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Tankers and Differential Resilience in Horticultural Farming: Evidence from Maharashtra, India

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Abstract

This study analyses differential resilience among horticultural farmers in Maharashtra, India. Based on a primary survey of 290 farmers across four villages in Jalna district, we find that farmers in the region shifted to grape cultivation over the past two decades as it provided a higher and more stable income compared to cotton. The recent years has seen depletion of groundwater table, a common pool resource and the primary source of irrigation for the farmers. In building resilience against groundwater risks, farmers resorted to water imports to satisfy irrigation requirements. With this background, we analyze the factors that affect tanker water use and the returns thereof. Our paper finds that intensity of tanker water use is inversely related to farm size indicating higher intensification of water imports among smallholding farmers. Our production function analysis indicates that both tanker use and expenditure on tanker water has no relation to horticultural production. Given the higher dependence on horticulture among the small and marginal farmers and that these farmers use tanker water extensively with no significant returns to production, our paper posits a case of differential resilience among farmers in the region.

JEL Codes: Q120 Micro Analysis of Farm Firms, Farm Households, and Farm Input Markets

Q150 Land Ownership and Tenure; Land Reform; Land Use; Irrigation; Agriculture and Environment

Q250 Renewable Resources and Conservation: Water

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Abstract: *This study analyses differential resilience among horticultural farmers in Maharashtra, India. Based on a primary survey of 290 farmers across four villages in Jalna district, we find that farmers in the region shifted to grape cultivation over the past two decades as it provided a higher and more stable income compared to cotton. The recent years has seen depletion of groundwater table, a common pool resource and the primary source of irrigation for the farmers. In building resilience against groundwater risks, farmers resorted to water imports to satisfy irrigation requirements. With this background, we analyze the factors that affect tanker water use and the returns thereof. Our paper finds that intensity of tanker water use is inversely related to farm size indicating higher intensification of water imports among smallholding farmers. Our production function analysis indicates that both tanker use and expenditure on tanker water has no relation to horticultural production. Given the higher dependence on horticulture among the small and marginal farmers and that these farmers use tanker water extensively with no significant returns to production, our paper posits a case of differential resilience among farmers in the region.*

1. Introduction

Indian agriculture has been growing slowly in the recent years. This is a significant concern as there is still a large population in the country which is dependent on agriculture.[1] Such a slow movement of labour from agriculture despite a reduction in share of agriculture in output is sometimes referred to as 'stunted' structural transformation (Binswanger, 2012). A slow growth and a stunted structural transformation has led to an agrarian crisis despite the country not facing any agricultural production crisis (Mishra, 2006). There has been substantial efforts towards improving the incomes of the farmer. Most of these efforts have emphasized the need for farmers to diversify into non-farm sectors for employment or to high-value agriculture like horticulture. In particular, efforts towards horticultural diversification have been underscored ever since the Tenth Five Year Plans 2005-06, whilst improving nation's nutritional security.

Studies evaluating the impact of the National Horticultural Mission (NHM) conclude that the effects are positive and encouraging. The area under fruit production increased from about 5 million to 6.5 million hectares in 2005-06 to 2019-20. The yields are impressive too with an average tonnage of 12.49 per hectare compared to a tonnage of 2.23 hectare in food grain production. A third of the sectors contribution to gross value add is from horticulture. The top two states with the highest share of land under horticultural production are the states of Maharashtra and Andhra Pradesh, allocating 12 % and 11% of the total agricultural land respectively (appendix 1). Notably, more than 70% of the land in these states are categorised as semi-arid, the continued success of horticultural crop production here is unclear.

[1] As of 2019, there is still about 49% dependent on agriculture in India.

