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# Theory and evidence for a large-scale agroecological transition in India

CSH Seminar, 15<sup>th</sup> February 2021, 17:00-18:30

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**Theory and evidence  
for a large-scale agroecological transition in India**

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Workforce Livelihood → Food

Agro-industrial scenario? → A World Without Farmers

Agro-ecological scenario? → A World With Farmers and Nature

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www.cirad.fr  
www.centre-cired.fr  
www.csh-delhi.com

(1) Dorin B., Hourcade J.-C., Bernot L., Castin W., (2013). A World without Farmers? CIRED WP 47, Paris, 26 p.  
(2) Dorin B., Aubron C., 2016. Croissance et revenu du travail agricole en Inde, Economie Rurale, 352, 43-65.  
(3) Dorin B., 2017. India and Africa in the Global Agricultural System (1960-2050), EPW, III: 25-26, 5-13.  
(4) Dorin B., Joly P.-B., 2020. Modelling world agriculture as a learning machine: From malstream models to Agribiom 1.0. Land Use Policy, 96: July, pp. 103024

Dear colleagues and friends,

I would like to thank our director Nicolas Gravel for pushing me to make a CSH presentation of my work before his departure in a few months, and to Jean-Thomas, Samuel and Neeru for taking charge of its organization and its advertising in our CSH network. It is true that for the last 4 four years that Nicolas has directed our centre, I have presented and discussed my works many times in Delhi and elsewhere in India, but never at the CSH except with my interns or research assistants. I have decided today not to present to you any specific research or publication on which I have worked since my return to CSH in 2014, such as on group farming with Bina Agarwal (Agarwal et Dorin, 2017), or on the rebound effect of Land Sparing strategies with Marion Desquilbert from the Toulouse School of Economics (Desquilbet *et al.*, 2017), or on Indian milk and livestock economy with Claire Aubron from MontpellierSupAgro (<http://web.supagro.inra.fr/IndiaMilkSeminar>), or on my Agribiom bioeconomic model for collective and quantified retro-prospective studies from the 1960s to 2050 (Dorin et Joly, 2020), now extended to Indian states and not only world countries. Rather than that, I have chosen today to try to give you an account of larger works and reflexions, on which I have now been working for more than ten years, and which in economics is called "structural transformation" or "modern economic growth." To position this work in economics, I would say that it extends questions asked by economists like Nicholas Georgescu-Roegen, with the aim of building an

economic theory for the development of agroecology in countries like India where the availability in agricultural land per capita are particularly low.

My presentation, which closely resembles the conference that the Indian Government asked me to give on November 18 at NITI Aayog, is divided into 5 sections of unequal importance: an introduction which quickly presents the foresight project "AgroEco2050" on which I have been working intensively for the past two years, a section 2 entitled "the Lewis Path", a section 3 entitled "The Lewis Trap", a section 4 rising the question "Can India ever get out of the trap?", a section 5 entitled "A New Paradigm for Agriculture", and a conclusion in the form of 5 bullet points.

**Foresight AgroEco2050**  
A retro-prospective analysis (1960-2050) focused on Andhra Pradesh

1960

(2018-21)

2050

Agro-Industry?

Agro-Ecology?

- **A joint RySS-CIRAD-FAO project** (Oct. 2018 – Dec. 2021)
  - Rythu Sadhikara Samstha, Government of Andhra Pradesh ([www.ap.gov.in](http://www.ap.gov.in))
  - Food and Agricultural Organization, Delhi ([www.fao.org/india/fao-in-india](http://www.fao.org/india/fao-in-india))
  - French Agricultural Research Centre for International Development ([www.cirad.fr](http://www.cirad.fr))
  - ...with the support of the Azim Premji Philanthropic Initiatives (APPI)
- **Objectives**
  - (1) to develop a comprehensive and credible scenario of full-scale NF/agroecology in AP
  - (2) to contribute to state, national and international debates and researches on agroecology
- **Means**  
A foresight platform with various experts and public/private stakeholders:
  - to revisit and discuss collectively past evolutions since the 1960s
  - to build/discuss/compare 2 contrasted scenarios: BaU vs. NF

☺ Before starting, I wanted to say a few words about my main research project for more than two years, because it is a concrete illustration of what my talk today can lead to implement and support.

“AgroEco2050” is a retro-prospective project which started in October 2018 with 3 main partners: the RySS of the Government of Andhra Pradesh, FAO-India, and Cirad, the *French Agricultural Research Centre for International Development* where I am a macro-economist.

The two broad objectives of our project are:

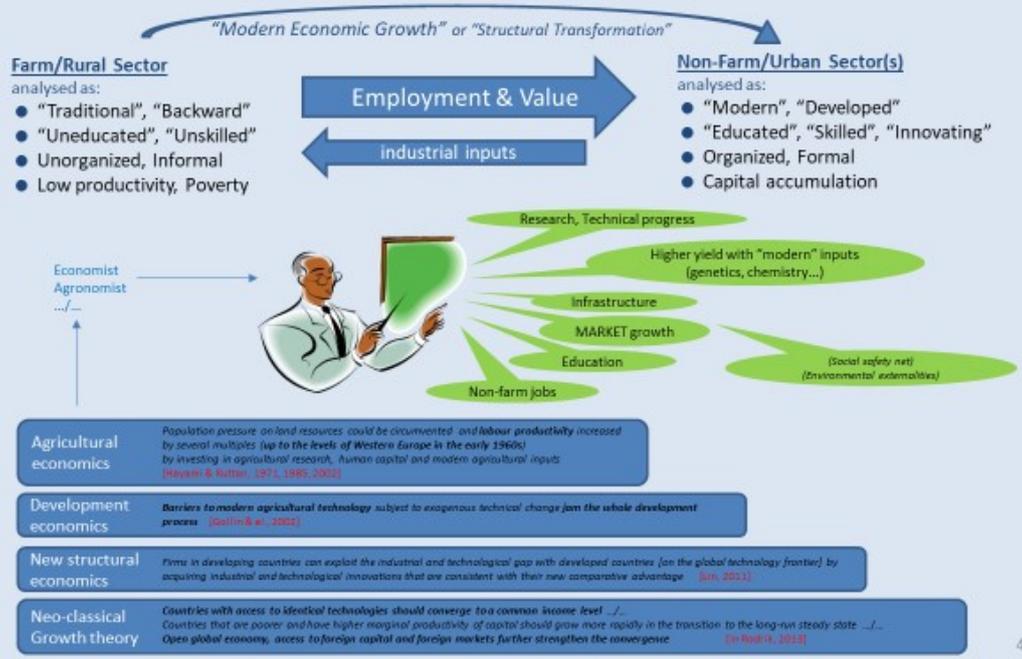
- (1) to develop a comprehensive and credible full-scale scenario of Natural Farming in Andhra Pradesh
- (2) to contribute to state, national and international debates and researches on agriculture and agroecology

To meet these objectives, we set up a foresight platform with various experts and stakeholders in order:

- firstly, to revisit and discuss collectively past evolutions since the 1960s, from land use to diets, human and animal populations, GDP, land and labour productivities, etc.
- secondly, to build/discuss/compare a least 2 contrasted scenarios: BaU vs. NF

## 2 The “Lewis Path”

### ■ The theory of “modern economic growth”



☞ Now let us go to the heart of my presentation. Before showing you data, I have to say few words on the theory of “*modern economic growth*” that has strongly shaped our brains and world in the recent decades.

In the different schools of economics, be it agricultural economics, development economics, new structural economics (Lin, 2011) or the neoclassical growth theory (Rodrik, 2013), there is a strong belief that in the long run, we will all converge to the same level of income wherever we are in the world. In technical terms, it is called in economics “an unconditional convergence in labour productivity”.

This belief is more based on theory and mathematical models than empirical evidences. It is regardless of today’s disturbing ground realities, with billions of people still in extreme poverty, rising inequalities and the accelerated depletion of natural resources.

