LOOKING AHEAD AT INDIAN AGRICULTURE AND THE AGRARIAN ECONOMY

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The share of agriculture in the Indian economy is shrinking as measured by its contribution to GDP but agriculture remains essential for two reasons. First, India is a large country, and I believe that we cannot rely on imports to ensure the basic food needs of 1.38 billion persons. Secondly, there are over a 100 million rural households with operational land holdings (as per SAS 2018-19), and around 93 million agricultural households. Village-level evidence shows that irrespective of the share of agricultural income in total income, over 90 per cent of households resident in rural areas participate in agriculture in some form (be it as a cultivator or working as a field labourer or by cattle-raising). Thus, both from the perspective of employment as well as consumption, from the perspective of producers and consumers, agriculture remains vital to the Indian economy and requires our urgent attention.

This lecture is motivated by deep concerns about the ability of the agricultural economy in its present form to meet the challenges of production and food security in the context of climate change.[1]

Productivity concerns

My first concern relates to the precariousness of present levels of productivity and productionand its implications for ability to meet food requirements of the country.

Available demand-supply projections for major food crops in India, such as by Praduman Kumar, PK Joshi and S Mittal (2016) predict, with the exception of rice and wheat, major shortages for pulses, edible oils, sugar, vegetables, fruit and meat in 2030. The demand-supply gap or shortfall is estimated to be 2.1 million tonnes for edible oils and 1.2 million tonnes for meat.

[1]I thank Soham Bhattacharya, Kaushik Bora, Deepak Johnson, and S. Niyatifor their inputs.

Today, we need to factor in the effects of climate change – long term trends such as in temperature as well as increasing incidence of climate extremes – on these predictions. Kumar, Joshi and Aggarwal (2014) have estimated the effect of droughts on supply and demand of major crops. While there is no predicted shortage of rice in a scenario of normal rainfall, there is a deficit of almost 14 million tonnes of rice in a scenario with a 20 per cent rainfall deficit. As expected, drought results in a reduction in area cultivated in yields, and in output.

In respect of yield gaps, the current situation is unenviable. Irrespective of the definition of potential yields, as Singh, Aggarwal et al (2009) show there are big yield gaps for rainfed crops including rice. Taking the yield in the experimental station as the potential yield, the yield gap in Uttar Pradesh, for example, was 2230 kg/ha. The gap between actual yield and simulated potential yields was 2000 kg or 2 tons/ha in Bengal and even higher in Bihar and Uttar Pradesh. Worryingly, the yield gaps are widespread among major pulses and oilseeds. In many groundnut growing States (other than Tamil Nadu), there is a potential to double yields. Actual yields of rainfed groundnut ranges from 850 to 1340 kg/ha, experimental yields were found to be 1660-2590 kg/ha and simulated yields were 2330-3490 kg/ha.

It is important to note that yield gaps remain even under irrigated conditions. ICAR studies show that big additions to production of wheat and rice can come by bridging existing yield gaps (Swaminathan and Bhavani2013).

The picture is even more striking when international comparisons are made in addition to comparisons across regions. According to Lobell et al (2009), average yields of rice in India were 61 per cent of potential yields, while the corresponding figure was 78 per cent for China. Disaggregating within India, average rice yields in Bihar were only 30 per cent of potential yield; the proportion was 85 per cent for Tamil Nadu

Once again, yield variability as well as potential yields are going to be affected by climate change. As Mueller et al (2012) point out "global yield variability is heavily controlled by fertilizer use, irrigation and climate. Large production increases are possible from closing yield gaps….(though) changes to management practices that are needed to close yield gaps vary considerably by region and current intensity."

The first challenge is to close the yield gap and I argue that this can only be done bytheapplication of modern science and technology to the problems of productivity in the context of climate changeand sustainability. There are two issues I would like to dwell upon: the judicious use of modern chemical inputs and the role of genetic science including gene-editing.

I argue that solutions to the challenges of sustainable and higher productivity in the context of climate change induced effects are to be found in modern science. To take one example, the work of Joanne Chory at the Salk Institute (Harnessing Plants Initiative) is based on the use of cutting-edge genomics to make more robust root systems to enable plants to better capture and store carbon. Writing on the new genetic tools including CRISPR-CAS technology Katherine Hefferon (RAS 2017) shows how they can "accelerate the crop breeding process in an unprecedented fashion and expand the range of crop varieties with improved precision and lower costs." The technology is being used, for example, to develop maize varieties that will be drought-resistant and less susceptible to pathogens.

