

Promises and Challenges of Natural Farming in India

CLAND Workshop

« Reducing chemical input in agriculture: barriers & solutions »

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Promises and Challenges of Natural Farming in India

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Agro-industrial scenario?

Workforce livelihood → **A World Without Farmers** → Food

Agroecological scenario?

A World With Farmers and Nature

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Paris, 3-4 February, 2022

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(1) Dorin B., 2021. Theory, Practice and Challenges of Agroecology in India. *International Journal of Agricultural Sustainability*
(2) Dorin B., July P.-B., 2020. Modelling world agriculture as a learning machine? From mainstream model to Agriforum I.C. Land Use Policy, 96, pp. 103624
(3) Dorin B., Aubron C., 2016. Croissance et revenu du travail agricole en Inde. *Economie Rurale*, 352, 41-65.
(4) Dorin B., 2017. *India and Africa in the Global Agricultural System* (1960-2020). *EPW*, (1): 25-26, 5-13.
Dorin B., Hourcade J.-C., Berio-Cattin M., 2013. *A World without Farmers?*, CIREN Wp 47, Paris, 26 p.

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1) Dorin B., 2021. The (re) Practices and Challenges of Agroeology in India. *International Journal of Agriculture, Sustainability and Food Security*, 10(1), pp. 1-10.
2) Dorin B., B. P., 2020. Modelling world agricultural trends at learning machine? Farm management models to Agriculture 1.0. *Land Use Policy*, 96, pp. 103624.
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Dorin B., Heuvelink J.-C., Beau-Cassin M., 2013. *A World without Farmers?* CIRED, WP 47, Paris, 26 p.

Agro-industrial scenario? → Agroecological scenario?

Without Livelihood → Food

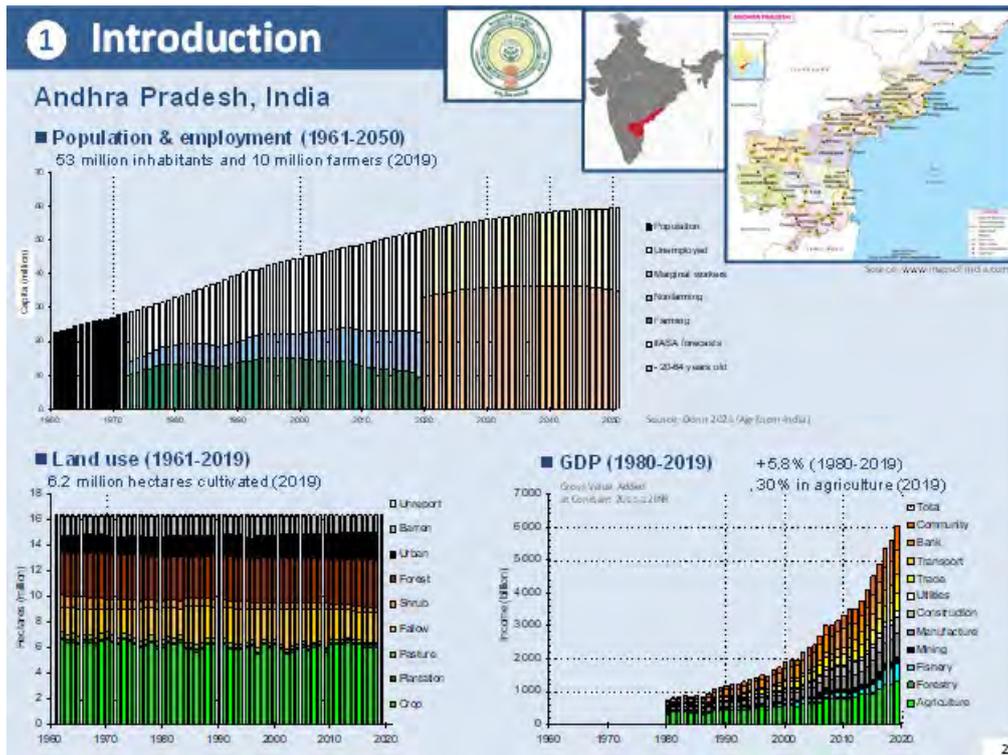
A World Without Farmers.

A World With Farmers and Nature

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Dear colleagues,

Let me first thank my colleague Thierry and the CLAND Institute for having organized this workshop on « *Barriers & Solutions for Reducing chemical input in agriculture* », and for having invited me to present and discuss my own work on Natural Farming in India with zero chemicals at all.



[*] My talk today will be focused on a rising alternative agriculture in Andhra Pradesh, a State of South India accounting about 53 million inhabitants and 10 million farmers in 2020, a State where also, 30 years ago, I did my first field surveys in India for my Ph.D. in economics on the then so-called “Yellow Revolution” of vegetable oil and oilseeds.