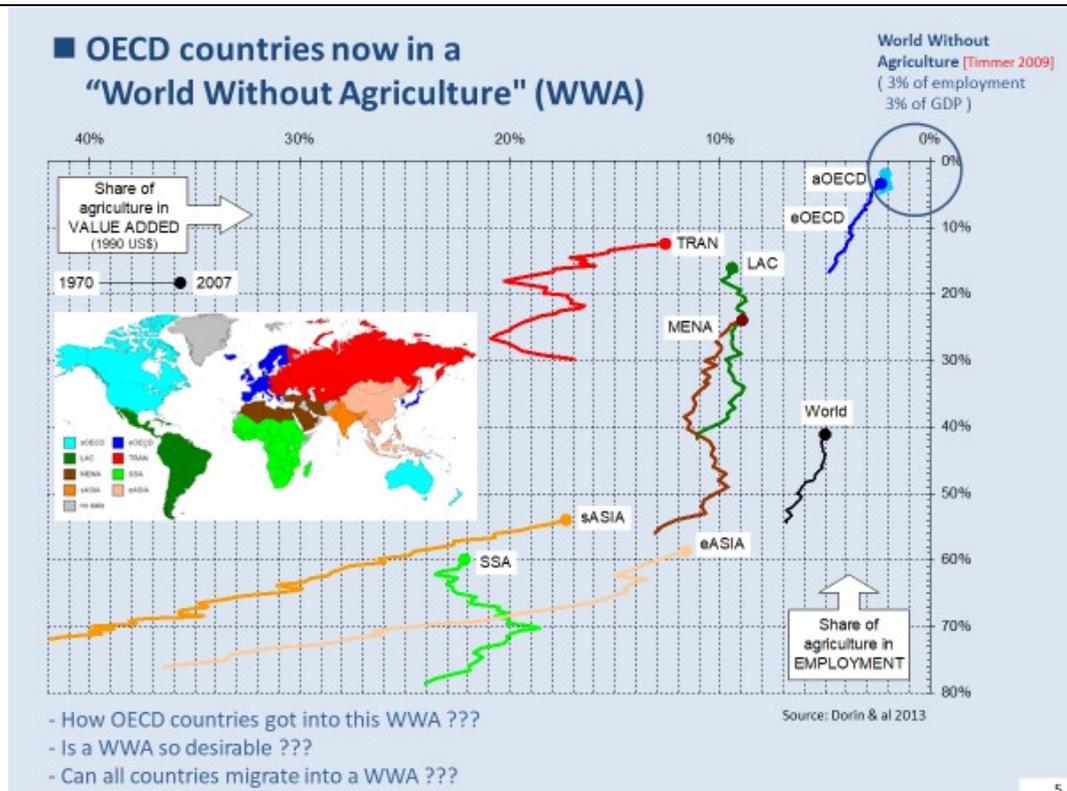
☞ The belief in the long-term convergence of free-market economies is rooted in the paradigm of “structural transformation” that shaped economic thought after WWII (Johnston et Mellor, 1961, Chenery et Srinivasan, 1998, Herrendorf *et al.*, 2014). “Structural transformation” refers to the reallocation of economic activity across three broad sectors: agriculture, industry and services or, in other words, the primary, secondary and tertiary sectors. This theory is anchored in some historical experiences of what the Nobel price (1971) Simon Kuznets named the “modern economic growth” (Kuznets, 1966), as also in dual economy models inspired by another Nobel prize in economics, Sir Arthur Lewis (1954). These models aim to represent the interrelated structural changes between what is called

- either the “subsistence” sector (in Lewis) or the “agricultural”, “traditional”, “backward”, “informal” sector

- and the “capitalist” sector (in Lewis), also named the “non-agricultural”, “modern”, “urban”, “formal” sector.

☉ From all this literature emanates a development model where agriculture provides cheap labour to propel the process of industrialization and urbanization, which, in turn, deliver technology and increasingly cheaper industrial inputs that increase agricultural yields and allow people to be fed at ever lower costs so that they can escape poverty and enjoy goods and services from the secondary and tertiary sectors.

These models and theory of “*modern economic growth*” have for sure been self-fulfilled and verified in my native country, France. And I will illustrate my point with a brief personal story. In the late 1980s in France, when I was a Master student in agricultural economics, the Ministry of agriculture asked me to build a scoring system to detect the preliminary signs of farm bankruptcies. At that time (and even today I would say...), many farms were facing serious financial difficulties, mostly due to their over-investments and over-indebtedness in powerful machineries and costly modern inputs. The ministry had already helped these farmers in the past, with rather huge subsidies, but as I had shown one year earlier in my thesis in agricultural engineering, this financial helps were useless, since few years later the beneficiaries had not recovered at all, and sometimes even worsened their situation. Hence public funds had been wasted, and the Ministry wanted to improve its efficiency by detecting farm financial difficulties before it was too late. I do not know how the ministry used the scoring system I built. But all what I know is that farm bankruptcies continued. All in all, the number of French farms and farmers was divided by 3.2 between 1970 and 2010. However, this enabled the remaining farmers to enlarge their cultivated land, from 19 ha in 1970 to 55 ha in 2010, on average. In other words, in France, we have now – very roughly – 4 times less farmers than in Punjab, but our net sown area is still almost 5 times higher than the Punjabi one.

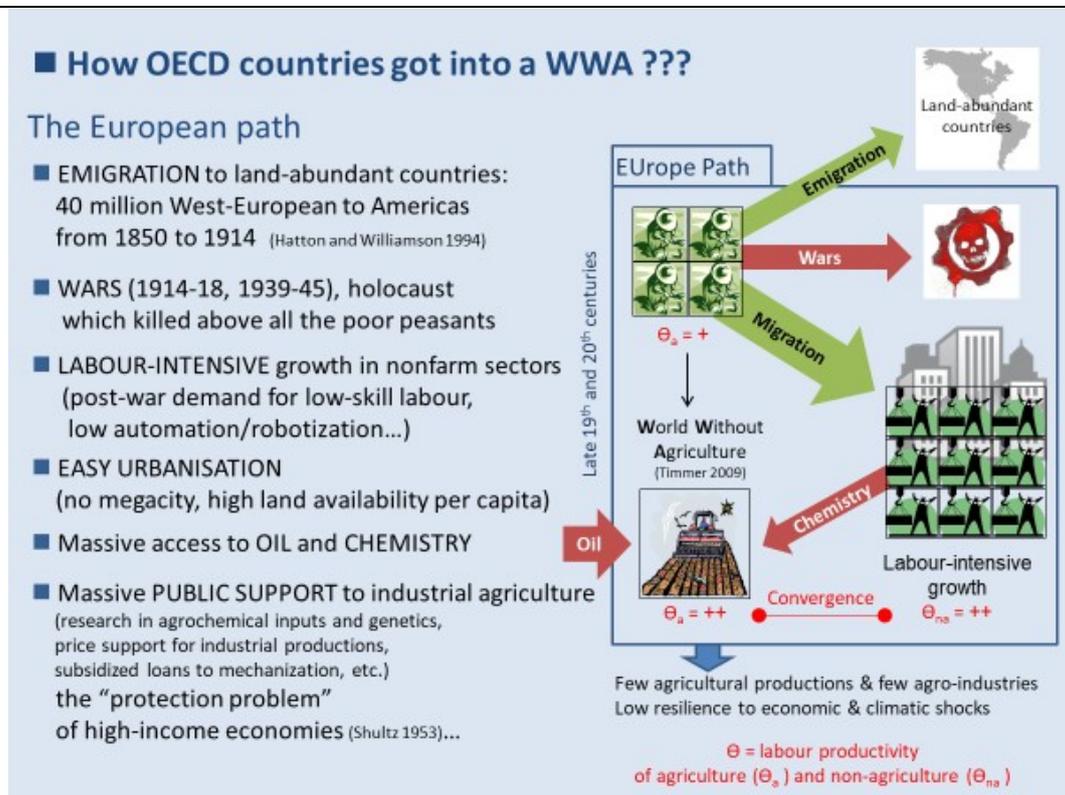


☉ As a result of this process, in 2010 in France, agriculture do not account more than 3% of total employment and 3% of total GDP. We are in fact in a world that Peter Timmer depicted as a “*World Without Agriculture*” (Timmer, 2009). In this world are also now all other OECD countries. This WWA looks like the destiny of all countries or global regions as we can observe on this figure, where we see that the share of agriculture in both GDP and employment is

declining everywhere. These declines are normal since we want to enjoy manufacture good and services, and we need people to produce them.

☹ But the long-term perspective of a WWA rises three questions at least:

- (1) How did OECD countries get in this WWA?
- (2) Is this WWA so desirable?
- (3) Can all countries migrate into this WWA?



☹ Let us start with the first question, and take Western Europe as an example.

How Western EU managed to remove some many people from its agricultural lands? I identified at least 6 factors:

- ☹ (1) a large emigration to the Americas: around 40 million West European emigrates to the Americas from 1850 to WWI, which today would represent around 360 million people if the same phenomenon were to occur in India from 2015 to 2078
- ☹ (2) Two world wars, which killed above poor peasants
- ☹ (3) A labour-intensive growth in nonfarm activities, at a time when manufacture and other big industries were not automatized or robotized as today
- ☹ (4) An easy and rather cheap urbanisation, with no megacities and mega-slums as today in many developing or emerging countries having a low land availability per capita
- ☹ (5) A massive access to oil and chemistry, notably to provide cheap agrochemical inputs and replace farm labourers by big tractors and other agricultural machineries
- ☹ (6) Last but not least, massive public support for industrial agriculture, with high research spending on agrochemical inputs and genetics, price support for industrial productions and export, subsidized loans for mechanization and other industrial technologies, etc. This massive public support is what Shultz called the “protection problem” of high-income economies, but I think that problem has become India’s as well...

## ■ Is this WWA so desirable ???

### State of agriculture in OECD countries



- Farmer income  $\approx$  non-farmer income (on average...)
- Big farms with big machineries and robots
- Within global trade to “feed the world”
- .../...



- High farm specialisation: **low resilience to economic, climatic & biotic shocks**
- Dependence on **fossil-energy**
- Dependence on big machineries, industrial inputs and IPR
- **Over-indebtedness** and **suicides of smaller farmers**
- **Corporatization** of farms, **oligopsony** of input suppliers
- High level of **public subsidies**
- **Erosion of biodiversity, soil, water and air resources**
- Unbalance diet, junk food, obesity, **cardio-vascular diseases, cancers...**
- Sad landscape and rural life for tourism...
- .../...

↳ Need for invent another dream of “modernity”,  
another model of economic development,  
with and for farmers and nature...

■ **Can all countries migrate into a WWA ???** => see next section

☹ Now, is this WWA so desirable?