The challenges to improving crop diversification is not homogenous across all parts of the country and the semi-arid dry regions in particular face certain peculiar issues. These are a fragile ecosystem characterized by degraded natural resources, and supports livelihoods of a significantly large proportion of small holding farmers. A vicious cycle of poor productivity, leading to poor income, poor ploughing back of investment in land and water resources, foster a downward spiral of poor productivity (Kerr, 2007). The situation is further accentuated by rising climate risks – increased volatility in rainfall received and dry spells. The micro-watershed development programmes are among the more promising solutions to the problems of dryland agriculture as it works to rejuvenate the natural resource system through various soil and water conservation treatments. The late 1990s marked the beginnings of these projects, prior to which conservation works were only planned at the river basin and sub-basin scale and not the smallest hydrogeological unit a micro-watershed (Shah, 2009). Trial projects were implemented at a scale by NGOs working on reducing rural poverty (Joshi et al., 2004, Symle et al., 2014) , but soon the model was adopted and supported by national policies (Bhandari et al., 2007, GoI, 2008). Terraces, contours, check dams and percolation tanks constructed to develop the irrigation potential of groundwater (Joshi et al. 2009, Wani et al., 2009). Successful implementation of the programme increased the overall soil moisture level and the water tables within the micro-watershed. Farmers valued investing in wells for irrigation.

The improvement in irrigation availability lead to agricultural intensification and vice-versa. Ownership of wells increased, to ensure per drop efficiency horticultural crops were grown only under drip-irrigated conditions, and farm ponds became characteristic to horticultural farming in the region. The ponds would collect the rainfall run off from the farms at the farm level to supplement groundwater irrigation. Nevertheless, this model agricultural intensification has pushed the limits of carrying capacity of groundwater (Prasad and Sohoni, 2019). As model of transitioning from cultivating only rainfed commercial crops to integrating it with high value crops had become a common knowledge, more and more arable land were converted to horticultural farms. To keep pace with increased demand and completion for irrigation, the ponds were filled with groundwater pumped out from the wells in during monsoons in addition to collecting the field run-off (Kale, 2017). Further, there were certain specified dimension for the ponds setting its storage capacity when it was introduced, but now there are several dimension of it.

Such mismanagement of groundwater has reduced water availability for irrigation despite having wells and farm ponds. Farmers now depend of water imports via tankers to irrigate the horticultural plots. This water comes at an additional cost to farmers, particularly in the summer. Our study investigates the burden of increasing costs of irrigation through tanker usage in the district of Jalna, Maharashtra. We investigate the following aspects of water imports through tanker use in fours villages of the study district. Irrigation sufficiency determines crop productivity, but is the higher cost of irrigation due to importing water using tankers compensated by higher incomes? Are farmers lockedup in another vicious circle of high investment and limited to option of cultivating only high value horticultural crops to be economically viable? Given that groundwater is a common pool resource and finite in its availability, is the water import using tankers building differential resilience among different categories of farmers?

Our study finds that *that intensity of tanker water use is inversely related to farm size indicating higher intensification of water imports among smallholding farmers* with a commensurate increase in returns from agriculture. The novelty of this study is its explicit focus of use of tanker water in horticultural crop production and its findings are relevant to groundwater management in semi-arid regions of India.

2. Methodology:

The data for this study was collected through a primary survey conducted in the year 2019-20. We surveyed 290 farmers across four villages from the Jalna district of Maharashtra. The survey collected data on agricultural production, ownership of irrigation assets i.e. wells and farm ponds, cost of cultivation, and the prices of farm produce, along with information on demography and socio-economics. The choice of the study villages were arrived at in consultation with the agricultural extension office, *Krishi Vigyan Kendra* (KVK), Jalna. The team has been collaborating with KVK Jalna for various projects since the 2017. The sample population were selected from groups stratified by land size, and covered about 12 to15% of the village population. Details on the ownership and distribution of the land in the villages were collected from the *Thesil* office. The sample confirmed to the pattern of land distribution in land registry.

All the four villages were covered under various micro-watershed development programmes. Village 1 is one among first village communities in the state to participate in the Indo-German Watershed Development Programme (IGWDP). The project began in 1996 and concluded in 2002 involving extension community consultation and engagement as the idea of micro-watershed development was then new. The communities had no prior experience of uptake of conservation activities and management of groundwater. The other three villages were convinced of the benefits of watershed progrmmes inspired by the success story of village 1. After a wait of nearly 10 years since the village 1, the watershed in the other three villages were developed under the Integrated Watershed Development Programme (IWDP). The villages are close neighbours and share common boundaries with each other. In the sample 67.5% of farmers allocated land to horticultural cultivation.