An important lesson can be drawn from the book *Tomorrow's Table* written by Pamela Ronald, a plant geneticist, and her husband Raoul Adamchak, an organic farmer. The book blasts the myth that organic farming and genetic techniques of crop modification are two opposite poles. They demonstrate serious limitations of organic farming such as in controlling pests or weeds that can be solved by genetic engineering. In his preface to this book, Gordon Conway writes that it demonstratesthe "potential marriage of two technologies" and how "technology can be applied in ways that strengthens organic farming performance."

Clearly, there is scope for new farming practices that include the judicious use of chemical inputs, integrated pest management, etc., but there is danger in responses that turn against all artificial inputs (be it chemical fertilisers or new seeds) in an unscientific manner as in the case of Zero Budget Natural Farming (ZBNF), promoted by the Government of Andhra Pradesh and the Honorable Minister of Finance.Experiments made by the ICAR Institute of Farming System Research in Modipuram show that ZBNF led to big reductions in yields (as much as 59 per cent for wheat and 32 per cent for basmati rice). A University of Agricultural Science study found significantly lower yields in other important cropping systems (groundnut-sorghum and maize-chickpea) with "natural" farming (NAAS). There are many questions about ZBNF including the income levels generated with lower output, the sustainability of production as soils are depleted of important nutrients, and the effects on food grain production and food security.

Public investment, R&D and Extension

To address this challenge, we need a massive expansion of public expenditure on research and development and on extension systems to take research from the "lab to land."

India's current expenditure on agriculture R&D is abysmal. In 2014, absolute public expenditure on agriculture in China (205 billion dollars) was ten times that of India (21 billion dollars). In 1980, the ratio of public expenditure on agriculturewas more favourable, with an India-China ratio of 1:4 (IFPRI SPEED data). Indeed it can be argued that in the 1960s and 1970s, the Indian NARS was better than the Chinese NARs but clearly the advantage has collapsed over the last few decades.

Taking another parameter, the ratio of public expenditure on agriculture to agriculture GDP, India's expenditure is low relative to China but also other south Asian countries where expenditure grew rapidly over the last three decades. In 1980, India sent 3 per cent of agriculture GDP, the share grew to 6 per cent in 2014. By comparison, the ratio went from 11 in 1980 to 24 in 2014 in China, and from 3 to 8 per cent in neighbouring Bangladesh.

Looking deeper we find that public investment (or gross capital formation) in agriculture has changed very little, averaging around 14 per cent of total agricultural investment over the last decade (Agricultural Statistics at a Glance 2019-20). Public investment differs in qualitative terms from private investment. Public investment in irrigation in West Bengal, for example, was in canals whereas private investment went to groundwater irrigation, resulting in larger inequalities in access to good irrigation (Modak 2018). There is ample evidence to show that public investment crowds-in private investment (Dhawan 1997).

From the perspective of scientific innovation, the expenditure on R&D is important. Gross expenditure on R&D in India has been a meagre 0.7 per cent of GDP. Agriculture's share of this has remained constant at about 10 per cent (DST 2019). Despite the fiscal constraints facing State governments, it is important to note that of R&D expenditure on agriculture, forestry and fishing, the expenditure by States combined exceeds that by the central government (Research and Development statistics at a glance).

The problem of inadequate expenditure on agriculture R&D is compounded by the lack of dissemination of agricultural research. Data from the Situation Assessment Survey of 2018-19 show that, first, only 49 per cent of agricultural households received technical assistance from any agency or individual. There are, of course, large inter-State variations: more than 70 per cent of households reported some access to technical information in Andhra Pradesh, Kerala and Tamil Nadu, while the proportion was less than 40 in Bihar and West Bengal (Patra 2021).

Secondly, technical assistance from government-supported institutions reached around 16 per cent of cultivators in the kharif season and 12 per cent in the rabi season. Government supported institutions included government agents, KrishiVigyan Kendra, Agricultural University, Kisan Call Centre, FPO and Cooperatives. Thirdly, access to public extension information was lower in the latest SAS of 2018-19 as compared to SAS of 2012-13.