The date of official birth of Natural Farming in Andhra Pradesh is 2016, when the State government and its Chief Minister Chandrababu Naidu proclaimed that Andhra Pradesh was investing in a chemical-free agriculture called at that time “Zero Budget Natural Farming” or ZBNF. The ambition was to convert 6 million farmers and 8 million hectares to ZBNF by 2027, an aim that the same Chief Minister boasted of at the World Economic Forum at Davos in January 2018 with the support of the UNEP.

Contents

- (1) Introduction
- (2) Modern growth ...and its deadlocks
- (3) Content and promises of Natural Farming
- (4) Until a frontal crash with the dominant species

Science and economics of agroecology



© Dorin 2014 (On a wall in Fort Kochi, Kerala, India)

Theory, Practice and Challenges of Agroecology in India

Blanca Dorin

Abstract

1 Introduction

2 The deadlocks of industrial agriculture in India

2.1 The industrial socio-technical regime and its justifications

2.2 The "Levitt Trap"

2.3 Ecological suicide

3 The promises of natural farming in Andhra Pradesh

3.1 Gambling on agroecology

3.2 Andhra Pradesh's Natural Farming

3.3 Boxes and practices of a theory of change

4 Established science vs synergistic knowledge and aspirations

<http://dx.doi.org/10.1080/14735908.2021.1930760>

[*] What are the theory, practice and challenges of such a chemical-free agriculture in India, the country of the Green Revolution which follows and highly support for decades the science-based principles of industrial agriculture? These are the questions I tried to answer in a paper published last year in the *International Journal of Agricultural Sustainability*, and it is mostly this paper that I will present today in my remaining 22 mn.

My presentation will first brief you on the framework I develop in economics (a) to analyse and understand the numerous deadlocks of industrial agriculture in a country like India, (b) as well as its current deep agrarian crisis, (c) and why a policy for Natural Farming emerged in Andhra Pradesh.

Then in my third section, I will try to give you few information of what is Natural Farming technically and institutionally, and what its main achievements, before concluding, as in my paper, on how Natural Farming was discredited in 2019 by the Indian National Academy of Agricultural Science.

The overall conclusion is quite thought-provoking, for me as for you: we, economists, agronomists and modellers, may be the most important barrier for developing a promising solution of highly productive chemical-free agriculture.

2 Modern economic growth ...and its deadlocks

■ **“Modern growth”, “Structural transformation”** (Lewis 1954, Kuznets 1966...)

- Value (GDP) and jobs migrate from agriculture to industry and services
- Up to a “World Without Agriculture” (Timmer 2009): agriculture = 2-3% GDP & 2-3% employment
- With:
 - large specialized, chemical and motorized/robot farms (thanks to abundant and cheap fossil fuels...)
 - unbalanced/unsafe food, but cheap (household income is no longer just for food!)
 - income convergence between farmers and nonfarmers (countryside finally out of poverty!)

■ **The “Lewis Path” of industrialized countries** (Dorin 2013)
 Path of structural transformation of OECD countries (1970-2007)

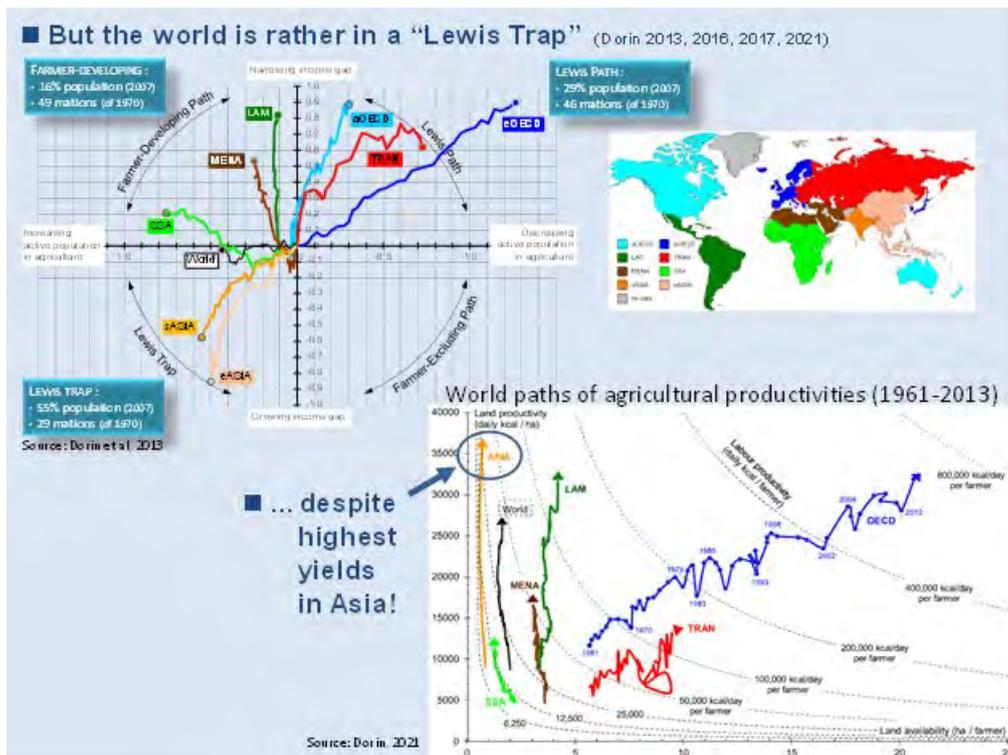
Source: Dorin et al (2013)

[*] Let me start presenting you or reminding you very briefly what we call in economics “modern economic growth” or “structural transformation”, which have strongly shaped agriculture and food policies all over the world for more than half-century now.

