
	Albania	24.88	63.98
	Russia	-24.33	6.40
	Montenegro	-28.60	89.90
	Subtotal	-13.44	23.41
The BRI region	Total	4.27	6.51

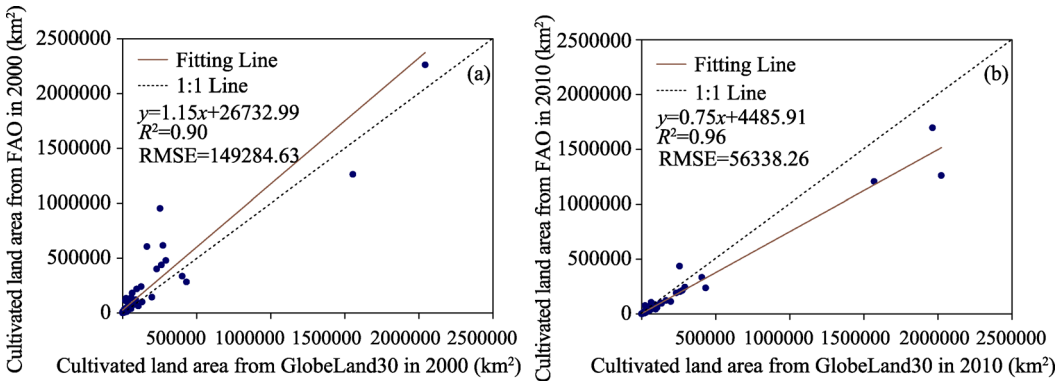


Figure S1 Comparison between the cultivated land area of GlobeLand30 and FAOSTAT in 2000 (a) and 2010 (b)