While there is need to re-invest in extension systems, new ways of doing so have also to be imagined. In a special issue of the CSI Transactions on ICT that I co-edited, we put together examples of a variety of applications of digital technologies to assist dissemination of information to cultivators including women and poorer and less literate section of cultivators(Swaminathan and Swaminathan 2018).

For ensuring a demand-supply balance for food security while taking account of existing yield gaps and potential yield gaps, and variability in yield on account of climate change, it is clear that major changes in public policy are needed. We need enhanced expenditure on agriculture R&D but also conversion of existing knowledge and technology in to on-the-ground practice. And the latter requires not just agricultural extension but a variety of forms of support including availability of quality inputs and price support.

Costs, Prices and Profitability

This takes me to my second concern around adequate incomes for cultivator households. Ensuring the adequate agricultural production in terms of quantity, commodity-mix and quality -- will only be maintainable if profitability is ensured.

In a recent ICAR lecture, Ramesh Chand (Chand 2021) argues that there is no evidence of a profit squeeze at the national level, though it may be the case in some States. I wish to differ and

argue that there are clear signs of a profit squeeze, and of low and precarious returns from agriculture for the large majority of cultivators.

What do we learn from the recent round of the Situation Assessment Survey of Farmers?
The average income of an agricultural household (from all sources) went from Rs 6426 in 2012-13 to Rs 10084 in 2018-19. This is equivalent to a 56 per cent increase in nominal terms and an 18 per cent increase in real terms (using the CPIAL deflator). Now, the SAS includes households that operate tiny parcels of land. For households operating very small plots of land (say less than 1 ha), income from crop production is never going to be the main source of livelihood support. For that reason, in studying profitability, I prefer to focus on households with more than 1 ha. Secondly, I focus on incomes from agriculture and not total household incomes.

The first striking finding here is that for all farmers with more than one hectare of land possessed, there was a decline in income from agriculture in real terms between 2012-13 and 2018-19. In absolute terms, the rise in crop income was of the order of 20-25 per cent across different size-classes, and in real terms, incomes fell by 3 to 8 per cent (Table 1).

Table 1 *Changes in real monthly incomes from agriculture by size class of land possessed, all-India, 2012-13 and 2018-19*

Size class of land possessed (ha)	2012-13	2018-19 (nominal)	2018-19 (real)	Difference (2018-19 real *minus* 2012-13)	Difference (% of 2012-13)
1.01 - 2.00	4,209	5,269	3,965	-244	-6
2.01 - 4.00	7,359	9,432	7,097	-262	-4
4.01 -10.00	15,243	19,645	14,782	-461	-3
10.00 +	35,685	43,599	32,807	-2,878	-8

Source: SAS 2013 and 2019.
Notes: 1. The net receipt from agriculture is calculated after taking into account only out-of-pocket expenditures.2. Consumer Price Index for Agricultural Labourers (CPI-AL) was used as the deflator.

To illustrate for a household with between 2 and 4 hectares of land, monthly income from agriculture were Rs 7359 in 2012-13 and rose to Rs 9432 in 2018-19, a nominal increase of 28 per cent. In real terms, agricultural incomes fell by 4 per cent. The magnitude of change is a little different with other price deflators, but the overall story is the same.

It is therefore totally unsurprising that agricultural households relied on multiple sources of income for survival. The share of crop income in total household income rose steadily as land possessed rose. For example, receipts from crop production were in the range of 46-58 per cent for those with 1-2 has or 2-4 has. The share of crop incomes was 71-72 per cent for those with 4-10 has or more than 10 has (Munjal 2021).

There are also large variations across States, both in the size of absolute returns from agriculture, and share of agriculture in total incomes as well as in changesin these parameters over time.

Secondly, the rate of annual increase (in nominal terms) of incomes from agriculture has slowed down: from 20 per cent between 2002 and 2012 (SAS 1 and SAS 2) to 12 per cent between 2012 and 2018-19 (Narayanamoorthy, 2021).

In short, the evidence is clearly of a slowing down in rise of net incomes from agriculture, and of a fall in a real terms in net incomes from agriculture.