In a nutshell:

- modern economic development means values and jobs migrating from agriculture to industry to services
- until arriving in what Peter Timmer called a “World Without Agriculture” where agriculture does not represent more than 3% of GDP and 3% of employment, as today in all OECD countries
- in this “World Without Agriculture” fed by ever-growing quantities of abundant and cheap fossil fuels, we have cheap but few standardized agricultural products that are produced by large specialized, chemical robotized farms
- we have also – and it a great achievement – an income convergence between farmers and nonfarmers. In other words, we emptied the countryside of farmers, but make those who remain much bigger and richer.

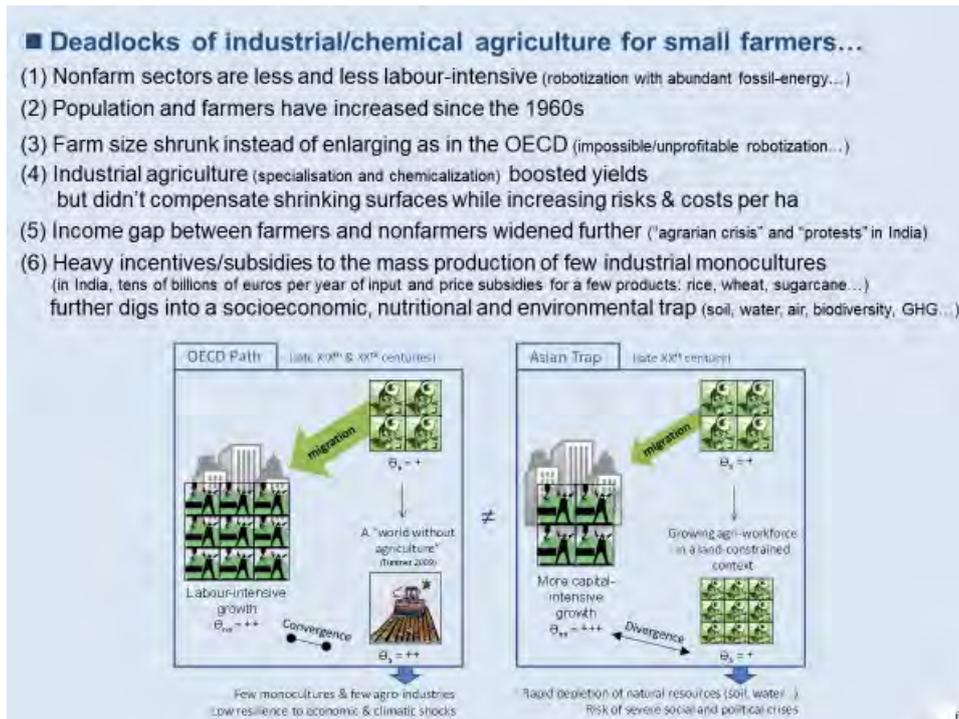
[*] I called “Lewis Path” this canonical path of modern growth, and tried to see what countries or world regions followed it since the 1970s with a graphic where I put on the x axis a proxy of the average farm size, and on the y axis a proxy of the average income gap between farmer and nonfarmers. As you can see, we found there only the OECD and transition countries. In 2007, these countries represented less than 30% of the world population. The question is now: “what other paths has been followed by most of mankind, and why?”



[*] In facts, more than half of the 2007 world's population, located in Asia, had been following what I called a "Lewis Trap", where average farm size has shrunk instead of getting bigger, and where the income gap has widened instead of narrowing.

[*] Last but not least, this worrying path of Asia is not because Asia lags in adopting modern technologies to increase agricultural yields, as we can read in the academic literature with the so-called “technological or yield gap”. On the contrary, Asia is most probably the world region where these modern industrial technologies, especially chemicals, have been adopted the most, and even overused, leading to the highest average yields in calories per ha. This is shown here on the y axis of the bottom-right graphic, a graphic where, once again, I put on the x axis a proxy of the farm size.

Overall, in Asia, we find the highest yields with the smallest farms. But in a country like India, we also see hundreds of farmers committing suicide every day mostly due to over-indebtedness, while malnutrition and health costs have increased dramatically, as well as the depletion of natural resources on all fronts: soil, water, air and biodiversity.