If you follow this path of industrialization and reach a “*World Without Agriculture*”, you get almost no farmer but the later are very proud to harvest huge piece of land with big tractors, combine harvesters and other machineries including powerful computers and sophisticated software. But above all, their incomes have climbed up to those of other workers in the society. There is no more “income gap” or “agricultural productivity gap” as it is said in economics. The farm labour productivity has increased thanks to powerful or sophisticated robots using fossil energy. Here it is the modern way to eradicate historical rural mass poverty, at least the one indirectly depicted in textbooks in economics.

☹ But we can also say that in this WWA, you have developed agriculture by expelling farmers from the land. This is not the only dark side of this WWA as you can see on the slide.

In this world, we have also:

- a high farm specialisation leading to low resilience to economic, climatic & biotic shocks
- a high dependence on fossil-energy
- a high dependence on big machineries, computers, industrial inputs and IPR
- over-indebtedness and suicides of smaller farmers (it happens not only in India...)
- corporatization of farms and oligopsony of input suppliers
- high level of public subsidies
- erosion of biodiversity, soil, water and air resources
- unbalance diet, junk food, obesity, cardio-vascular diseases, cancers...
- sad landscape and rural life for tourism...

☹ In France, only large-scale farmers and multinationals are happy with this situation. Others call for another dream of “modernity”, another model of economic development, with and for farmers and nature.

### 3 The “Lewis Trap”

#### ■ The dynamics of farm labour productivity

Farm labour productivity can be increased through:

- “Intensification” (with irrigation, fertilizers, HYV, pesticides, etc.) to get higher yields per hectare
- “Motorization” (with tractors, combine harvesters, aeroplanes, etc.) to crop more land per farmer.

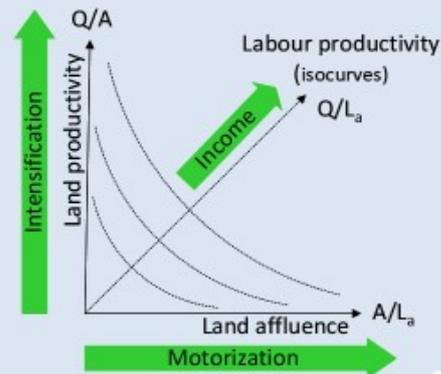
#### ① The “TALA” equation

$$\frac{Q}{A} \cdot \frac{A}{L_a} = \frac{Q}{L_a}$$

Technology
Availability
Labour  
(Land productivity)
in land
(productivity)  

(Land/Worker)
(Land/Worker)

#### ② The corresponding graph

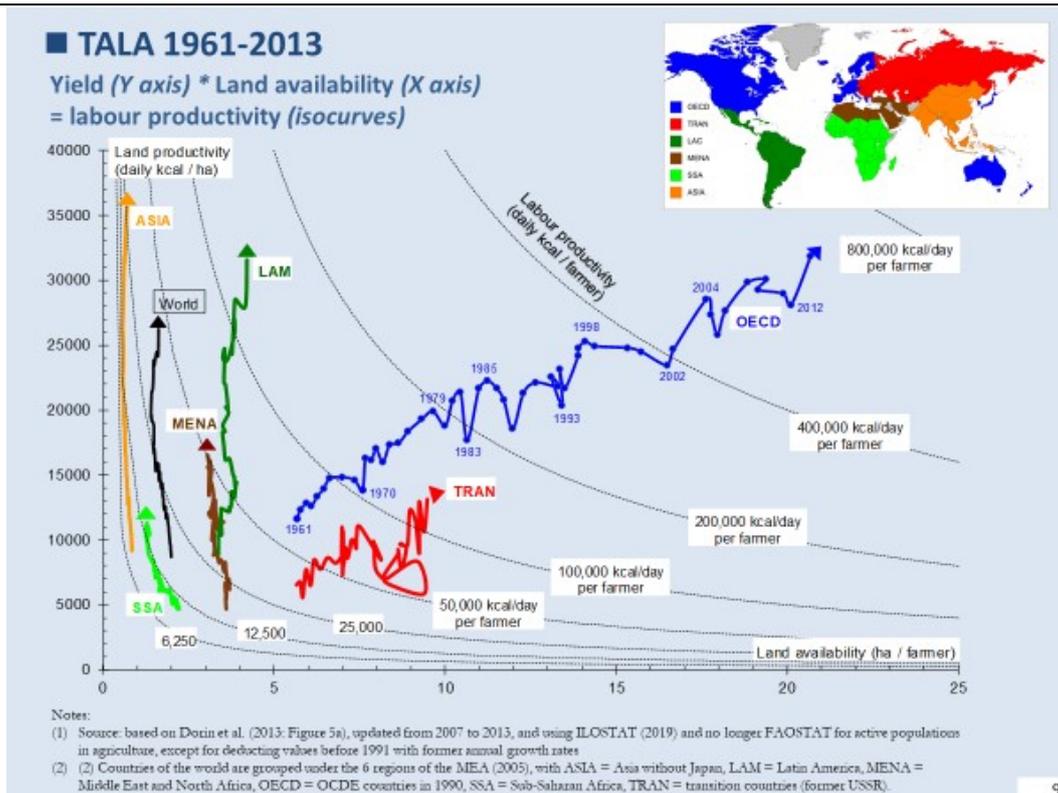


☹ Let us try now to answer the last question: “*Can all countries migrate into a WWA?*”, or, in our case, “*Can India and its States also follow this kind of modern economic growth?*” My answer is clearly no, or at extremely higher economic, human and environmental costs than for the OECD countries.

Thirty years later after my work for the French ministry of agriculture, I am now with you in India faced with a much more pathetic situation of Indian agricultural industrialization than the French ones in the 1980s. The reasons of this pathetic situation are rather easy to understand even if they are not told or listened. Let us start with the labour productivity in agriculture. Basically, it can be increased in two ways:

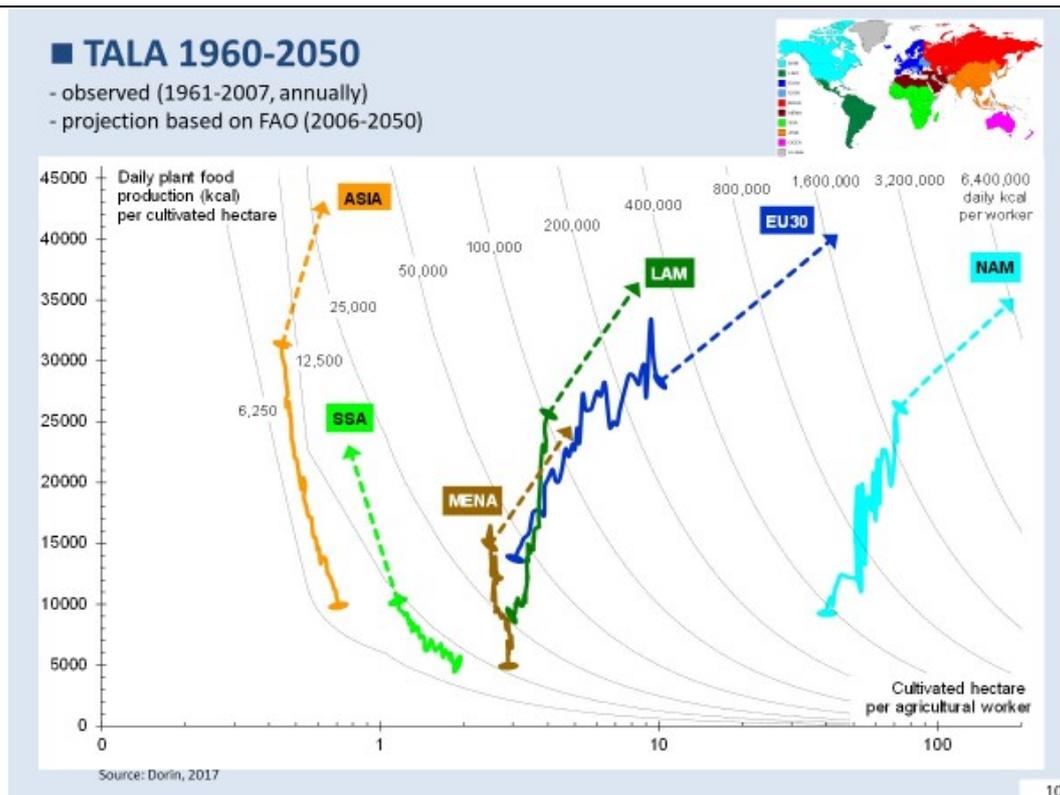
- Farm labour productivity can be increased through:
- “Intensification” (with irrigation, fertilizers, HYV, pesticides, etc.) to get higher yields per hectare
  - “Motorization” (with tractors, combine harvesters, aeroplanes, etc.) to crop more land per farmer.

These two ways can be proxied with available statistics, and successively be called “Technology” (of industrial inputs) and “Land availability per farmer”, then combined to give the corresponding “Labour productivity” in Agriculture. I called this simple equation or identity “TALA”, and I show you on the slide how it can be graphically represented, with  $A/L_a$  on the X axis,  $Q/A$  on Y axis, and  $Q/L_a$  as isocurves.