The unviability of agriculture for the majority of cultivators also emerges from smaller independent studies.Drawing on data from 17 village studies conducted by the Foundation for Agrarian Studies, Arindam Das and I identified the following features of small farmers (defined here as those with an operational holding of less than 2 ha of irrigated land or 6 ha of unirrigated land) (Das and Swaminathan, 2018).

First, there was variation in net crop incomes (using cost A2 or paid out costs) across villages located in different agro-ecological regimes. While net incomes per ha were invariably low in rainfed villages (less than 10,000 rupees per ha in 2010-11 or 18,000 today), the picture was more complex in irrigated villages. In some villages with assured irrigation and multiple cropping, returns were around Rs 50,000 a hectare (Rs 90,000 at current prices) but in others, incomes were much lower on account of multiple factors including natural factors such as pest attack and prices factors such as crash of potato prices.

Secondly, in all but one village, a section of small farmers suffered losses in crop incomes in the reference year. The proportion was over 30 per cent in rainfed villages (the exception was an irrigated rice-wheat growing village in the Gang Canal region of Rajasthan).

Thirdly, net incomes from crop production could not ensure a minimum subsistence income (derived on the basis of minimum wages) for a majority of small farmers.

Fourthly, in irrigated villages, net incomes per hectare for small farmers were lower than for large farmers, with the difference being primarily on account of differences in costs of production and not yields.

Putting these findings together, the conclusion that emerges is that small farmers, who constitute the majority of cultivators in India get very low returns from crop production and, face high variability in crop returns.

This conclusion is substantiated by data showing that costs of production have risen faster than output prices A study by the All India KisanSabhafor the decade 1990-91 to 2002-03 found that " the real COC [cost of cultivation] representing all selectedcrops increased by 2 per cent per annum, whereas the real gross returns remained stagnant."A more recent study by the AIKS showed that the WPI for electricity for agriculture rose by 12 per cent from 2010-11 to 2016-17, the price of fertilisers and pesticides rose by 4-5 per cent while the WPI of wheat increased by 6 per cent.

Another study for the period 1981-2 to 2007-8 found that "the purchasing power of farmers has remained low and has worsenedover recent years. The value of crop output has increased, but a disproportionate rise in inputcosts has resulted in a fall in crop incomes in several states, with the agriculturally developedPunjab being an exception" (Kannan 2015).More recently, between 2014-15 and 2018-19, the wholesale price index for paddy rose annually by 2.8 per cent while cost C2 rose by 4.3 per cent a year (Deepak Johnson, pers. comm).
(These issues shall be taken up in the Keynote paper by C P Chandrasekhar.)

Macro data as well as micro studies show an income or profit squeeze in agriculture during the 2010s. How has Covid-19 and subsequent lockdowns affected returns from agriculture? We have a Keynote on this topic so I will be brief.

As has been widely noted, crop cultivation was in some sense the least affected by the pandemic and subsequent lockdowns. Area cultivated in Kharif 2020 was at a record level and so was

production (GOI 2020, 2021). The key point I want to highlight is the rise in costs of production and consequent profit squeeze. Drawing on telephonic surveys of 100 cultivator households, Modak and Bhattacharya (2020) find reports of rising costs such as in fertilizer and seed on account of supply problems, in hired labour on account of labour shortages, in machine rent and irrigation charges on account of the steep (and continuing) rise in diesel prices. At the same time, farm harvest prices did not rise commensurately. As they conclude, the "increase in MSP for kharif crops between 2019 and 2020…did not compensate for the increase in the cost of cultivation of kharif crops."

Women's work and contribution

Another phenomenon that has to be taken note of is the substantial contribution of women workers to agriculture and allied activities and implications thereof.

I would like to argue against the view that feminization of agriculture is not grounded in data (Chand, 2021). It is correct that at a macro level, official statistics show that the rural work force remains male-dominated. As per the latest round of the Periodic Labour Force Survey (PLFS), 2018-19, of all agricultural workers in rural India, women comprised 32 per cent. We need to unpack official statistics further as well as examine evidence from other studies to understand the process of feminization of the rural work force.

First, even with with official statistics, the changes in the rural labour markets are very clear. The Census of India shows that in absolute terms, the number of female agricultural labourers is rising, and had reached almost 60 million by 2011, equivalent to the entire population of Italy. Secondly, the share of agricultural labour in female workers and in female population has risen steadily over the last four decades (Swaminathan, 2009). As per PLFS 2018-19, 71 per cent of female rural workers were engaged in agriculture and allied activities as compared to 53 per cent among male rural workers.