[*] To conclude this section, I tried to summarise in six points the macro story I wrote and argue better in my paper to explain the economic, health and environmental deadlocks of industrial chemical agriculture in a country like India full of micro-farmers:

- (1) One: during the second half of the 21st century, in India as elsewhere, population increased sharply but nonfarm sectors became less and less labour-intensive due to automation, hence less and less able to withdraw from agriculture the hundreds millions of workers that would have been required to enable developing countries to embarked on a Lewis Path;
- (2) Two: as a matter of fact, since the 1960s, the global number of farmers has increased in absolute terms even if the share of farmers in active populations has decreased everywhere;
- (3) Three: if large deforestation doesn't occur as in Latin America, then farm size logically shrunk, making impossible large-scale mechanization and robotization of farms, the profit-driver of land-abundant industrial farmers in developed countries;
- (4) Four: in this land-squeezed context, specialisation and chemicalization of agriculture as with the "Green Revolution" in India, led to boost yields and massively produce few crops such as wheat and rice; but in terms of income per farmer, it did not compensate shrinking surfaces while increasing risks & costs per ha, eroding natural factors of production, resilience to biotic and abiotic shocks, and food quality;
- (5) Five: these higher risks and costs of production per hectare widened further the century-old income gap between farmers and nonfarmers, leading to a deepening "agrarian crisis" in India;
- (6) Six: continuous scientific and financial incentives to industrial agriculture, which in India represent tens of billions of euros every year, only deepen these socioeconomic, nutritional and environmental traps.

3 Content and promises of Natural Farming in AP

■ Andhra Pradesh Community-managed Natural Farming (APCNF):

“a movement, a science and a practice” (Wezel et al, 2009, about agroecology)

A movement to meet five challenges (APCNF, 2019):

(1) farmer distress

(high dependency on chemical fertilizers and pesticides, high cost of cultivation, perpetual cycle of debt, climate and market uncertainty, drying up of borewells, landless labourers or insecure tenants, distress migration to urban areas...)

(2) consumer food and health crisis

(chemical residues in food, low nutrient content, almost 1.7 billion Indians to feed in 2050, urbanization, climate change, etc.)

(3) soil, water and biodiversity degradation (due to chemical agriculture and its monocultures)

(4) global warming and (5) climate injustice (the poorest and the least responsible are the most affected)

A science in the making, inspired by:

● Regenerative Agriculture (APCNF, 2019)

“A holistic land management practice that leverages the power of photosynthesis in plants to close the carbon cycle, and build soil health, crop resilience and nutrient density [...] whilst simultaneously increasing yields [...] utilizing in-situ biological resources [...] through diverse cropping systems (mixed crops, internal crops, 5-layer model, border crops, bund crops...)”

● Agroecology (Dorin, 2013, 2017, 2021)

“A land and labour productivity no longer based on a few large-scale mono-productions and the intensive use of water, fossil fuels, chemical molecules and laboratory genetics, but on a mosaic of localized agroecosystems that, each in their own way, stimulate biological synergies between many plant and animal species beneath and upon the earth’s surface, from soil fungi to cereals, pulses and trees, from bacteria or earthworms to large bovinds”

A practice (see next slide)

[*] So now, what is Natural farming in Andhra Pradesh, renamed APCNF in 2020, for *Andhra Pradesh Community-managed Natural Farming*? As I wrote in my paper, it is for me “*a unique illustration both of the political choice of agroecology and of the sociotechnical path agroecology can follow to be upscaled*”.

Indeed and for sure, APCNF belongs to the “science, movement and practice” of agroecology, to paraphrase the well-known article of our colleagues Wezel et al. published in 2009.

It is a **movement** to meet five challenges, five deadlocks of the dominant industrial sociotechnical regime which I tried to briefly introduce to you in my previous section. As written in an APCNF brochure published in 2019, these challenges are (1) farmer distress, (2) consumer food and health crisis, (3) soil, water and biodiversity degradation, (4) global warming and (5) climate injustice, where the poorest and the least responsible are the most affected, “particularly children, women and landless farmers” as it also written.

[*] APCNF is also a **science** in the making, inspired by Regenerative agriculture which, as APCNF wrote, is “*a holistic land management practice that leverages the power of photosynthesis in plants to close the carbon cycle, and build soil health, crop resilience and nutrient density [...] whilst simultaneously increasing yields [...] utilizing in-situ biological resources [...] through diverse cropping systems*” such as mixed crops, internal crops, 5-layer model, border crops, bund crops, etc.

