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Crop Intensity as an Indicator of Agricultural Transformation in Urbanizing Bhagwanpur Tehsil, Haridwar (Uttarakhand)

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Abstract:

This paper examines the effects of urbanisation on crop intensity and agricultural land use in Bhagwanpur Tehsil, Haridwar (Uttarakhand) based on Sentinel-2 Level-2A surface reflectance images on the year 2021. The main aim of the study was to examine the effect of urbanisation on agricultural activity and intensity of crop production in a fast-urbanising area. The study estimated crop intensity values at the tehsil by developing seasonal NDVI composites of three agricultural seasons, namely, Zaid, Kharif, and Rabi, and using thresholds of crop presence. The results show that urbanisation had a varying effect on crop intensity with peri-urban areas experiencing increased crop intensity brought about by the intensification caused by the demand in the urban areas and central urban areas experiencing reduced crop intensity brought about by the transformation of land into built-up lands. The paper also puts emphasis on the importance of infrastructure and market access in enhancing agricultural intensification in peri-urban areas. This study contributes to the significance of agricultural transformation by emphasising the use of crop intensity as a tracking measure of agricultural transformation valuable to urban planners, policymakers, and agricultural stakeholders. It highlights how vital it is to have integrated planning in order to harmonise urbanisation and agricultural sustainability.

Keywords: Urbanization, Crop Intensity, Bhagwanpur Tehsil, Agricultural Transformation, Sentinel-2, Land Use.

Introduction:

Urbanisation has a huge implication on land use and agricultural practise. The example of Bhagwanpur Tehsil, Haridwar (Uttarakhand) demonstrates that the rapid urbanisation has resulted in observed changes in the landscapes of the agricultural areas. The process of urbanisation which entails increase in infrastructure, population and industrialization usually results in development of agrarian lands into residential, commercial and industrial areas. This change in land use patterns is not only a physical change but also leads to alteration in agricultural activities, especially in regard to crop intensity in relation to the ratio of the area under cropping to the net sown area (Chand, 2020). This paper will set to explore the effect of urbanisation in the Bhagwanpur Tehsil on crop intensity, which in effect affects agricultural transformation.

Crop intensity can be used as a convenient measure of the productivity of agricultural production and the efficiency of land use. In the countryside, it is a measure of how hard the

land is utilised to cultivate crops, which is usually impacted by irrigation, soil fertility, and availability of markets (Singh, 2019). With urbanisation, the farmland is affected and it is put under pressure resulting in diminished farm activities. On the other hand, peri-urban areas might experience agricultural intensification where farmers in the areas embrace more intensive farming practises in order to satisfy the increased demand of food and raw materials. Accordingly, crop intensity can be used to determine how far agricultural activities are adapting to urbanisation (Gupta & Sharma, 2020).

The development of urbanisation i.e. intrusion of cities in Bhagwanpur Tehsil has a positive and negative outcome on agricultural activities. Increased crop intensity in the rural areas can be promoted by increased food and agricultural products demands in the urban areas. Nevertheless, the development of land to residential and industrial areas as well as the lack of labour to work in agricultural areas usually results in a reduction in agricultural land and, therefore, in the decrease of crop intensity. Crop intensity analysis can thus give some useful information as to how urbanisation affects the way farming is done in the Bhagwanpur Tehsil.

The main aim of the research is to examine the correlation between urbanisation and crop intensity in the Tehsil of Bhagwanpur, Haridwar. The study will entail a significant amount of data to the policymakers, urban planners and even the stakeholders who are involved in the impact of urban development on farming and crop production. In addition, it will help lead to a wider grasp of the multifaceted processes between urbanisation and agricultural revolution, particularly in the fast growing areas such as Bhagwanpur. This study intends to bring out the challenges and opportunities brought by urbanisation and its impact on the sustainability of agriculture.

Literature of Review:

Crop intensity has been an established concept regarding the agricultural land use and especially concerning the process of urbanisation and its effects on agricultural activities. Crop intensity is the ratio of cropped area to the net sown area that gives an indicator of the intensity at which land is utilised to produce crops. Urbanisation has been well-known as a relevant factor in the agricultural land use patterns and has been shown to affect the crop intensity differently based on the specifics of the region (Chand, 2020).