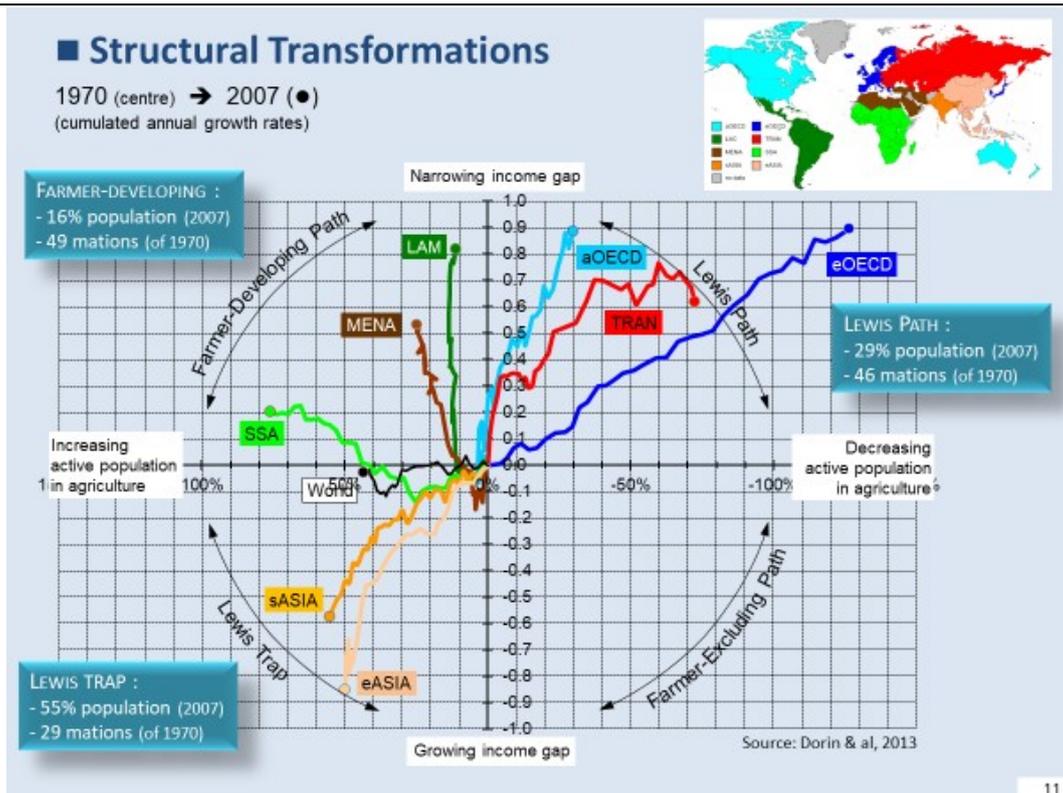
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☺ I am now putting millions of national plant food productions data behind this TALA equation to see how this equation has evolved over the past decades in different parts of the world. Above all, this figure illustrates that in OECD countries, the convergence of farm and nonfarm labour productivity was mainly due to an increase in land availability per farmer rather than in yield (Dorin *et al.*, 2013). To go into more detail, this figure shows the 1961-2013 evolution of the average yield in plant food calories (kcal) on the vertical axis, the evolution of the net cropped area per farmer on the horizontal axis (which is a proxy for the size of farms or the level of motor-mechanisation) and, last, the evolution of the concomitant progress of agricultural labour productivity on the isocurves. Over half a century, you can see that the labour productivity of OECD farmers has risen from 66,000 to 658,000 kcal/day on average, a tenfold increase, while in Asia it has only increased from 7,900 to 25,000, barely three times. Thus, we observe that while the gap in land productivity between Asia and the rich countries has more than closed, this is not true of the gap in labour productivity, which has continued to widen tremendously.



☞ In a paper published in 2017 in *Economic and Political Weekly* (Dorin, 2017), I have extended these curves up to 2050 using the projections of the FAO, which we can consider as a “business as usual” or BaU scenario (Dorin, 2017). According to this FAO scenario, and as you can see on this figure, the available land per farmer may grow up to 200 ha on average in North America in 2050, while the same figure would be less than 0.8 ha in both Asia and Sub-Saharan Africa. The today figure for India is about 0.7 ha.

In other words, according to these BaU scenario of the FAO, in 2050, each farmer in Asia, even with higher yield than elsewhere as it is projected, would produce less than 30,000 kcal per day per farmer while it would be more than 6.6 million in the large-scale motorized agriculture of North America. This is a huge gap and this gap, in fact, is increasing at least since the early 1960s. There is no international convergence in farm labour productivity but rather the opposite despite huge investments in irrigation and modern agricultural inputs as in India since the 1960s with the Green Revolution. And even in 2050, despite decades of high economic growth, India looks still trapped in extremely low farm incomes, which means a huge income gap with other workers in the society, hence agrarian crisis, again and again...



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☹ ☹ In fact, and at least since the 1960s, Asia is embarked upon what I called a “*Lewis Trap*”, the one that is represented on the bottom left of the figure, the polar opposite to the *Lewis Path* followed by OECD countries, on the top right.

We find on this figure the 2 indicators I used for this typology of structural transformation paths:  
- the agricultural labour force in absolute number on the X axis  
- the labour productivity gap between farm and non-farm on the Y axis.

Now we will see how 8 world regions evolved in this space, by cumulating till 2007 the annual growth rates of these two indicators from 1970, starting in the centre of the graph.

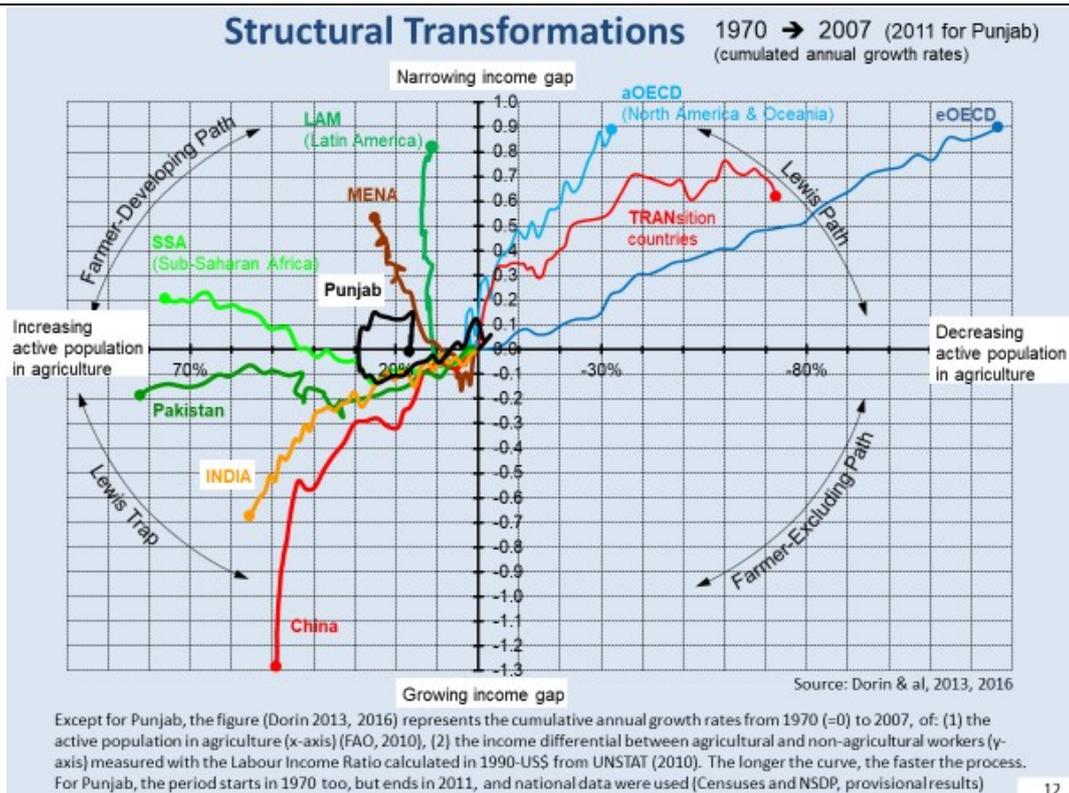
☹ ☹ ☹ Not surprisingly, we find that eurasianOECD, americanOECD and TRAN countries have followed what I called the “*Lewis Path*” which lead to a World Without Agriculture. This evolution was quite fast as far as eOCDE is concerned since the length of the curve reveals a speed.

☹ ☹ LAM and MENA are rather close to the LP, but followed what I called a “*Farmer Developing*” (FD) path as their agricultural labour force increases while the labour productivity gap decreases. The interpretation of this path is not univocally positive as, if agricultural demand is driven by the foreign rather than the domestic market, as in Latin America, it may be consistent with growing urban poverty.

☹ SSA is closer to what I called the “*Lewis Trap*”, where the income differential widens and the agricultural workforce increases, the polar opposite of my LP. SSA had even embarked upon this LT during the first half of the period.

☹ ☹ South and East Asia are clearly embarked upon this “*Lewis Trap*”, since the number of farmers has increased as well as the income gap of the farmers with the rest of the population.

☹ Finally, given the demographic importance of Asia, the whole world appears ultimately also trapped in this long term trajectory.