This matches very well with my own definition of agroecology, where “*land and labour productivity are no longer based on a few large-scale mono-productions and the intensive use of water, fossil fuels, chemicals and laboratory genetics, but on a mosaic of localized agroecosystems that, each in their own way, stimulate biological synergies between many plant and animal species below and above the earth’s surface, from soil fungi to cereals, pulses and trees, from bacteria or earthworms to large bovinds*”

■ **Natural farming in Andhra Pradesh**

(1) **A state/national crisis:** farmer suicides, bad food, soil & water depletion...
feeding grassroots aspiration: knowledge, technology and community much more in harmony with Nature

(2) **An alternative sociotechnical niche** with
- a guru : Subhash Palekar (Maharashtra)
- a core technology:
Zero chemical fertilizer
Zero Budget
Natural Farming
(ZBNF)

ZBNF Four Wheels

- 01 **Beejamrutham**
Microbial seed coating through cow urine and dung based formulations
- 02 **Jeevamrutham**
Enhance soil microbiome through an 'inoculum' of cow dung, cow urine, jaggery, pulse flour, uncontaminated soil
- 03 **Achhadana**
Ground to be kept covered with crops and crop residues as mulching
- 04 **Waaphasa**
Fast buildup of soil humus through ZBNF leading to soil aeration and water vapour harnessing

The Soil Food Web

(3) **An experimented & charismatic bureaucrat:** T. Vijay Kumar, IAS

(4) **A State enterprise:** RySS ("farmers empowerment corporation") <http://apcnf.in>

(5) **Some money:** RKVY/PKVY public schemes
Philanthropic organisations
Azim Premji Philanthropic Initiatives

(6) **Institutional innovations:**

ZBNF farmers organized in SHG

Pillars of APZBNF Model

- State Government
- Knowledge Experimental Learning
- Extension Empowered Farmers
- Onset Stage Business Model

[*] As far as the **practice** is concerned, it would require an entire book. In my paper, I identified at least 6 conditions explaining the emergence and upscaling of APCNF practices, beside of course “*the freedom of thought and initiatives permitted in a democracy*”:

(1) the first condition is a crisis, the agrarian and health crisis briefly described before and which has contributed to spreading questions and criticisms on the dominant sociotechnical regime of industrial chemical agriculture;

[*] (2) the second is the prior existence of an alternative sociotechnical niche, here the one occupied by Subhash Palekar, the Indian guru of natural farming with a core technology using:

- Beejamrutham [*bijamroutam*] or ‘ferment of immunity’, which is a coating for seeds to protect them and stimulate their growth;
- Jeevamrutham [*jivamroutam*], which is an inoculum based on local cow urine and dung that stimulates soil micro- and macro-organisms;
- Achhadana [*achadana*], which is a constant coverage of the soil with diverse crops and crop residue mulches;
- and Waaphasa [*vapassa*] or ‘microclimate’, which means an aerated soil humus that harnesses water vapour.

[*] (3) the third condition is a State with an experienced and charismatic senior civil servant, here T. Vijay Kumar, a man capable of designing and developing a public policy that connects the aspirations for change from the grassroots to the administrative apparatus and its government;

[*] (4) the fourth condition is a not-for-profit public company flexible enough to independently manage the inflow and outflow of funds, including for staff recruitment; this was here the RySS, which means in English the “*farmers empowerment corporation*”;

[*] (5) the fifth condition is of course money, of public but also private origin such the funds and staff of the foundation of the Indian billionaire Azim Premji;

[*] (6) the sixth condition is a range of organizational innovations to orchestrate the entire project and develop the sociotechnical niche at a sufficiently large scale to undermine, or even replace, the dominant sociotechnical regime.

AP-ZBNF Main Organisational Components

- SPMU: State Program Management Unit, with its Executive Vice Chairman (EVC: T. Vijay Kumar) and the RySS staff (project executives, facilitators, recruiters, accountants, public relations staff ...)
- SRP: State Resource Persons, including those from the TSU (APPI's Technical Support Unit)
- DGF and FFS: Digital Green Foundation (to provide teaching tools, pico-video projectors, etc.) and Farmer Field Schools (with FAO guidance)
- RNGO and FNGO: 'Resource' and 'Field' NGOs
- DPMU: District Program Management Units
- MAO: Mandal Agricultural Officers (civil servants from the Department of Agriculture)
- Cluster: group of (roughly) 2000 farmers belonging to 5 GP (Gram Panchayats or village councils), with 1 NFF (Natural Farming Fellow), young agriculture graduate recruited to experiment and show for himself the benefits of natural farming on a rented plot
- CRP: Community Resource Persons at the scale of the village community (over 5600 at the beginning of 2020), champions in the practice of natural agriculture with their MT (Master Trainers)
- CMSS: Community Managed Seed Systems
- Schoolteachers and schoolchildren with their ZBNF kitchen gardens
- SHG: Self-Help Groups (over 160,000 at the beginning of 2020): each one has their leader and their federation (over 7000); both below and above everything, these SHGs are viewed as the real owners of the programme, its social capital and its platform
- ZBNF farmers: 695,000 farmers in April 2020

Source: Dorin, 2021

Pillars of APZBNF Model

Why some adopted APCNF?

- Higher net income*** with lower input cost (fertilizer, pesticide, energy, seed...)
- No yield penalty* (rice, sugarcane...) or higher yields** (pulses...)
- Better food*** (diversified, nutritious, safer...)
- Good feed/forage for livestock***
- Happiness** (experimentation and work in harmony with nature, recognized knowledge, community work and innovation...)
- .../... (Need additional studies to validate and extend!!!)