Bhatia (2015) states that in terms of urbanisation, when the urban land grows, farms are usually turned to residential, commercial, or industrial use, which shrinks the overall number of lands that can be cultivated. The overall effect of this urban intrusion is the degradation in crop intensity whereby, the arable land is lost and land occupation alters to non- agricultural activities. Nevertheless, Sahu et al. (2019) indicate that in peri-urban areas, the nearness to urban centres may contribute to the rise in intensity of crop production because of the need of local food production and improvement of market, infrastructure, and technology.

A study by Suresh (2017) in the Delhi-NCR area revealed that urbanisation resulted in a major change in agricultural activities in the area. The region also had intensification and de-intensification effects as there was the need to serve the expanding urban population and urban sprawl respectively. This is the impact of urbanisation experienced in most urbanising areas,

usually, due to water, workforce, and the introduction of modern farming methods (Suresh, 2017).

Singh (2018) on the other hand observed how urbanisation affects crop intensity in rural Punjab. The study ended by concluding that although urbanisation resulted in the change in land-use, the agricultural productivity and the intensive of the crop production were comparatively steady owing to the governmental support as well as an increased technological level in the farming activities. This shows that urbanisation does not have the same level of effects on crop intensity and that it could be highly different depending on local policy, infrastructure and resource accessibility.

In their research, Gupta and Sharma (2020) examined the agricultural land change in the peri-urban centres of Haridwar and discovered that due to its urbanisation proximity, the agricultural land was transformed to commercial agriculture, which increased crop intensity. They established that intensive agricultural activities were usually practised in regions that had greater accessibility to irrigation and markets, yet encountered environmental problems like the depletion of ground water.

Rai et al. (2016) have highlighted the importance of technological innovation in determining the intensity of crops in urbanising areas. Their research has brought to the fore the role played by the use of modern methods of farming like drip irrigation, varieties with high yield, and the use of machines in ensuring that the adverse effects of urbanisation are offset especially in those regions where land is scarce but the agricultural products required are in high demand. These innovations have enabled farmers to withstand or even enhance crop intensity despite the urban pressure.

Kumar and Mehta (2018) examined impacts of infrastructure in urban centres and its externalities to agriculture. The researchers discovered that in some of the areas, the increase in crop intensity among farmers in the peri-urban areas was due to improvement in infrastructure i.e. better transportation networks that helped farmers minimise losses incurred after harvest and facilitated their accessibility to broader markets. Conversely, crop intensity declined in regions where urbanisation resulted in land fragmentation because there was no cohesion in agricultural practises.

Chowdhury et al. (2020) studied how land use change affects crop intensity in the fast-urbanising district of Howrah in West Bengal and discovered that urban growth has resulted in loss of farmland as well as in intensive agricultural activities in the urban outskirts. The paper indicates that whereas the intensity of crop may rise in peri urban areas as a result of urban pressure, it reduces in urban centre regions where agriculture can no longer be practised.