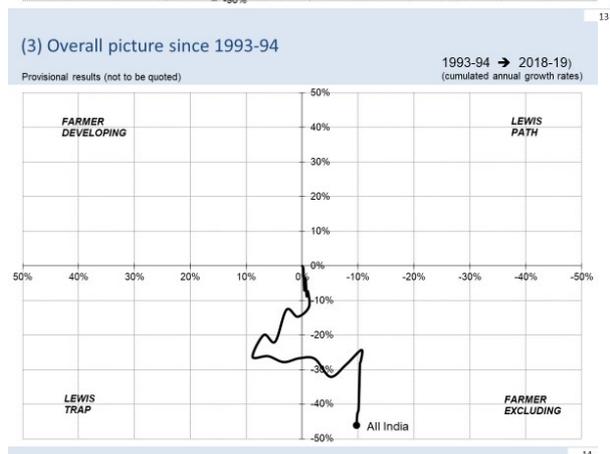
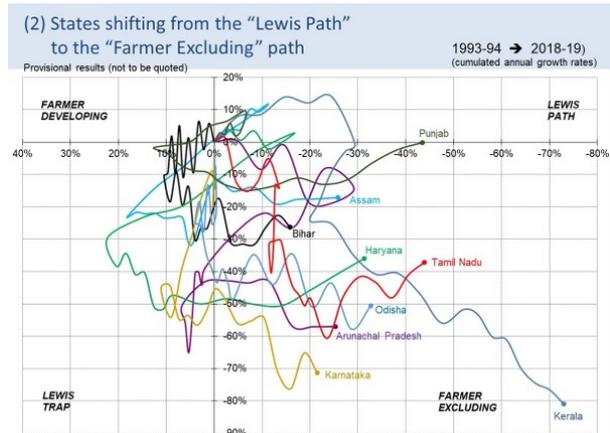
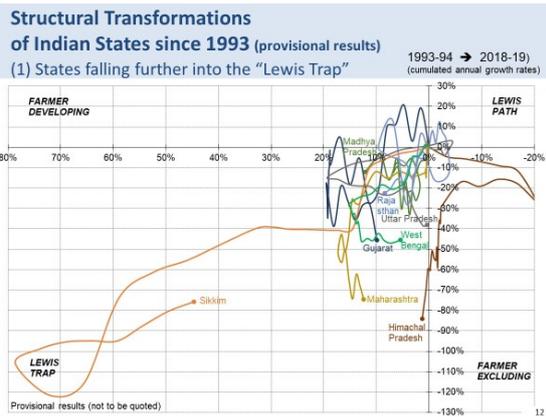


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☹ On this graph, I have tried in 2016 to add Punjab with the Indian statistics I could found at that time. And what do we see for Punjab, the so-called best performing agricultural State of India? It goes around in circle since 1970. All in all, in 2011, compared to 1970, the income gap with other workers has not increased nor decreased, but its active population in agriculture has increased. Hence the average available land per farmer has shrunk in 40 years. And how to increase the farm labour productivity when your land is shrinking from a generation to another instead of enlarging? The only option is to increase your yield per unit of land, with the crops and technology sponsored by national and international organisations, public and private. Hence, you go for mono-cropping, with ever more genetic engineering, groundwater, chemical fertilizers and other agrochemical inputs whose marginal productivity is declining while your costs are rising and your natural capital is eroding faster than elsewhere: soil, biodiversity, safe water, etc.

☹ In the following charts updated to 2018-19, I no longer used the Indian population censuses to estimate people employed in the agricultural and non-agricultural sectors, but the national sample surveys on employment and unemployment. However, these results are very provisional since here, the employment estimates in absolute numbers were made by NITI Aagog, and I have some doubts about the 2017 and 2018 estimates that we need to clarify, in addition to extending these estimates from 1973. So please do not distribute or quote these very preliminary results.

- This first chart shows you Indian States falling further into the “Lewis Trap”
- ☹ This second chart show you States that are moving from the “Lewis Path” to what I have called the “Farmer Excluding” path (FE), where farmers are both fewer and poorer
- ☹ And here you see the picture at the All-India level. Note that worldwide, from 1970 to 2007, I discovered only one country following an FE trajectory during this period: Ireland

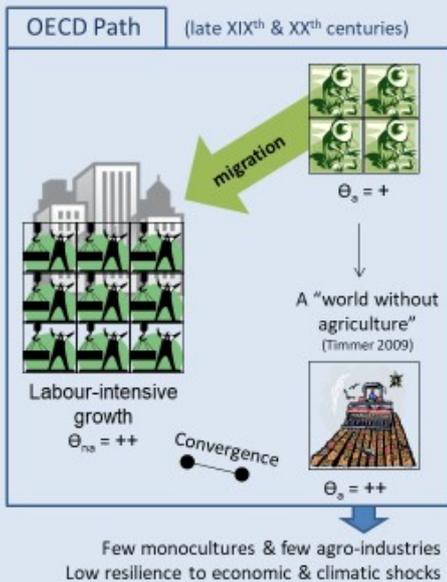


Hence Indian farmers are dangerously trapped in a low-profit business and would like to escape it, but they are also trapped in the world history:

- (1) Firstly, they can no more emigrate massively to land-abundant regions, as did the Western Europeans to the Americas from 1850 to WWI and even after;
- (2) Secondly, they have to compete a lot to find a job in nonfarm sectors since, due to automation, these industries are much less labour-intensive than they used to be in the past; these industries may grow fast as in India today, but without employing the hundred millions of people it should in order to follow the *Lewis Path*.

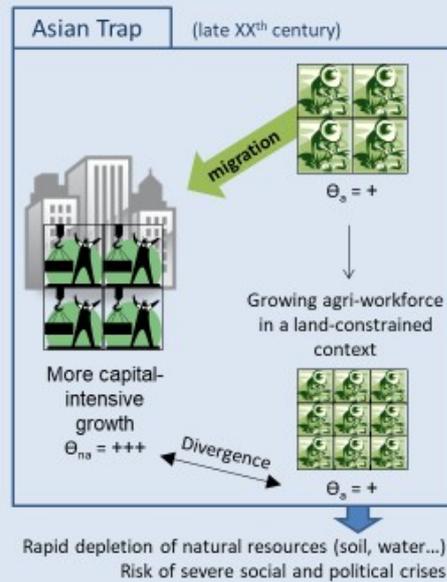
■ From a modern path to a postmodern trap...

Basic mechanisms



Historical evidences

Higher land acreage per farmer was the main driver for boosting:  
 - agricultural labour productivity ( $\theta_a$ )  
 - convergence of labour productivity across sectors ( $\theta_a = \theta_{na}$ )



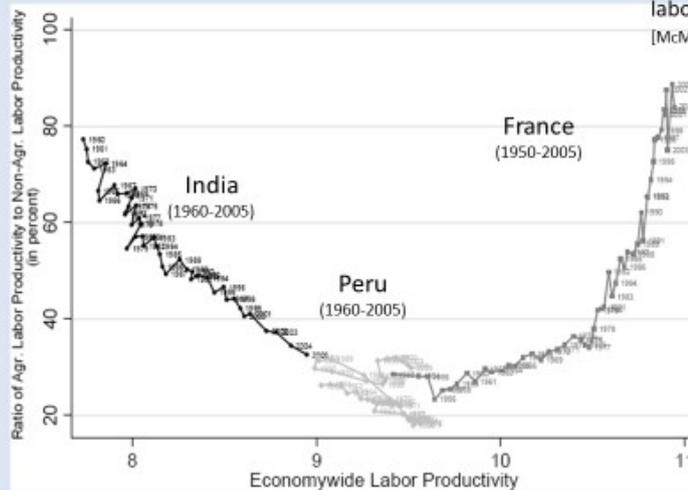
☹ Let us summarize now. In the world today, we have on the one hand, growing large-scale and capital-intensive agriculture with few farmers whose incomes are based on specialization and economies of scale and, on the other hand, hundreds of millions of very small-scale farmers who are locked up in agriculture because they cannot find a better livelihood in other sectors. Any breakthrough in biotechnology will not reverse such a trend as some want us to believe. As far as I am concerned, I now believe that a sustainable path lies in a high-tech agriculture of a very different nature from that which has been strongly encouraged and subsidized over the last half century, in India, in France and everywhere else in the world.