Why others did not yet adopted APCNF?

- Higher work** (seeding, monitoring, harvesting...)
- Much more complex system***
- No premium for NF products*** (higher price)
- No subsidy benefit for large monocultures** (chemical fertilizers, electricity & water, support prices...)
- .../... (Need additional studies to validate and extend!!!)

* degree of confidence (B. Dorin's self-preliminary assessment)

[*] These organizational innovations really impressed me the most since they have multiple local versions and involve many different actors, whose main ones are listed in the box. This complex organizational scheme, with no real bases or leaders, or even a hierarchy, seems there to develop, first of all, a constant collective-learning capacity.

As the RySS wrote in 2019,

“we have been firmly believing in three important theories of change in implementing our Natural Farming programme:

- (1) One: Transformation should happen in a democratic way wherein women SHGs and farmer institutions are involved in programme planning, implementation and monitoring;*
- (2) Two: Knowledge dissemination and handholding support is constantly provided through farmer-driven extension architecture led by Community Resource Persons [or CRP];*
- (3) Three: Saturation of entire village, cluster, Mandal and the state (in that order) involves converting all villages, all farmers, all farms and all practices leading to a total transformation”.*

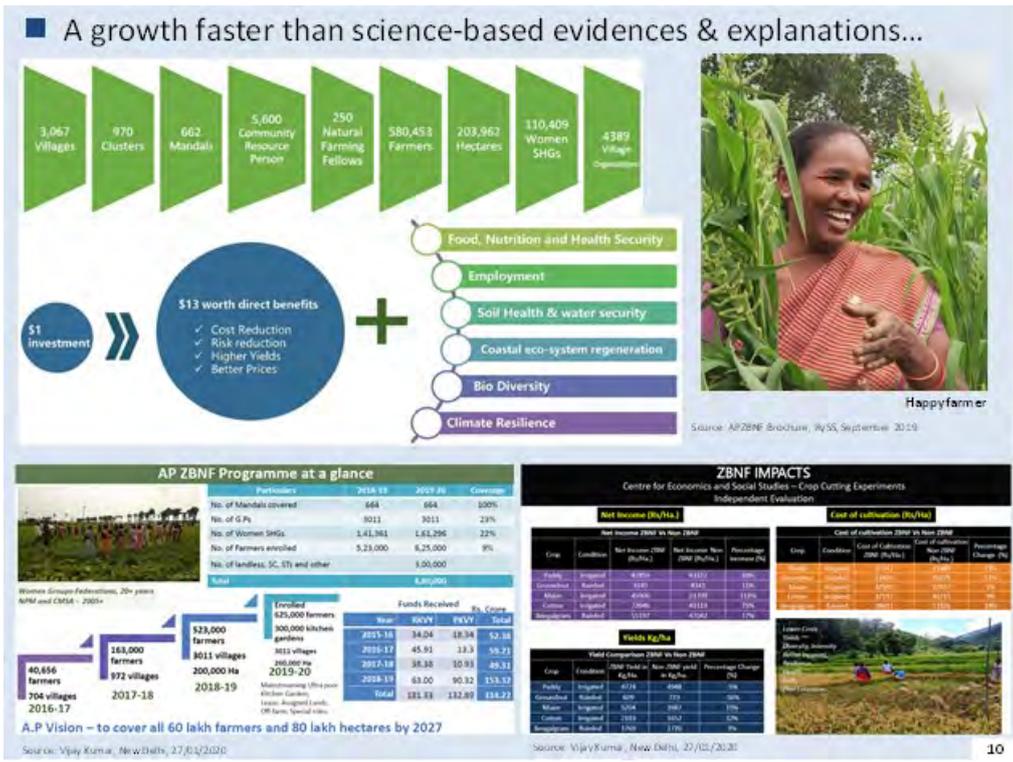
In April 2020, as you can read in the last line of my box, about 700,000 micro-farmers had been partially or totally practicing natural farming since 2016, on 190,000 ha spread over 3011 villages. Today, we are close to 1 million farmers, about 10% of Andhra farmers. Hence, in five years or so, the flourishing of Natural Farming in Andhra Pradesh has been very good, particularly given RySS’ modest budget of about 10 million euros a year between 2015 and 2019. After including civil servants’ salaries and those of the other partners involved, the RySS estimated that the cost of helping a farmer to convert completely to ZBNF after 5 to 6 years was 25,000 rupees, about 320 euros.

[*] Why these farmers adopted APCNF?

According to preliminary studies and our own ongoing surveys, it is above all because they get a higher income by saving on industrial inputs, mostly fertilisers, pesticides and electricity, but it could also be seed, credit and insurances. The second reason is no-yield penalty, and even much higher yields in some cases such as pulses. The third is the access to much better-food, diversified and pesticide-free. The fourth reason that is often overlooked, is the production and availability of good feed and forage for livestock which, in India, is a key income and nutritious supplement for micro- or landless farmers. Last but not least, there is also happiness, with experimentation and work in harmony with nature, recognized knowledge and expertise, community work and innovation...