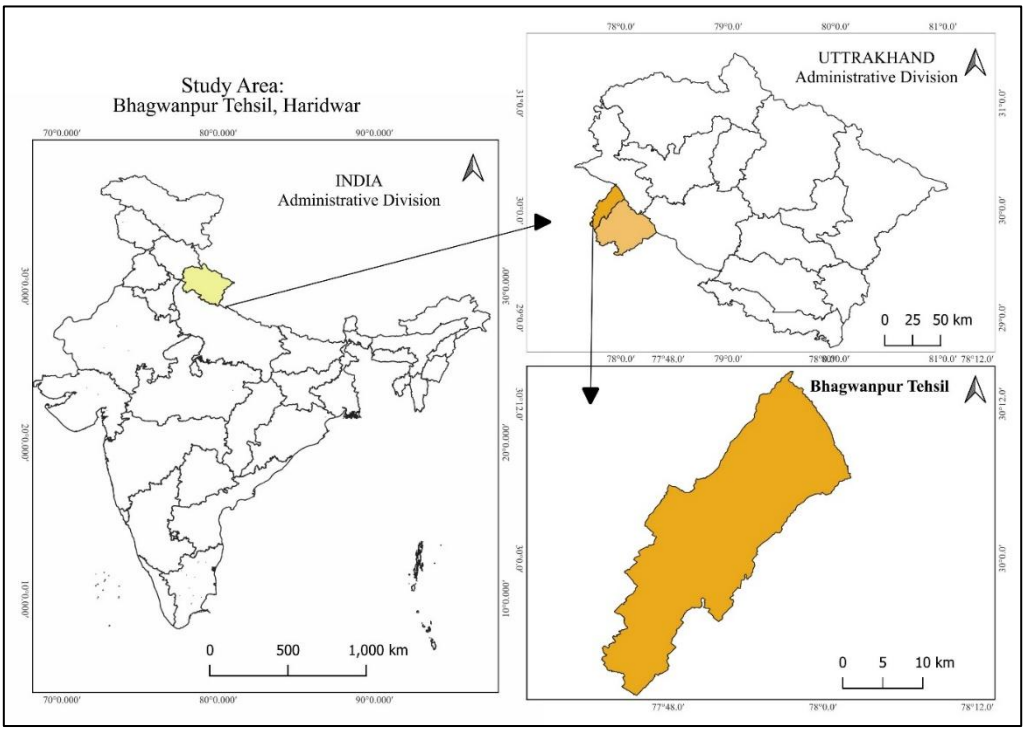
Regarding the land use and its implications on agricultural transformation, Pandey (2019) investigated the influence of the urban sprawl in transforming the mode of farming in the state of Uttar Pradesh. His research established that urban sprawl was a cause of erosion of fertile farming land leading to decreased agricultural production and diminished crop intensity in the main city areas. This has been caused by the fact that urban expansion has led to more competition in the land and water resources.

Finally, Sharma (2021) carried out a study on how local agricultural policies can be used to reduce the adverse effects of urbanisation on crop intensity. The research discovered that supportive policies, including subsidised irrigation, availability of high-yield seed varieties and training on newer practises of agriculture could help to maintain crop intensity despite the accelerated urbanisation. It also highlighted the need to ensure that urbanisation does not have drastic impacts on agricultural productivity by role of the government.

Study Area:

The Bhagwanpur Tahsil of the Haridwar district of Uttarakhand is the area of great agricultural and socio-economic value, with a powerful subject of urban and rural residents. In 2011 Census, the tahsil had a population of 228,583, and the population density of the tahsil has been rising, since 2001 (where it was 4,953 people per square kilometer), which is evidence of rapid urbanization. The area has been experiencing a slow urbanization and agricultural production is still the major activity even as industrial activities have increased since the neighboring city of Haridwar.

Figure 01: Study Area map



Source: Prepare by QGIS Using SOI Data.

Agricultural sector of the tahsil relies extensively on the use of traditional farming methods and rain-fed irrigation practices, which dominates the 90 percent mountainous region, and the rest 10 percent of the land area is the Tarai plains where commercial agriculture is also practiced at a greater scale. The phenomenon of urbanization has however resulted in agricultural lands being converted into built in regions which has made the traditional agricultural activities to be difficult to sustain. Population is heterogeneous, and both the male population and the female population are engaged in agricultural and industrial development, whereas the gender ratio

stands on 880 per 1,000 males, which means that the socio-economic processes continue to be active in the region. Rural settlements of the region are in the process of profound change, where demographic pressures are placing more pressure on the land, infrastructure, and services, which leads to the additional land-use change.

Objectives:

1. To study the changes in crop intensity in Bhagwanpur Tehsil due to urbanization.
2. To understand how urban growth has affected agricultural land use and crop intensity in Bhagwanpur Tehsil.

Data Base and Methodology:

The research paper writing process started with the literature review, which conducted an extensive literature review to find out the available researches on crop intensity, urbanisation, and their effects on agricultural land use. In this introductory part, the relevant literature was used to support the mentioned scholars such as Chand (2020), Gupta and Sharma (2020), and Bhatia (2015) and develop a theoretical premise of the impact of urbanisation on the process of agriculture. The study was then shifted to data collection where Sentinel-2 Level-2A surface reflectance data of the year 2021 was used to measure crop intensity in Bhagwanpur Tehsil. The satellite data was pre-treated by eliminating the cloud-contaminated pixels with the help of Scene Classification Layer (SCL), and seasonal NDVI composites of Zaid, Kharif, and Rabi were created. Crop intensity was determined based on finding the presence of crops at an NDVI threshold of 0.30 and adding the presence of crops between the seasons to obtain crop intensity values ranging between 0 to 3.