Table 1: Study villages and the sample size

	Sample Size	Horticultural farmers
Village 1	85	69
Village 2	92	53
Village 3	48	33
Village 4	65	41
Total	290	196

The tanker expenses in the region varied from 5,000 INR to about 8,80,000 INR, with average expenditure of 49,000INR per year. Not all horticultural farmers did spend on tanker. Given the nature of the dependent variable with some of the entries taking a zero value and the others exhibiting a range of values, Truncated regression technique was applied to determine the causal relationship. The expense is modelled as a function of land and ownership of irrigation assets, both the access to irrigation through ownership of wells and the capacity to store irrigation.

$$Tanker\ exp = f(Landcat, Sh\_HLand\ lnFP, Wells)$$

Tanker exp = Per horticultural acre tanker expense in agricultural year 2019-20

Landcat = categorical variable, base category = farmer with <2.5 acres, 1 = 2.5 to < 5 acres, 2 = 5 to <10 acres, 3 = ≥10 acres

Sh_HLand = share of land under horticultural cultivation

lnFP = natural log of total farm pond capacity

Wells = number of wells

Subsequently, an Ordinary Least Square regression estimate was performed to the relevance of water imports in securing horticultural production. Tanker expenses is modelled as a factor input in along with the other factors inputs of production (Takeshima et al, 2017).

$$\ln\_Pdt = f\ (\ln\_Age, \ln\_Hland, \ln\_Hlab, ln\_Tank, \ln\_FPcap, Wells, \ln\_Ins., \ln\_Fer, \ln\_Man.)$$

ln_Pdt = natural log of horticultural production

ln_Age = age of the horticultural plot

ln_Hland = natural log of horticultural land of the total agricultural land

ln_Hlab = natural log household farm labour

ln_Tank = natural log of total tanker expenditure in the agricultural year 2019

ln_FPcap = natural log of farm pond capacity installed

Wells = number of privately owned wells

ln_Ins = natural log of insecticide cost that year

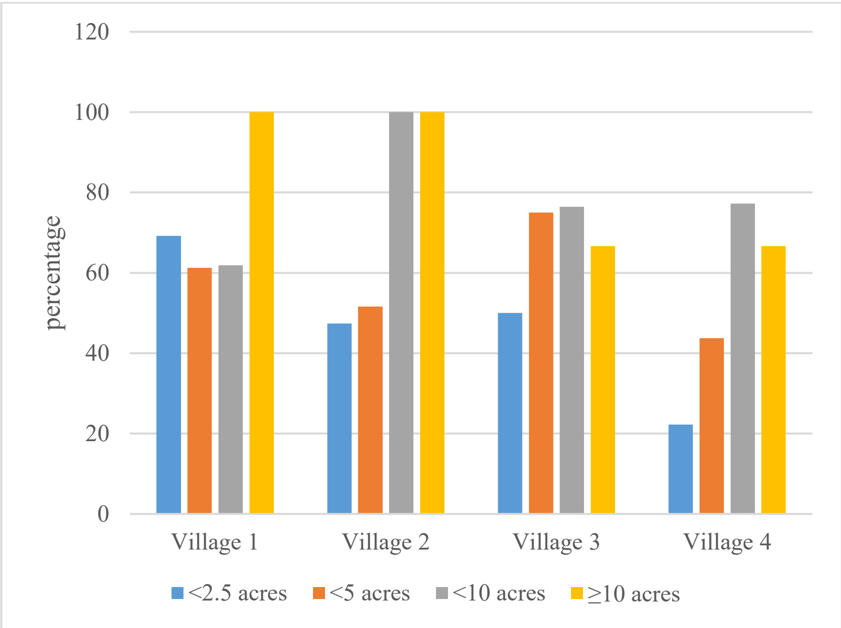
ln_Fer = natural log of fertilizer cost that year

ln_Man = natural log of manure cost that year

3. Results

Horticultural adoption across all the study villages are high, 81.17% , 60.22%, 68.75 % in and 54.66% in villages 1, 2, 3 and 4 respectively (Figure 1). Adoption is higher among farmers with large land holdings, but marginal and smallholding farmers too are keen on horticulture. Grape is the primary horticultural produce. In the early phase post-watershed development crops of sweet lime, pomegranate and grapes were trialed. Grapes emerged as the most commercially successful produce. Traders procure the produce from the farm gate at spot prices.