[*] With all these advantages, why all other farmers did not yet shift to APCNF?

Here we have so far identified four main reasons. The first is that APCNF requires, at least during a couple of years, more work for covering the soil with mulches, preparing and applying natural inputs, planting, monitoring, harvesting multiple crops, etc. The second reason is that building your local agro-ecosystem is very complex, whereas industrial recipes are simple and universal as long as you can afford it. The third reasons often quoted by farmers is the non-existence of a higher market price for APCNF products. And last but not least, with the current Indian subsidy regime in favour of industrial input and crops such as rice or sugarcane, it is more profitable to practise conventional chemical agriculture as long as you have enough land to amortized its costs.



[*] Whatever the reasons, converting about 1 million micro-farmers in five years remain quite impressive, and this bottom-up agroecological transition was faster than science-based evidences & explanations to legitimate it.

Growing interests from India and abroad

National and International Recognitions for APZBNF

World Future Council selected AP ZBNF as one of the top 30 most promising policies in agroecology

Global Alliance for the Future of Food has selected AP ZBNF as one of the 21 'Beacons of Hope'

UN Agencies (WFP, UNEP, CBD, WHO, IFAD, FAO, UNDEP) has approved the Scaling up Agroecology Initiative work plan for 2019-2020. Mexico, Senegal and APZBNF selected for the first phase of implementation.

The Hon'ble Prime Minister has mentioned ZBNF as a way forward for farming in India during Parliament session and in COP 14 speech in Sept'19

NITI Aayog, Govt of India has commended the Government of Andhra Pradesh's ZBNF strategy. The Ministry of Agriculture is setting up a National Mission for scaling up of ZBNF in all the States.

Himachal Pradesh, Karnataka, Rajasthan States have visited AP and are interested to adopt APZBNF model.

Partnerships and Collaborations

Source: APZBNF Brochure, RVSS, September 2019 <http://www.apzbnf.com/wordpress/wp-content/uploads/2019/09/09-2019-APZBNF-brochure-11-11-2019.pdf>

11

[*] However, this agroecological transition attracted growing interest from abroad and from India,

Growing studies too...

Reports

Peer-reviewed articles

Münster Daniel, 2016. "Agro-ecological double movements? Zero Budget Natural Farming and alternative agricultures after the neoliberal crisis in Kerala", in Mohanty B.B. (Dir.), *Critical Perspectives on Agrarian Transition: India in the Global Debate*, Routledge, New Delhi, pp. 222-44

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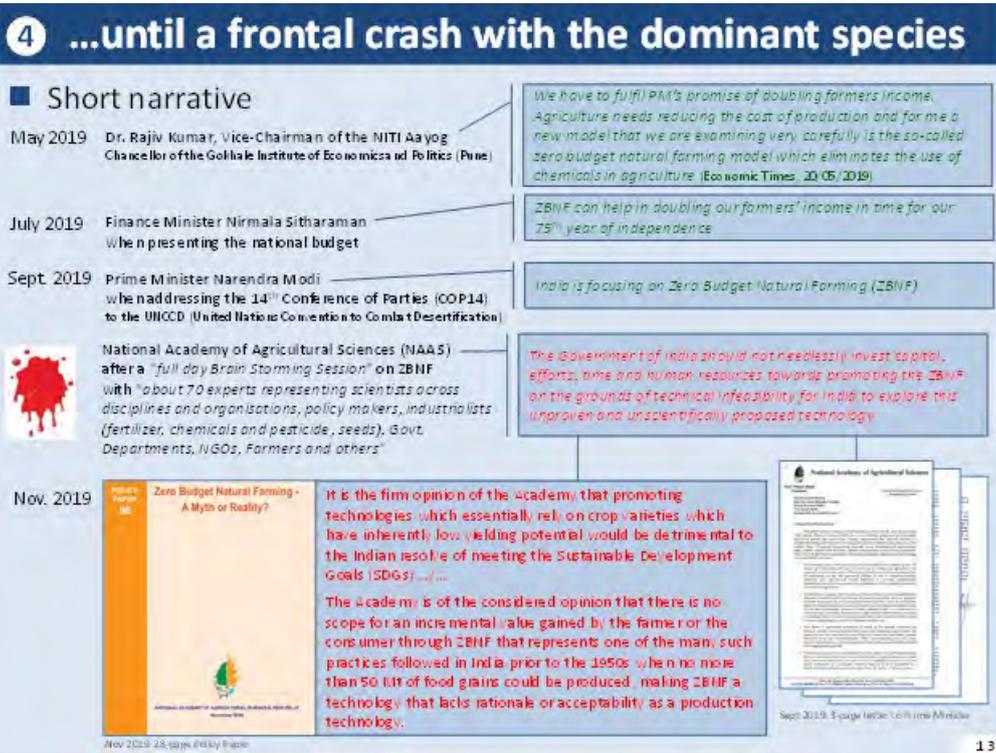
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Veluguri Divya, Bump Jesse B., Venkateshmurthy Nikhil Srinivasapura, Mohan Suresh, Pulagurtha Karthik Teja, Issako Lindsay M., 2021. "Political analysis of the adoption of the Zero-Budget natural farming program in Andhra Pradesh, India", *Agroecology and Sustainable Food Systems*, pp. 1-24.