Urban and water areas were excluded in the crop intensity map after processing the data and analysis of the results by masking methods with the help of NDBI, NDVI, and NDWI. The results were projected in a crop intensity map that gave a visual representation of crop intensity distribution in Bhagwanpur Tehsil. The discussion section has given a reflection of the impacts of urbanisation on agricultural land use and crop intensity on which parallels were drawn with the existing literature. Lastly, the conclusion was the summary of the research findings, and it highlighted the importance of crop intensity as one of the indicators of agricultural transformation in the urbanising areas. Around several analysis, interpretation and revision, the whole writing experience was taken through repeated analysis, interpretation and revision so that the paper was communicating the relationship between the urban growth and the agricultural change in a clear manner.

Table 01: Data of Crop in intensity in Bhagwanpur Tahsil with Class

Sr. No.	Class_Name	Area_sqkm	Percentage
1	Single crop	33.21730923	6.37
2	Double crop	76.94690337	14.75
3	Triple crop	196.0546238	37.59
4	Permanent vegetation	181.5992203	34.82

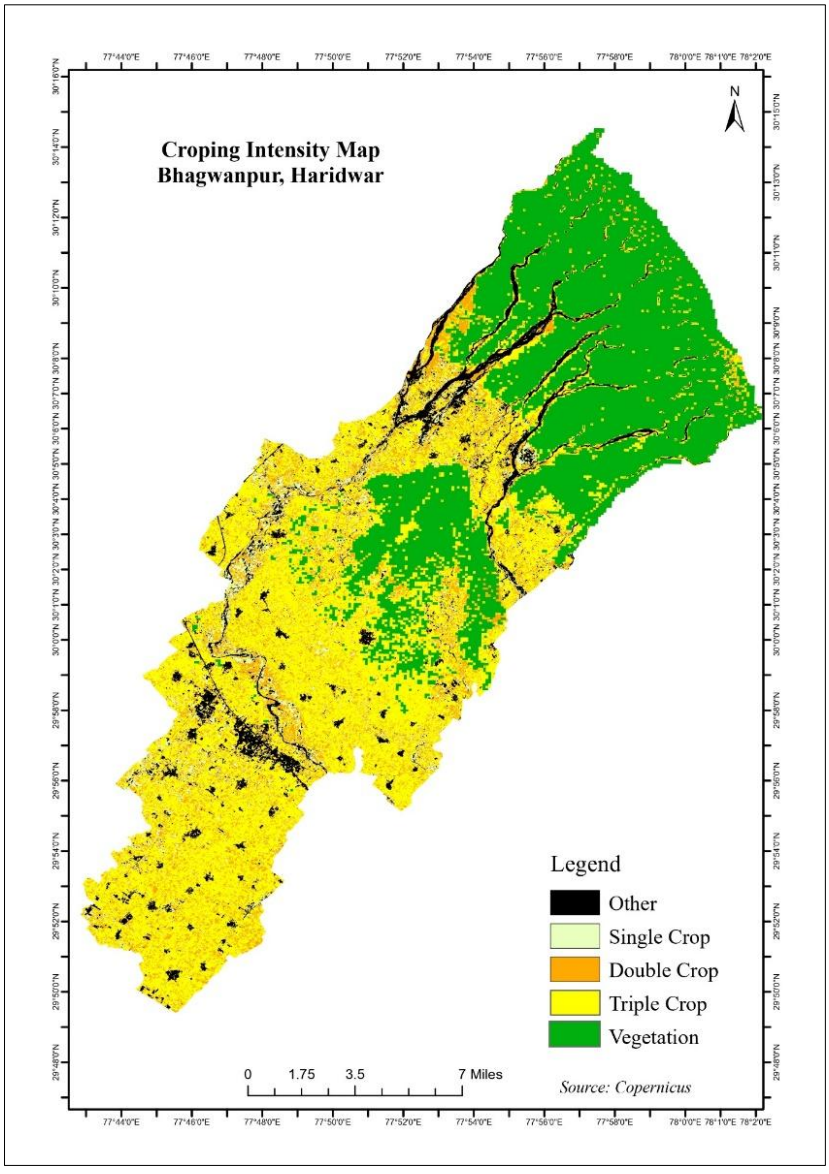
5	Other area	33.74675842	6.47

Source: Data Calculated from Sentinel-2 Level-2A surface reflectance data for the year 2021.