## 4 India out of the trap in the future?

### ■ Nothing wrong, let us wait?

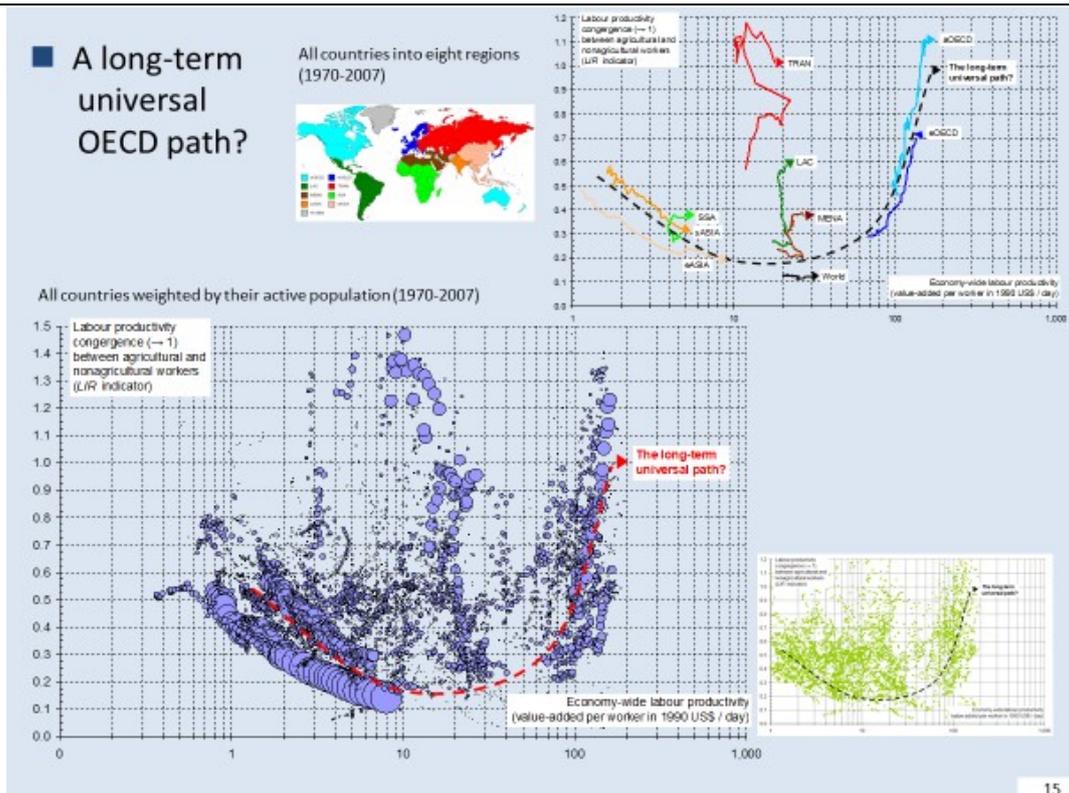
Structural transformation is a long historical process characterized in the early stages by a widening gap between farm and non-farm labour productivity

[McMillan & Rodrik, 2012, pp. 9-10]



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☺ Before presenting the fundamentals of this new high-tech agriculture, very different by nature from industrial agriculture, I have added a section here for the special attention of economists who, I know, think we should not really worry about the widening gaps between farm and non-farm labour productivity. Indeed, and as observed in the past, inequality rise at first with economic growth, but then fall as additional growth distribute prosperity more widely. Our Lewis Trap could thus be a preliminary stage of the Lewis Path, and the universal path of structural transformation would be U-shaped as pictured on this figure from McMillan and Rodrik in 2014 (McMillan *et al.*, 2014). They show this U-shaped relationship over time after having collating the time-series observations for three countries at different stages of development: India, Peru and France, from 1950-1960 to 2005. As they wrote, “*India, which is the poorest of the three countries, is on the downward sloping part of the curve. As its economy has grown, the gap between agricultural and nonagricultural productivity has increased. France, a wealthy country, has seen the opposite pattern—as income has grown, there has been greater convergence in the productivity levels of the two types of sectors. Finally, Peru represents an intermediate case, having spent most of its recent history around the minimum point at the bottom of the U curve*”.



☺ I traced similar curves with my data and indicators

- Here with all countries grouped into 8 regions, from 1970 to 2007, with a log scale for the X axis like McMillan and Rodrik

- ☺ and there without regional grouping but after weighting each dot by the annual active population unlike in the small figure at the bottom right.

As you see, both figures show a kind of barrier or frontier that segregates OECD countries from the rest of the world, at an economy-wide labour productivity between 20 to 30 per day in 1990 USD.

From these figures, one can legitimately wonder if the greater part of humanity can sooner or later embark upon the historical OECD Lewisian path of development.

But let's take a step forward.

## ■ A heuristic numerical experiment on India

Source: Dorin & al, 2013

<https://hal.archives-ouvertes.fr/hal-00866413>

	Past 1980 => 2007	Shukla & Dhar's scenario 2007 => 2050	"Lewis Path" scenario 2007 => 2050
<b>Population</b>	+1.94 % => 1165 M	+0.76 % => 1615 M	+0.76 % => 1615 M
<b>Growth (GDP) (<math>\gamma</math>)</b>	+6.1 %	+7.3 %	+7.3 %
- agriculture ( $\gamma_a$ )	+3.0%	+2.6 %	+2.6 %
- non-agriculture ( $\gamma_{na}$ )	+7.2%	+7.7 %	+7.7 %
<b>Labour productivity (<math>\theta</math>)</b>	+3.9 %	+6.2 %	+6.2 %
- agriculture ( $\theta_a$ )	+1.6 %	+3.0 %	+9.3 %
- non-agriculture ( $\theta_{na}$ )	+3.7%	+5.4 %	+4.6 %
<b>Workforce (<math>L</math>)</b>	+2.2 % => 463 M	+1.1 % => 735 M	+1.1 % => 735 M
- agriculture ( $L_a$ )	+1.4 % => 259 M (56%)	-0.4 % => 217 M (30%)	-6.2 % => 17 M (2%)
- non-agriculture ( $L_{na}$ )	+3.4 % => 204 M (32%)	+2.2 % => 518 M (70%)	+3.0 % => 718 M (98%)
<b>Income gap Agri/Non-Agri</b>	1 / 6	1 / 17	1 / 1
<b>Workforce in agriculture (change over the period)</b>	+ 82 M workers (+146 M people)	- 41 M workers (- 156 M people)	- 242 M workers (- 547 M people)
<b>Land availability (end year)</b>	0.66 ha/worker	0.78 ha/worker	Max 10 ha/worker

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☉ In my 2013 paper (Dorin *et al.*, 2013), I conducted a numerical experiment focused on India, taken as a typical country currently pursuing a polar direction to the Lewis Path. The purpose of this exercise was just to illustrate conditions under which a giant country like India can switch from its current trends to embark upon a Lewis Path up to a « World Without Agriculture ».

In this numerical experiment up to 2050, but it could have been 2100:

(1) I use the “simple mathematics” of Peter Timmer (2009: 10) to deduct the growth of workforce ( $L_a$ ) and labour productivity in agriculture ( $\theta_a$ ) from:

- the growth of the total number of workers ( $L$ ),
- the GDP growth in agriculture and other sectors ( $\gamma_a$  and  $\gamma_{na}$ )
- and the labour productivity growth in non-agricultural sectors ( $\theta_{na}$ ).

(2) I also build upon the Shukla and Dhar (2011) baseline scenario for India from 2005 to 2050, founded on a computable general equilibrium model used for long run projections describing the links between the energy sector, macroeconomic parameters (like demography and saving behaviours) and productivity trends at the sector level.

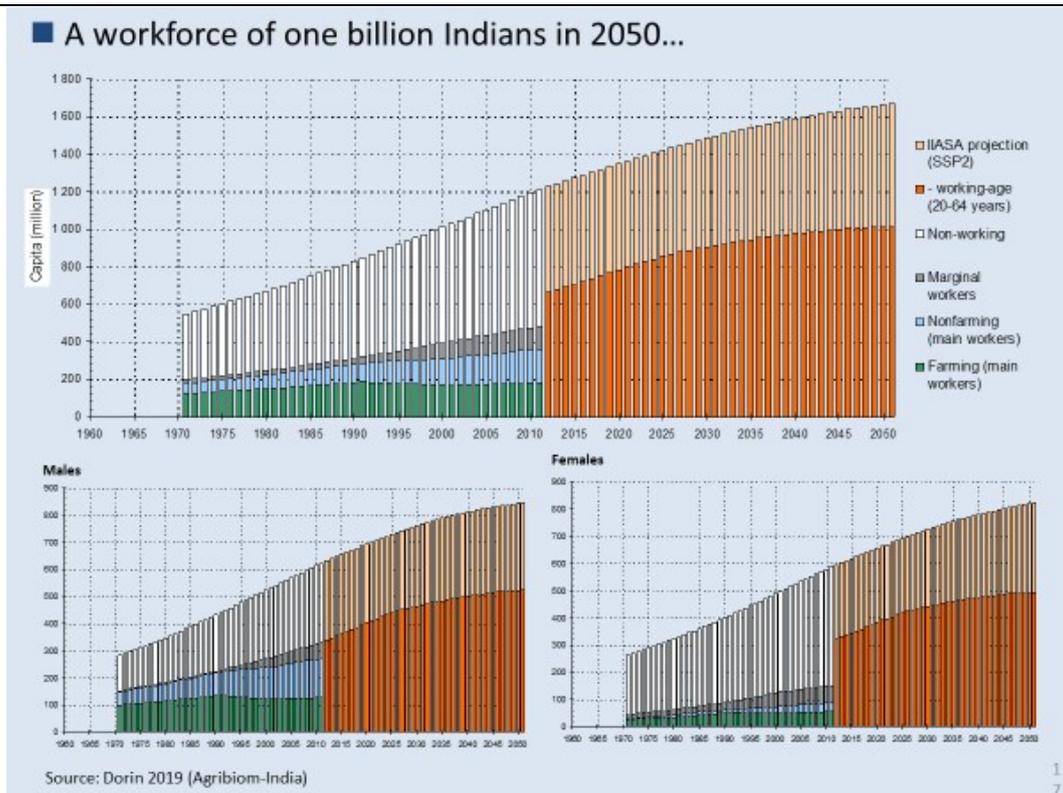
☉ This baseline is characterized by the 3 following points:

- (1) the GDP growth rate is 7.3% p.a., and the one of the overall labour productivity is 6.2% p.a., to reach 67 USD per day per worker in 2050
- (2) the sector annual growth of agriculture is 2.6% against 7.7% in remaining sectors
- (3) the annual labour productivity growth in agriculture is 3.0% against 5.4% in other sectors.