Duddigan Sarah Collins, Chris D, Hrossas Zakis, Ozbair Henry, Shaw Liz J., Sinclair Fergus, Simms Tom, Thilman Vijay, Ann Winowicki Leigh, 2022. "Impact of Zero Budget Natural Farming on Crop Yields in Andhra Pradesh, SE India", *Sustainability*, 14(5), pp. 1689.

12

[*] which also stimulated the publication of the first reports and articles on Natural farming, and you have a list here of the main ones that I have identified



[*] All this before a frontal crash in September 2019 with the dominant species embodied here by the Indian National Academy of Agricultural Sciences and the agricultural inputs industry defending a market that has come to represent several tens of billions of dollars a year in India, with seeds, fertilizers, pesticides, irrigation equipment, credit and, increasingly, agricultural machinery and digital farming. They wrote among others to the Indian Prime Minister:

“It is the firm opinion of the Academy that promoting technologies which essentially rely on crop varieties which have inherently low yielding potential would be detrimental to the Indian resolve of meeting the Sustainable Development Goals (SDGs). [...] The Academy is of the considered opinion that there is no scope for an incremental value gained by the farmer or the consumer through ZBNF that represents one of the many such practices followed in India prior to the 1950s when no more than 50 Mt of food grains could be produced, making ZBNF a technology that lacks rationale or acceptability as a production technology”.

Results
Zero budget for Zero Budget Natural Farming...

Some conclusions...

(1) APCNF is "a grassroots movement that is attempting to improve India's capacity to produce its own food by farming with nature and ending farmers' reliance on purchased inputs and credit" (Smith et al. 2020)

(2) Its core technology and productivity are based on complex biological synergies amongst many plants and animal species, notably soil organisms (bacteria, fungi, worms, insects...) that have been poorly investigated by agricultural science for the past half century (too complex?)

(3) The industrial sociotechnical regime of the Green Revolution is so strong that Indian science, instead of sending a mass of scientists to the field to document, validate (or not) and understand what is happening, has felt its legitimacy and authority shaken and condemned Natural Farming as witchcraft as soon as it appeared seriously on the national scene

(4) All in all, today's societies have to choose between two contrasting paths:

- continue to massively produce a few products that are processed and assembled downstream, where market values, investments and jobs are increasingly concentrated, particularly to resolve the social and environmental flaws in the system (rising cost of healthcare, water treatment, soil restoration, fight against climate change...)
- produce in symbiosis in and with nature, with markets values, investments and jobs concentrated upstream to provide a diversity of quality products, as well as services (currently unpaid) such as water filtering or soil carbon storage.

13

[*] Thus spoke science and the industrialists of modern agriculture. They are very influential as, in December 2019, the press headlines announced: *"Modi govt supports Zero Budget Natural Farming but doesn't have enough budget to promote it"*

All in all, zero budget for Zero Budget Natural Farming, what could be more natural?

[*] Let me now finish this presentation with some conclusions that may contribute to the discussion of this workshop.

One: as wrote Smith and colleagues in a paper published in 2020 in Nature, APCNF is *"a grassroots movement that is attempting to improve India's capacity to produce its own food by farming with nature and ending farmers' reliance on purchased inputs and credit"*.

[*] Two: the core technology and high productivity of APCNF are based on complex biological synergies amongst many plants and animal species, notably soil organisms (bacteria, fungi, worms, insects...) that have been poorly investigated by agricultural science for the past half century, may be because it is too complex and subject to infinite local variations

[*] Three: The industrial sociotechnical regime of the Green Revolution is so powerful that Indian science, instead of sending a mass of scientists to the field to document, validate (or not) and understand what is happening, has felt its legitimacy and authority shaken, and condemned Natural Farming as witchcraft as soon as it appeared seriously on the national scene.

[*] Four: All in all, today's societies have to choose between two contrasting paths, and no science will help here, since it is a political choice and trade-off:

- the first path is to continue to massively produce a few products that are processed and assembled downstream, where market values, investments and jobs are increasingly

concentrated, particularly to resolve the social and environmental flaws in the system (rising cost of healthcare, water treatment, soil restoration, fight against climate change...)

- the second path is to produce in symbiosis in and with nature, with markets values, investments and jobs concentrated upstream to provide a diversity of quality products, as well as services (currently unpaid) such as water filtering or soil carbon storage.

Indian natural farming and agroecology are clearly rooted in the latter path, and industrial agriculture in the first one. How to reconcile the two, I don't know since I think it is impossible and have to choose now in which world we would like to be in 2050 and beyond...