Result and Discussion:

The aim of the study was to examine the alterations in crop intensity in the Tehsil of Bhagwanpur as a result of urbanisation and to have a clue on how urbanisation has impacted the agricultural land use and the crop intensity in the area. Sentinel-2 Level-2A surface reflectance data of 2021 were analysed to obtain the crop intensity values of three important agricultural seasons: Zaid (March -June), Kharif (June -October), and Rabi (November - March). The findings bring to the fore the impact of urbanisation process on agricultural activities in Bhagwanpur Tehsil and there are wide disparities in the extent of crop intensity in different regions.

Figure 02: Crop Intensity Map of Bhagwanpur Tahsil



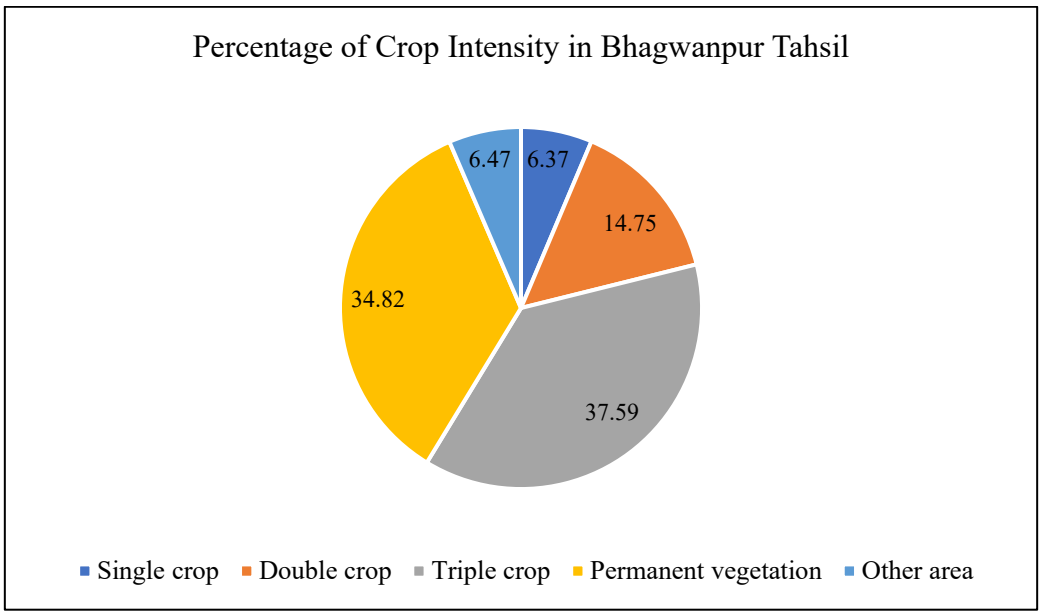
Source: Prepare by QGIS Using *Sentinel-2 Level-2A surface reflectance data for the year 2021.*

The Crop intensity class in Bhagwanpur Tehsil are visually represented as the crop intensity map (Figure 2) that was created based on the processed Sentinel-2 data. It is evident that the area of triple crops (37.59) is the largest, which implies the existence of considerable locations within the area that are highly engaged in intensive agriculture activities. This is especially witnessed in regions that have more access to irrigation and fertile soil as well as close to urban areas where agricultural products have high demand. Contrastingly, single crop (6.37) and double crop (14.75) intensities also represent less intensive agricultural practises, probably because of the lack of irrigation facilities, pre-modernised agricultural systems, and the intrusion of urbanisation.

Effects of Urbanisation on Intensity of Crop:

The results indicate that in Bhagwanpur Tehsil urbanisation is simultaneously affecting crop intensity. Urbanisation on the one hand is causing agricultural intensification in some regions especially those near urban centres. These peri-urban regions are more and more being drawn under the intensification process as farmers are engaging more efficient farming methods in order to satisfy the rising demand of food and raw materials in urban regions. Regulations visibly can be seen in the intensity of crop map (Figure 2) where agricultural land is still available is the area around urban zones and these areas experience intense crop intensity more especially in triple crop regions.