In this scenario, India no longer follows a “Lewis Trap”. It switches towards what I called a “Farmer-Excluding” path. In other words, farmers are fewer and they earn on average 17 times less than non-agricultural workers in 2050 compared to 6 times less in 2007. Their share in the total workforce falls to 30% against 56% in 2007, and urban population passes from 340 million in 2007 to 947 million in 2050. Land availability per farmer increases but very slowly: 0.8 ha in 2050 against 0.7 ha in 2007.

From this scenario, I tested the sensitivity of this pathway to alternative assumptions about labour productivity growth rates in non-farm activities, ceteris paribus. Due to time constraint, I will present you today only one variant.

☺ In this variant, I calculated the annual growth rate of labour productivity in non-farm activities which could lead to an « India Without Agriculture » in 2050. This rate is 4.6% p.a. against 5.4% in the baseline. With this much lower labour productivity rate in non-agriculture and a concomitant rate of 9.3% in agriculture to get the same GDP, the discharging mechanism operates very efficiently: we have 200 million less workers in agriculture than in the baseline scenario, which represents almost 400 million people when we include family members. Thus, in this variant, after four decades of unprecedented rural drift, the share of agriculture in total labour and in GDP is 2% and incomes of agricultural and non-agricultural workers converge at 67 US\$ in 2050 (LIR = 1).



☺ Is this Lewis Path scenario realistic for India with a workforce of one billion Indian adults in 2050, as shown in orange colour on the right part of these charts which combines demographic projections from the IIASA and data from the past population censuses on the left side?

## ■ The elusive “Lewis Path” through industrial agriculture

Unless labour is as free to move worldwide as capital today, a country like India can hardly follow the Lewis Path of OECD countries

### (1) Industry is less able to absorb labour than at the time of “manufacture”

- Labour productivity  $\nearrow$  (economy of scale, motorization/automation)
- Sector growth slows down (increasing cost of oil and other non-renewable raw materials, strengthening of environment-friendly regulations, market saturation in industrialized countries, slower increase of wages in developed economies not compensated by an increase elsewhere...)

### (2) It would require a mega-urbanization ever faced in history

- No more “open spaces” for exporting labour surpluses  
(60 million Europeans emigrate to the “New Worlds” between 1850 and 1930)
- Lewis Path scenario for India (2050): 80% of the population (1.3 billion people out of 1.6) lives in cities whose density reaches 55,000 inhabitants per km<sup>2</sup>  
(35,000 in Dhaka and 27,100 in Mumbai in 2010, the two current densest cities in the world)

### (3) Farm labour productivity cannot be boosted as in OECD countries

Limited prospects of:

- Large-scale moto-mechanization: max 10 ha/farmer in 2050 (150 in CA, 63 in US, 30 in FR... in 2007)
- Higher yield with modern industrial inputs (fertilizer, pesticide, oil...):  
ever-increasing costs + decreasing marginal productivity + negative externalities  
(on natural resource, climate, animal and human health...)
- International market: trade barriers + market powers  
(from large-scale and well-organized agro-industries that emerged during the past century)

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☹ I don't think this Lewis Path scenario can happen by 2050 and even 2100 unless labour is as free to move worldwide as capital today, which is very doubtful since this would involve emigration of hundreds of millions of people. My concluding arguments are gathered under 3 headings, using my numerical experiment and other points developed during this presentation:

☹ Firstly, industry is less and less able to absorb labour than in the time of “manufacture” some decades ago

- because labour productivity in manufacture has increased and will continue to increase and converge everywhere in the world due to economy of scale, motorization & automation, etc.
- also, because the industrial sector is likely to slow down compared to the past, due to increasing cost of oil and other non-renewable raw materials, strengthening of environment-friendly regulations, market saturation in industrialized countries, slower increase of wages in developed economies not compensated by an increase elsewhere, etc.

☹ Secondly, such a path would require a mega-urbanization in India ever faced in human history

Why?

- first of all, because there is no more “open spaces” for exporting large labour surpluses outside India, unlike between 1850 and 2014 for instance, when 40 million Western Europeans could emigrate to the Americas
- second, because in such a context, our Lewis Path scenario for India leads to have in 2050 broadly 1.3 billion people out of 1.6 (80%) in cities where the density would reach broadly 55,000 inhabitants per km<sup>2</sup>, that is to say almost double than the two densest cities in the world in 2010, which were Dhaka with 35,000 inhab/km<sup>2</sup> and Mumbai with 27,100. FYI, in Paris, we have only 3,400 inhab/km<sup>2</sup>.

What would then be the financial and human costs of such a mega-urbanization? Is it a desirable future? Would it not be a mega-slum urbanization? Is the way to double farmer incomes to shift poverty from rural to urban areas instead of eradicating poverty?

☹ Thirdly, farm labour productivity in India cannot be boosted as in OECD countries

for 3 main reasons:

- First, you may have noticed that in our Lewis Path scenario for India, we get an average availability of land per farmer of max 10 ha in 2050, whereas in 2007, it reaches already 150 ha in Canada, 63 in USA or 30 in France. So prospects of boosting farm labour productivity through large-scale moto-mechanization are very limited in a country like India

- Second because prospects of higher intensification with modern industrial inputs like chemical fertilizers, pesticides and even GM seeds, are also limited, due to their ever-increasing costs, plus their decreasing marginal productivity, plus their negative externalities on natural resources, climate, animal and human health, externalities that consumers are more and more aware of and more and more ready to denounce.

- Third because prospects of international market seem also limited, due to trade barriers and, may be above all, to the market power now exerted by the large-scale and well-organized agro-industries that emerged during the past century; I remind you here that we have a WTO for free trade only, but no international competition policy, which a non-sense and is even counterproductive if we really want to favour competition and discourage market powers.

## 5 Rethinking agriculture

### Rethinking Agriculture

**■ The equation at stake**

Increasing farmers' income & production

...without sending most of them to shantytowns

$$\theta_a = (pQ - Y_{na}^a) / L_a$$

Prices                      Costs of non-agricultural inputs

**■ A 2050 vision**

Science & farmers managing a mosaic of agro-ecosystems boosting local synergies amongst many plant and animal species above & below the ground surface.

**AGROECOLOGY**

"A science, a movement and a practice"  
(Wezel & al, 2009)

- 1 Higher biodiversity & biological synergies
  - ↗ production  $Q$  (total useful biomass)
  - ↗ resilience to economic & climatic shocks
- 2 Saving of inputs  $Y$ 
  - ↘ production costs (higher incomes)
  - ↘ environmental costs
- 3 Higher prices  $p$ 
  - ↗ quality (tasty/nutritious food)
  - ↗ co-products (wood, fuel, fibre, drugs...tourism)
  - ↗ ecosystem services (local & global)
- 4 Higher labour intensity  $L_a$ :
  - for knowledge-intensive & context-specific work
  - small family farms usually more productive & profitable per hectare (Sen 1964; Wiggins et al. 2010)

☺ I come to the fifth and last point of my presentation: we have to rethink agriculture. Because India face today all the economic, social, nutritional, financial and ecological burdens of conventional intensive industrial agriculture, and because it is also the biggest world democracy with dynamic farmers and a large scientific community, I am convinced that this country could lead a much more sustainable and inclusive agricultural model. The technical and institutional challenges are vast and complex. However, we are not starting from nothing. In recent years, there has been more and more international debates and literature about “agroecology”, and here are the seeds for a paradigm shift in our thinking of agriculture, especially for smallholder agriculture that will continue to remain largely dominant in the world as I have shown you.

Agroecology still embraces many definitions. In my opinion, agroecology does not completely ban the use of industrial inputs like in organic farming or permaculture. But in agroecology,

these industrial inputs are no more the core drivers of land productivity. Increase in agricultural productivity does not rest, above all, on few large-scale monocultures and an intensive use of water, fossil fuels and agrochemical inputs, but rather on context-specific agro-ecosystems boosting biological synergies below and above ground, amongst numerous plant and animal species, from soil fungi to trees, from soil bacteria or worms to buffalos, etc.

According to me, boosting biodiversity and ecological functions in each unique agro-ecosystem is highly complex and requires marrying the best science with traditional indigenous knowledge. But compared to current techno-centric modern agriculture, this agroecology is likely to be in the long run:

- (a) more productive per unit of land,
- (b) more resilient to climatic or economic shocks,
- (c) more labour-intensive than capital-intensive,
- (d) more profitable for farmers if commodities of higher quality (diversified tasty nutritious food, pesticide-free products, etc.) and ecosystem services of local and global importance are equitably priced on local and international markets, such as safe water, biodiversity pools, soil fertility, nutrient recycling, pollination, disease and flood control, climate mitigation and adaptation, etc.