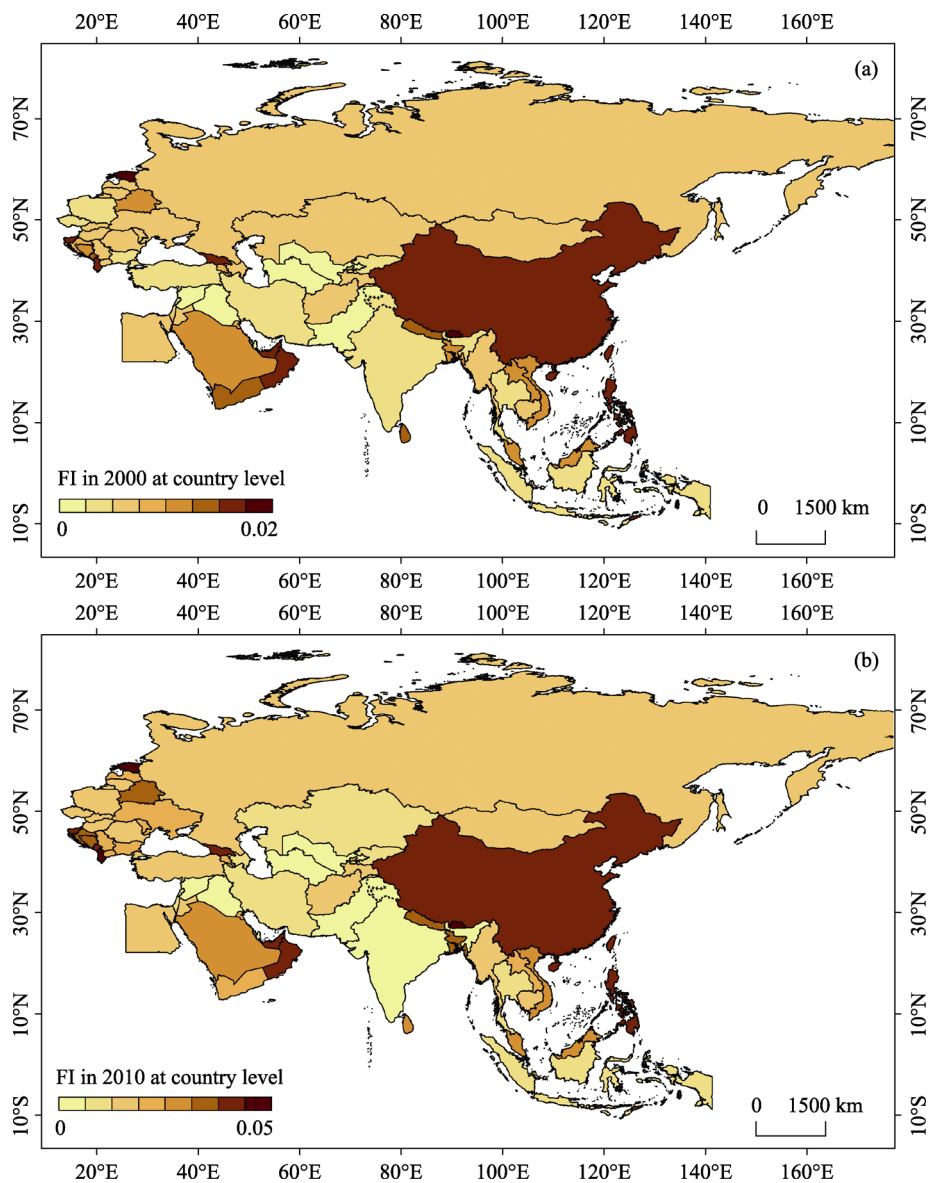


Figure S2 Fragmentation index of cultivated land in 2000 (a) and 2010 (b) in the BRI region at a country level

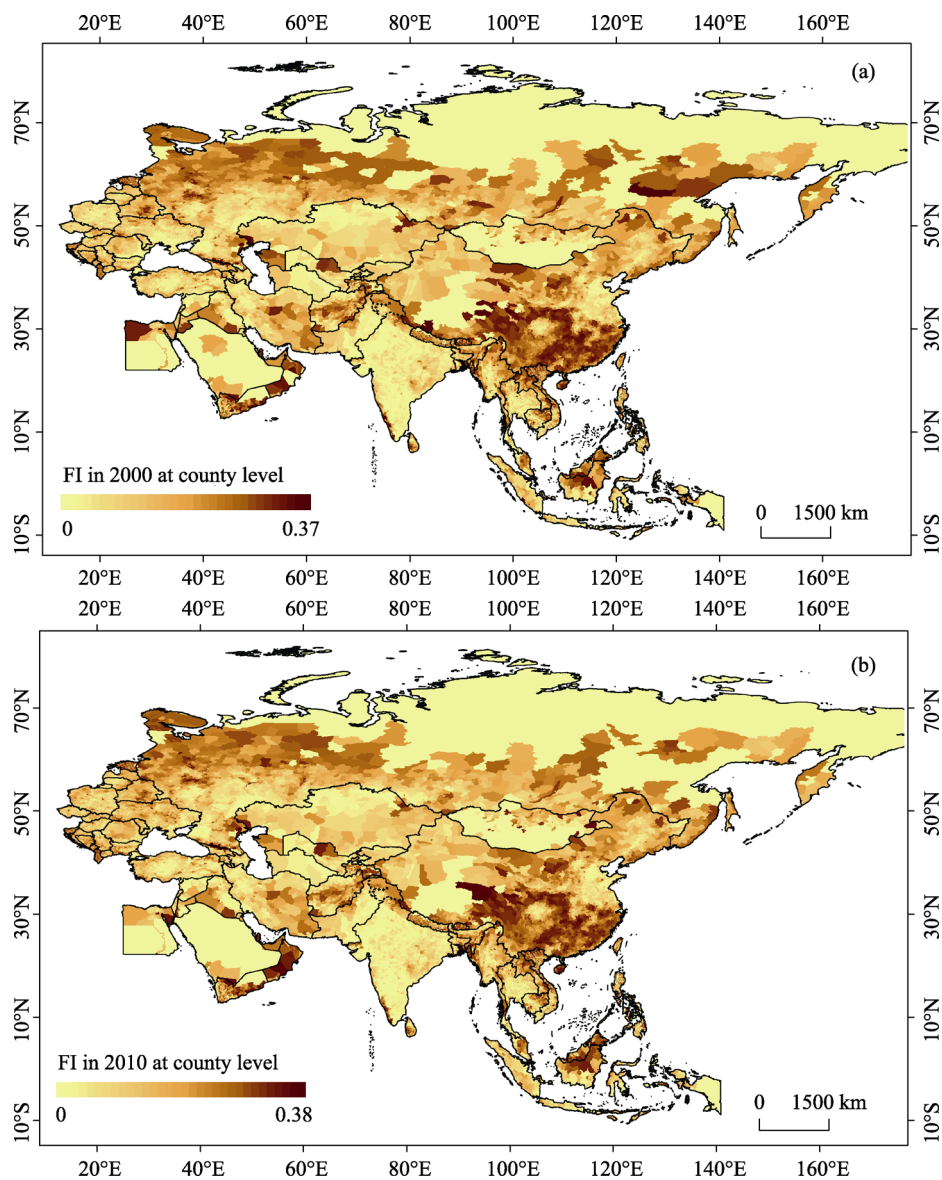


Figure S3 Fragmentation index of cultivated land in 2000 (a) and 2010 (b) in the BRI region at a county level