Figure 03: Pei diagram of Crop Intensity in Bhagwanpur Tahsil with Percentage



Source: Data extracted from Table No.01

Conversely, urbanisation process is causing reduction in the intensity of crops in regions that are more impacted by land reclamation to residential, commercial, and industrial purposes. The consequence of this transformation has been land fragmentation that decreases the possibility of continuous agricultural land and hinders intensive farming. With urban sprawl taking over agricultural lands, the area that is under cultivation reduces, and crop intensity decreases especially in regions that had been part of bigger agricultural areas.

Agricultural loss and Permanent Vegetation:

The existence of permanent vegetation (34.82) in the study area indicated by Table 1 illustrates the areas of land that are left fallow or use of such land is not agricultural. This group comprises of forests, conservation land or any other form of land that is not used to produce crops. The majority of the permanent vegetation implies that large percentages of Bhagwanpur Tehsil is not actively involved in crop production, which could be because of land conversion to urbanisation or natural vegetation conservation. Urbanisation has been mostly linked with loss of agricultural land since agricultural land is turned into urbanised areas to be used as residential areas, industrial estates, and other construction projects.

Conversely, other regions (6.47%) could include the areas which are under non-crop agricultural activities, which include fallow and lands that have been temporarily abandoned because of urban pressure. Urbanisation causes the disappearance of agricultural land, population growth, and urban development, which pose a scenario whereby farming activities become more challenging to be maintained especially in those regions where urban sprawling is great.

Agricultural Intensification in the Peri-Urban Areas:

In spite of the problems of urbanisation, however, the study also indicates that in peri-urban regions, urban proximity is increasing crop intensity. This is more so in the triple crop regions where farmers are utilising the intensive methods of farming to deal with the demand that has significantly risen to obtain food and other agricultural commodities. This aspect is consistent with the report by Gupta and Sharma, (2020), who noted that urban centres tend to have a positive effect on agricultural intensification since they have more access to the market, better infrastructure, and access to more effective farming technologies.

The research however also found infrastructure development as a key element in increasing the crop intensity. Regions that have experienced better irrigation systems, road network and access to markets have experienced higher productivity in agriculture. Indicatively, in areas close to the Tarai plains, where commercial agriculture is more prevalent, the availability of double crop and triple crop areas is probably associated with improved irrigation and availability of urban markets to the people, which make it easy to adopt more intensive agriculture.

The Urban Sprawl problems to Crop Intensity:

Urban sprawl has led to a loss of agricultural land and this is a major problem to Bhagwanpur Tehsil. With the growth of the urban areas, huge pieces of fertile arable land are being turned into residential, commercial, and industrial areas. This observation negates the results of Bhatia (2015) who pointed out that urbanisation can be accompanied by the decrease in the intensity of crops since the land used on farms are encroached. This data also indicates that regions with the strongest urban increase exhibit lower crop intensity especially in regions where single crop farming is the dominant practise.

Land conversion is also a cause of land fragmentation, hence, farmers are unable to carry out intensive agricultural activities. Urban expansion has exerted strain on the agricultural sector,

which has resulted in a change in the way farming is done and low agricultural productivity in some regions. This is indicative of the general concern of urban sprawl adversely affecting agricultural production as explained by Suresh (2017) and Pandey (2019).

Conclusion:

The researchers point out that there is a complicated correlation between urbanisation and intensity of crop in the Tehsil of Bhagwanpur. It has been indicated that although urbanisation benefits agricultural intensification in the peri-urban areas, it simultaneously causes agricultural intensities to decrease in the urbanising areas because of the conversion and fragmentation of land. These shifts are represented in more detail as the crop intensity map (Figure 2) indicates that there is more crop intensity in peri-urban regions and less in urbanised regions. The results are consistent with the available literature concerning the impact of urbanisation on agriculture, which confirms that urbanisation leads to both intensification and deintensification of agricultural activities, based on the local circumstances, existence of infrastructure, and distance to urban centres. These findings highlight the necessity of urban and agricultural planning to reduce the negative impacts of urbanisation on crop intensity and make agricultural practises sustainable in the midst of the rapid growth of urban centres. This paper can be of great help to policy makers, city planners, and agricultural stakeholders who are interested in finding a balance between urbanisation and farming agricultural land and sustainable agriculture.

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