Figure 1: Horticulture adoption across land holding sizes and study villages



An inverse relationship between the share of land under horticultural adoption and land holding category can observed. On an average, small holding farmers allocated 65% of their total cultivated land to horticulture while farmers with 10 and more acres of land allocated only 40% of the land to horticultural farming (Table 2). A minimum of an acre of land seem to be the viable plot size for horticultural plot development.

Table 2: Share of land allocated to horticulture across land holding sizes and the study villages

	Village 1	Village 2	Village 3	Village 4
<2.5 acres	63.72	80.09	71.83	100*
< 5 acres	57.11	52.7	53.7	51.15
<10 acres	43.24	34.04	43.28	47.19
≥ 10 acres	41.68	47.45	35.17	52

**(of the 9 farmers in this category, 2 are horticultural adopters with 100% of land under horticulture)*

The other commercial crops cultivated are cotton, soybean and a variety of lentils, namely *Toor dal, Moong dal and Urid dal*. Cotton too is procured at the farm gate, and farmers have an opportunity to stagger the sale of this produce to opportunities presented by the market prices. Lentils are usually transported to the nearest agricultural market – the Jalna Agricultural Produce Market Committee (APMC).

Table 3: Horticultural production, incomes and tanker expense across villages

	Average horticultural yield (quintals/acre)	Average horticultural production (quintals/acre)	Average tanker expense (INR)	Average tanker expense per acer	Average net income from horticulture (INR)
<2.5 acres	54.45	75.67	39,348.80	31,344.40	1,03,564
< 5 acres	45.76	100.17	34,771.70	20,642.40	88,689.70
<10 acres	64.23	175.5	47,812.50	19,078.30	3,29,008
≥ 10 acres	76.33	386.5	96,250	15,436	8,86,829

An inverse relationship is observed between yield and land category. Average yield increased by about 10 quintals/ acre from the category of marginal farmers to that of the larger farmers (≥10 acres) with an exception of category 2 of farmers (<5 acres). Tanker expenses are show a proportional relationship with land category. The average tanker expense to marginal framers are INR 31,344 and this number reduces to half for large landholdings. Finally, the average net income increased by 3 times and 7.5 times for category 3 and 4 farmers compared to category 1 (Table 3).

Table 4: Tobit regression results - marginal effects

Tobit regression	Number of observations =193				LR chi2(5) =7.87	
	Uncensored = 117				Prob > chi2 = 0.1636	
Limits:	Left censored = 76				Pseudo R2 = 0.0083	
	Right censored = 0					
Lntanker/acre	Coef.	Std. Err.	t	P>|t|	[95%	Conf. Interval
Landcat						
2 (< 5 acres)	-3.1858	1.6350	-1.95	0.053*	-6.4114	0.0397
3 (< 10 acres)	-4.4634	1.7761	-2.51	0.013**	-7.9673	-0.9596
4 (≤ 10 acres)	-4.8999	2.2182	-2.21	0.028**	-9.2759	-0.5239
Sh_Hland	-1.3348	1.1788	-1.13	0.259	-3.6603	0.9906
No. of well(s)	-0.6339	0.9915	-0.64	0.523	-2.5899	1.3220
FP capacity	0.0531	0.1592	0.33	0.739	-0.2609	0.3672
_cons	13.0015	5.0832	2.56	0.011	2.9736	23.0294
var (e.logtanker)|	57.7600	8.5399			43.1467	77.3212

The expenditure on tanker per acre by category 1 or the marginal farmers are the highest among the four categories. Based on marginal effects estimation, we find that the category 2 farmers spent 318% lesser than category 1 farmers. The category 3 and category 4 farmers spent 446% and 489%

lesser than the category 1 farmers. This indicates a high level of intensification with regard to tanker water use among marginal farmers. A higher share of land under horticultural production may result in higher dependence on tanker water. Similarly, the ownership of well(s) and farm pond capacity is likely to dampen tanker expense, but no statistically significant results were estimated. This imply that, the large landowners with a higher chance of owning multiple wells and allocating a larger share of their land to construction of farm ponds, are depended on tanker water to meet their full irrigation requirements. They too experience the stress of the groundwater resource system. The system is stressed when water harvested from the groundwater table is more than the recharge.