A key indicator is the ratio of male to female agricultural workers, and this seems to have fluctuated over time, as per the Censuses of India and the labour force surveys of the NSSO. In 1999-2000, women comprised 26 per cent of the rural worker force (NSS 55th round), the ratio went up to 36 per cent in 2011-12 and down to 32 per cent in 2018-19. While the pattern of change is not very clear, the broader story is that women are an important constituent of the agricultural work force, and their strength is likely to rise in the coming years.

Moving ahead, it is well established that large-scale labour force surveys severely underestimate women workers, on account of the fact that women's work is often within the home or family farm, it is unpaid, it is intermittent, and so on. With an augmented definition of work participation that includes women engaged in processing, tending livestock, collection of firewood and other economic activities, activities under category 92 or 93, Usami (2018) showed that women's work participation rate almost doubled. So, even official statistics yield a very different picture with a different definition.

I now turn to a more nuanced understanding of women's work that emerges from independent village studies.

The Foundation for Agrarian Studies (FAS) conducted a unique set of time use surveys in two villages of Karnataka, where women were interviewed daily for seven consecutive days over two or more agricultural seasons (Swaminathan 2020). Using these data, when I applied a weekly status definition of a worker, that is, one who engaged in economic activity for the major time during the reference week, then,around 70 per cent of the women surveyed were identified as workers. (By the ILO's new one hour a week criterion, all women were workers.) A further salient finding was that of seasonal variation, with lean season work participation being lower than in the harvest season, and with universal or near universal work participation during the latter period. As I have argued, the lower work participation in the lean season reflects the fact that women drop out of the work force when there are limited work opportunities.

Another aspect of labour use emerges from gender-disaggregated data on forms of labour in direct crop production. Using data from 15 villages in different agroeconomic regions, NiladriDhar (2017) showed that male workers contributed more to household production (that is, labour on own farms) than female workers in all villages, whereas women workers comprised the majority of hired workers in 11 out of 15 villages. In short, there are differences in the gender composition of hired labour and family labour. This is particularly relevant as hired labour has gained importance across the country and total hired labour use exceeded family labour use even on small farms (ibid.) While demand for labour has fallen in aggregatewith the spread of mechanization, and the gender division of labourvaries over time and space, the point to note is the continued engagement of women workers in many crop operations.

In some cropping systems such as rice-based systems, S Niyati showed, using evidence on 7 villages from different parts of the country, that, (a) the share of hired labour use exceeded family labour use, and (b) in the majority of villages, the share of female labour in rice cultivation was higher than that of male labour. Certain tasks continued to be female-specific tasks, although the introduction of piece-rate wages had blurred the gender division of labour(Niyati 2020).

Another piece of evidence on women's work comes from a recent study of 19villages that disaggregated data on labour supply, and found that in a large majority of villages, the number of workers per manual labour household was two (FAS 2020). This was also the case in poor and middle peasant households. In short, in wage labour households, men and women participated equally in the labour market. At the same time, when labour demand or absorption was examined, the same study found huge underutilization of labour time. The study found that actual labour use in crop production was never more than 30 per cent of potential labour time available within the village. This gap in labour demand and supply can again lead to women "withdrawing" from the labour force.

There are two implications of this discussion. First, we need to recognise women's work in agriculture, horticulture, dairying and other activities, count it better and value its contribution, even if it is unpaid work. With better data collection, we may even find that theagriculture labour force is dominated by women. This would not be surprising, as men are increasingly seeking work outside the village and in non-agricultural jobs, in skilled labour at higher wages, while leaving women to complete agricultural tasks. Secondly, if women are going to be the mainstay of the agricultural work force, we need to plan accordingly, be it in terms of land rights, mechanization or access to inputs or provision of extension and credit.

Food and nutrition security

Last but not least, the agricultural economy plays a foundational role in ensuring universalfood and nutrition security. For a country with a large population, food sovereignty is essential; we cannot depend on international trade to meet our basic food needs, this will have to come mainly from domestic production.