## ■ Changing the sociotechnical regime

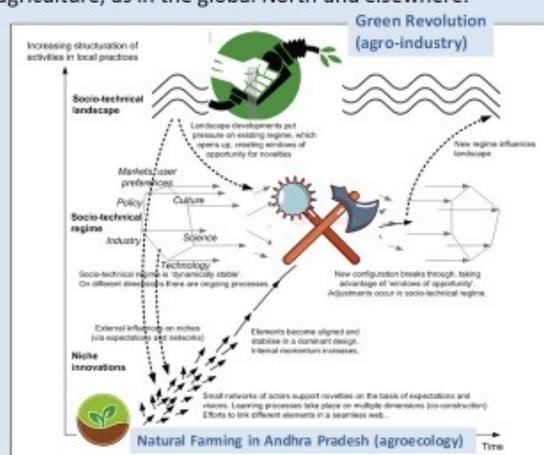
A **sociotechnical regime** is a set of aligned rules that are carried by a range of actors (firms, users, government, scientists...) that together form a community for how to produce, use and regulate specific products and processes [Schot et Geels, 2007]

Since the Green Revolution of the 1960s, India has extended the sociotechnical regime of **industrialisation** (born in the 18th century) to agriculture, as in the global North and elsewhere:

- specialization of tasks and specialization in a few products (wheat, rice, corn, sugar cane, cotton, etc.) to benefit from economies of scale (the larger you are, the better), the main driver of profit and labour productivity in any industry
- use of a common technology (genetics + irrigation + chemical fertilizers + pesticides/antibiotics... and fossil fuels for the whole system!) which theoretically guarantees poor countries to converge in the long term with rich countries (savings in R&D expenses and faster development), all then served by robots and fed with medical solutions.

But the industrialization of agriculture is a **trap in land-squeezed countries**

**Agroecology**, such as Andhra-Pradesh Community-managed Natural Farming (APCNF), looks a better sociotechnical regime, but it has to fight hard against the dominant one to change the mindsets on how to increase land and farm labour productivities...



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☞ This means changing a sociotechnical regime whose roots go back to the 18th century. According to Geels and Schot, a sociotechnical regime consists of a set of aligned rules that are carried by a range of actors that together form a community. These actors are typically firms, users, governments, and scientists. They share engineering search heuristics, ways of defining problems, user preferences, expectations, product characteristics, skills, standards and regulatory frameworks. And the nature of their binding is not based on direct interaction but on the participation in the production and reproduction of the sociotechnical regime.

☞ Since the Green Revolution of the 1960s, India has extended the industrial sociotechnical regime to agriculture, as in the global North and elsewhere. This industrialisation of agriculture has two main characteristics:

- specialization of tasks and specialization in a few products (wheat, rice, corn, sugar cane, cotton, etc.) to benefit from economies of scale (the larger you are, the better), the main driver of profit and labour productivity in any industry
  - use of a common technology (genetics + irrigation + chemical fertilizers + pesticides/antibiotics... and fossil fuels for the whole system!) which theoretically guarantees poor countries to converge in the long term with rich countries (savings in R&D expenses and faster development), all then served by robots and fed with medical solutions.
- ☹ As I tried to show you today, the industrialization of agriculture is not only a trap for the incomes of millions micro-farms, but also for natural resources, public finances, human, animal and plant health, etc. However, shifting from a dominant sociotechnical regime based on industrialisation, to another based on agroecology such a Natural Farming in Andhra Pradesh, is very challenging and implies fights to change the mindsets on how to increase land and agricultural labour productivities.

### Guidelines for a paradigm shift to convert the burden of small-scale farming into a comparative advantage...

Source: Dorin Bruno, 2019. "Rethinking Indian Agriculture: A French Economist's Perspective", *Development Alternatives Newsletter*, 292, pp. 8-9.

- (1) Deep overhaul of agricultural incentives towards agroecological practises and markets
- (2) Information, communication, training (farmers, consumers, central government, foreign markets)
- (3) Special incentives for group farming & group actions
- (4) Payments for Environmental Services (from local & global organizations)
- (5) Benchmarks for quantifying future improvements
- (6) Need for new performance measures beyond yield
  - water withdrawal per unit of biomass produced (plant and animal products)
  - fossil energy used per unit of biomass produced (including through chemical fertilizers and other inputs)
  - soil organic carbon (SOC)
  - annual work unit equivalents (AWUs) engaged permanently or temporary on the farm (production, processing, marketing)

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☹ To change these mindsets, and help scaling-up an agroecological transition in Andhra Pradesh but also elsewhere in India and around the world, let me read you a draft action guide that I suggested in January 2018 at a meeting with Indian policy makers and FAO in Chandigarh, Punjab (Dorin, 2019). These are six guidelines for a paradigm shift to convert the burden of small-scale farming into a comparative advantage. Keep also in mind that the bulk of the scientific literature shows that agriculture – unlike other sectors – is more efficient at small rather than large scales.

(1) Radically change the rationality of Indian incentives to agriculture. Huge amounts are at stake and could be much more beneficial to small-scale Indian farmers in the end. Instead of incentivizing directly or indirectly the mono-cropping of wheat and rice, as well as the use of groundwater, chemical fertilizers and fossil fuels, distribute these huge subsidies by rewarding the saving of water or fossil energy by ton of biomass, the storage of soil organic carbon, the crop and livestock diversity, etc. Deliver also cheap credit and insurances, especially to

encourage entrepreneurship in small-processing units, new marketing strategies, safe storage and transport.

(2) Start advertising in the state, in the country and also abroad, as do Vijay Kumar for Andhra Pradesh, that Punjab agriculture is moving firmly towards agroecology, and may be 100% organic by 2025. You could even claim an ambition to become a world net exporter of very various plant and animal organic products whose demand is growing sharply everywhere. Affirm this ambition by passing a State law for changing production models to combine economic and environmental performances, as did the French in 2014 with their “*loi d’avenir*” in favour of agroecology.

(3) Do encourage also group farming, so that they can save on credit, input, machinery, storage, transport and advertisement costs, have more time for experiment, training and leisure, develop geographical indications, labels, brands or participatory guarantee schemes, and, all be proud to be the new modern farmers of India since they are able to deliver to their community and the world a wide range of economic, social and environmental services that are greatly missing today.

(4) Assess and bargain future payments for environmental services from local municipalities, the National Capital Region, the Central government as well as international organisations. Join for instance the 4p1000 initiative ([www.4p1000.org](http://www.4p1000.org)) and become its leader in order to claim that any sink of carbon by agricultural soils must be a major part of the carbon trade system.

(5) Register accurate numerical benchmarks of how disastrous is current Punjab agriculture, especially on environmental, health and income aspects. These benchmarks are key to assess how Punjabi agriculture could improve in the future, and get payments for that. In future, Punjabi cultivators and labourers must be paid not only for their production, but also for all the services they can deliver to the local as well as global societies. They can clean water and air instead of polluting them, they can sink carbon instead of emitting large quantity of greenhouse gases, they can help preventing floods and other disasters instead of accelerating them, they can secure the national long-term food security with fertile soils and large stocks of biodiversity instead of eroding them, they can increase the resilience to climatic and economic shocks of the overall Indian economy.

(6) Employ high-qualified people to improve your annual statistics and modelling at the farm level, at least in four fields:

- water withdrawal per unit of biomass produced (plant and animal products)
- fossil energy used per unit of biomass produced, including through chemical fertilizers and other inputs
- soil organic carbon
- Annual Work Unit equivalents (AWUs)<sup>1</sup> engaged permanently or temporary on the farm, for either production, processing or marketing.

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<sup>1</sup> One AWU is equivalent to one adult working full time for a year on the farm; it is termed ‘*Unité de Travail Agricole*’ or UTA in France.

## 6 Concluding bullet points

- 1 Enlargement of farm size (economy of scale) is the profit driver of industrial agriculture, and it worked well in land-abundant OECD countries (“Lewis Path”)
- 2 In India (and many other countries, especially in Asia), not only has the average farm size not increased, it has declined, due to population growth and less-and-less labour-intensive industries (“jobless growth”)
- 3 Despite world best growth and ranking in agricultural yields (to counter the decrease in farm size), labour income gap of Asian farmers has widened (1960-2020) vis-à-vis OECD farmers but also nonfarm Asian workers
- 4 The Indian agrarian crisis won't be solved with industrial agriculture, or at very high socioeconomic/health/environmental/public costs
- 5 Small-scale agro-ecological farms (such as Natural Farming in AP) could be an alternative to mega-slum-urbanization, and could give India a comparative advantage in the long run

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☺ Thank you for your attention! I hope I haven't bothered you too much. Allow me to summarize my message in 5 bullet-points before your questions, comments or criticisms which will all be welcome.

## The path to follow, to encourage, to learn from...

### Natural farming in Andhra Pradesh

A niche with a guru (Maharashtra)

Zero Budget Natural Farming (ZBNF) with Subhash Palekar



A national/state crisis: agrarian distress, farmer suicides...

A grassroots aspiration: “Knowledge + Technology + Community in harmony with Nature”

An experimented & charismatic bureaucrat: T. Vijay Kumar, IAS

Who is T. Vijay Kumar, and what's he doing to promote natural farming in Andhra Pradesh?



[www.thehindu.com](http://www.thehindu.com) (14/07/2018)

A State enterprise: RySS (2014)

A core Technology:

Regenerative agriculture

Zero chemical fertilizer

Zero pesticide BUT:

Some money:

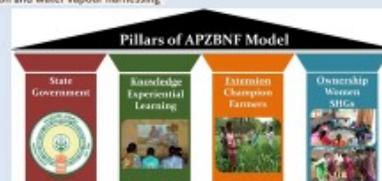


+ Schemes of the Govt of India (RKVY & PKVY)



<http://zbnf.in>

Institutional innovations:



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