In testing whether tanker expense have become a vital agricultural input, the OLS regression results (Table 5) suggest that it is not yet a fixed component of factor inputs, result not statistically significant. The number of wells too are not statistically significant, but this could also be because of the lack of information on the productivity of wells owned. The model could be improved potentially by incorporating information on well depth. Farm pond capacity created does determines production performance, statistically significant at 8%. Adding a meter cube or 1000 water storage capacity can increase production by 8%. The field notes does read that farmers see the expense on tankers as a wasteful expenditure and are more keen to build up water storage capacities to avoid the tanker expenses. Some were of the opinion that they are happy to invest in storage capacities three times more as advised by the agricultural office KVK to be certain.

The production function confirmed the proportional relationship between land and production. A unit increase in the land increased grape production by 120 % and 150% for farmers belong to categories 3 and 4. The performance of category 2 farmers (< 5 acres) did not differ significantly from that of the marginal farmers. Maturity of crop is another factor contributing to production. An increase in maturity by a year will increase production by 146%.

Among factor inputs of fertilizer, insecticide, and manure, the organic input of manure positively influenced production. A unit increase in manure cost (by 10,000 INR) will see an 18% increase in production. Assuming that manure is relatively less expensive, a more or less homogenous product and locally available, the costs are akin to the usage of the product. Other regenerative agricultural practices such as soil mulching was observed as widely practiced. Cost of fertiliser and insecticide were insignificant.

Table 5: OLS regression estimates of the production function

Source	SS	df	ms	Number of obs	193
Model	277.447	12	23.1206	F(12, 180)	6.55
Residue	635.159	180	3.5286	Prob > F	0.0000
Total	912.606	192	4.7531	R-squared	0.3040
				Adj R-squared	0.2576
				Root MSE	1.8785

lnPdt	Coef.	Std.Err.	t	P>|t|	[95%	Conf.Interval]
Landcat						
2	0.591222	0.385856	1.53	0.127	-0.17016	1.352604
3	1.218876	0.391988	3.11	0.002**	0.445393	1.99236
4	1.549055	0.503006	3.08	0.002**	0.556508	2.541603
No of wells	-0.0117	0.238802	-0.05	0.961	-0.48291	0.459512
lnTanker	-0.00065	0.02651	-0.02	0.98	-0.05296	0.051657
lnFPcap	0.079648	0.037807	2.11	0.037**	0.005046	0.15425
Expcat	1.462581	0.305126	4.79	0.00**	0.860496	2.064666
lnFercost	-0.14011	0.096799	-1.45	0.15	-0.33112	0.050896
lnInsectcost	0.137006	0.109483	1.25	0.212	-0.07903	0.353041
lnManucost	0.187366	0.089551	2.09	0.038**	0.010661	0.364072
lnLabcost	-0.00254	0.102655	-0.02	0.98	-0.2051	0.200021
lnHLab	0.308543	0.309072	1	0.319	-0.30133	0.918414
_cons	-1.72382	0.951796	-1.81	0.072	-3.60194	0.154289

Horticulture is labour intensive. Seasonal labour is hired during the harvesting season, participation of household labour is also high. The vineyards require dedicated attention and frequent supervision. Farmers report that they have moved their residence closer to the vineyards to be able to offer the careful attention these crops require. Further, some said that horticultural crop diseases are very quick to spread and affects production significantly. It is matter of few hours from the spotting of the disease that pesticides or insecticides be applied. Nevertheless, both the variables labour cost and households contribution to agriculture measured only in terms of number of people contributing to labour and not in hours of work, did not produce statistically significant results.

4. Discussion

The study presents a case of a region where villages have shifted to horticultural crops in pursuit of higher and more stable incomes. The micro watershed projects in the region have provided farmers with farm ponds, an essential infrastructure to manage irrigation for cultivation. Following initial successes with this model of cultivation, there is an emerging ground water crisis which is questioning the viability and sustenance of this model. Farmers have responded to this emerging situation by using water imports through tanker usage. Our study finds that this situation has resulted in a scenario where the marginal and small farmers use tanker water extensively for production. This is anticipated given their reduced access to ground water and smaller farm pond capacity. However, the more concerning finding is that use of tanker water does not lead to increased production. This means a situation where a larger burden of increased costs are spent by small and marginal farmers without commensurate returns. The findings underscore existence of differential vulnerabilities and resilience across different categories of farmers.