Hunger and malnutrition prevails at unconscionable levels in the India of the 21st century. The just-released National Family Health Survey (NFHS-5)Report shows meagre progress on child malnutrition: the proportion of underweight children below the age of 5 fell from 36 in 2015-16

to 32.5 in 2018-19; the proportion of wasted children fell from 21 to 19.3 over the same period, and proportion of stunted children fell from 38 to 35.5 per cent. This sluggish improvement has no doubt been reversed over the last two years of the pandemic. In short, at least one third of India's children suffer various forms of malnutrition.

Food security is more than adequacy of cereals, and this point is now gaining recognition in the debate on measurement of the food insecure population. In 2020, the State of Food Insecurity (SOFI) report of the FAO defined three types of diet: (i) a "basic energy-sufficient" diet where the cheapest starchy cereal is consumed to meet the required calorie intake, (ii) a "nutrient-adequate" diet, where the required calorie norms is met in addition to the stipulated requirement of 23 macro and micro-nutrients, and (iii) a "healthy diet", which meets the calorie norm and the macro- and micro-nutrient norm but allows for consumption of a diverse diet with items from several food groups.

The most important finding of SOFI is that for persons in India on the equivalent of an international poverty line of 1.9 (PPP) dollars a day, only the energy-sufficient diet is affordable. The nutrient-adequate diet was estimated to cost 2.12 dollars a day, and the healthy diet cost 4.07 dollars a day. The SOFI Report estimates that 18 per cent of south Asians – numbering 586 million people – cannot afford the nutrient-adequate diet, and, 58 per cent or 1337 million people cannot afford the healthy diet.

Global studies as well as surveys in India suggest a huge rise in the number of food insecure persons over the last two years of the pandemic, not surprising given the widespread loss of livelihoods and reduction in incomes, especially among wage workers and poorer sections of the population. Food price inflation is rising in India as in many other parts of the world, and there has been variability in prices during the pandemic years (Ramakumar, Keynote address).

The central government did initiate a new scheme during the pandemic, the PM GaribKalyan Anna Yojana (PMKAY), a scheme that offered an additional 5 kg of wheat or rice a month and one kg of gram or lentils free of cost to all priority households in the public distribution system (PDS). Many State governmentshad their own initiatives, such as the 17-item grocery kit provided by the government of Kerala. The impact of the expansion of Covid-related food distribution measures has been a dramatic rise in offtake of food grain from the Food Corporation of India (FCI). In 2020-21,the offtake of rice and wheat from the FCI on account

of PMGKAY and other Covid-related schemes was 31.4 million tonnes in 2020-21, and it had reached 22 million tonnes in the current year (as of October 2021). Thus, in 2020-21, total offtake (excluding OMSS and exports) was at an all-time record of around 86 million tonnes.

Theoperations of the FCI have been on a phenomenal scale and very welcome. Nevertheless, I argue that more is needed. We need a universal safety net that includes both food and cash transfers. In this time of crisis, at the very least one nutritious meal (with protein and fruit and vegetables) must be ensured for the majority of our people. The programme of school meals has just restarted in large parts of India, and the quality of this meal needs to be enhanced, and its coverage extended to elderly and other vulnerable people in the neigbourhood. The Supreme Court has directed the government to come up with a policy on community kitchens.The Covidcrisis can be an opportunity to universalize and strengthen food-based transfer programmes.

The Way ahead

The last challenge is that of persistent agrarian inequalities. From the early years of the Green Revolution, it has been noted that the progress of agriculture has been uneven across regions, classes and castes. Agrarian India is characterized by very high levels of inequality, be it in ownership of the means of production, land and machinery, or be it in levels of crop and household income. In the 30 years since policies of liberalization were introduced, inequalities have escalated (Swaminathan 2022).These inequalities are reflected in all policies. Do income transfers to farmers reach Dalit tenant cultivators in the Cauvery delta? Do peasants with tiny land holdings in West Bengal get the Minimum Support Price for their paddy? Are extension services accessible to small farmers in dryland regions? Are new technologies made available to women workers?

To sum up, I reviewed some key challenges facing Indian agriculture, notably that of enhancing productivity in the context of climate change, assuring adequate incomes or returns from crop production, and paying attention to women's work in agricultural and allied activities. My focus was not on detailed policy analysis. However, I wish to underline that it is only science-led public policy with a renewed commitment to public expenditure that can address the uneven path of development that characterizes rural India.

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