The marginal and the small holding farmers are the most affected by the rising cost of irrigation. The alternative cash crop is cotton, but it yields an average income of about 30,000 INR to these farmers. They are at a cross roads deciding to cultivate rainfed cotton or to cultivate grapes by incurring a higher farm investment supported by agricultural loans. The preference to cultivate horticultural crop also arises from the need to mitigate climate risks. In a year of poor rainfall, cotton yields suffer while horticultural incomes can be secured by water imports. The results highlight the importance of groundwater management. The non-separation of land right from water rights challenges the sustainable use of this resource. Proliferation of wells and storage of groundwater in ponds can lead to depletion of watertables. In shallow aquifers, the depletion may be reversible, but in hard rock regions, such possibilities are limited with consequence on availability of even drinking water. Farming is a community enterprise and that social skills should to turn towards management of groundwater. Preparation of water budgets – monitoring, allocating and regulating – though is hard to achieve, cannot be overlooked. The objective of farm diversification and intensification, both need to satisfied to earn well out of the farming system.

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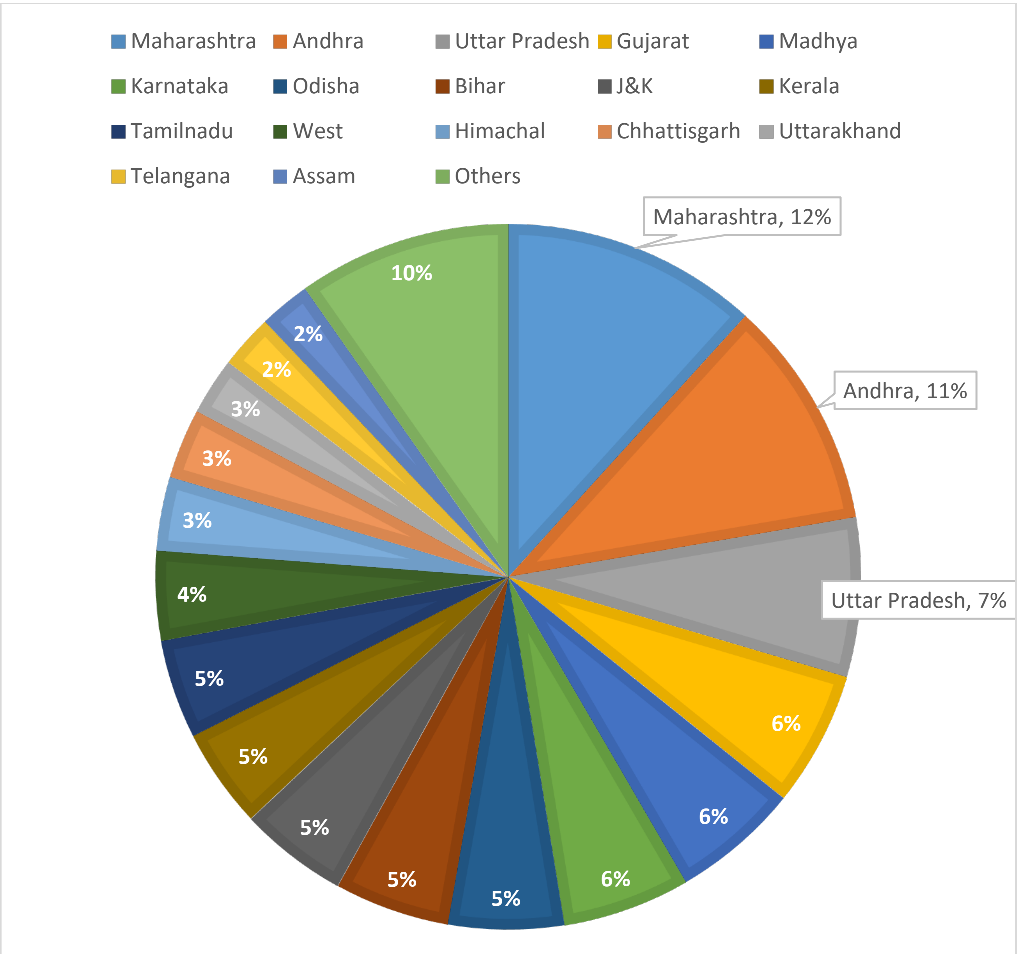
Appendix 1: Area under horticultural crop production in India



Source: Agricultural Statistics at a glance, 2021.