

# Towards a Material Society

*Development as Engineering*<sup>1</sup>

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<sup>1</sup>Based on manuscript "Making of India as an Engineering Society" 

# Organization of the talk

- Society and the University
- Engineering in India-Demand, Supply and Consequences.

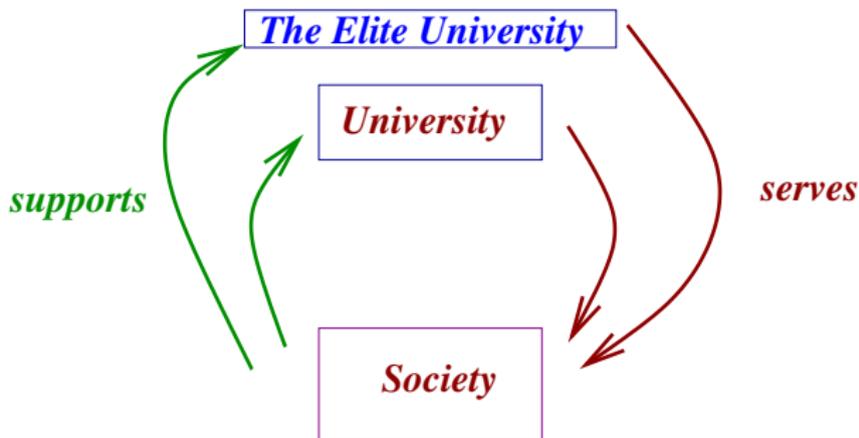
## How and Why has the University failed?

- **Micro-analysis:** New jobs definitions  $\Rightarrow$  new jobs, better serve society
- **The Three Problems:** Knowledge, Outcomes and the Elite University.



- Regional and Development Engineering
- *What is the social science of it?* How is it doing and why is it relevant?
  - ▶ has it failed too?
  - ▶ material before social? community before political?
  - ▶ *scientific temper and skills of language before anything else?*
- Finally...

# Society and the University-*a virtuous loop*



- **The University**

- ▶ repository of knowledge and practices
- ▶ training agents who deliver value

- **The Elite University**

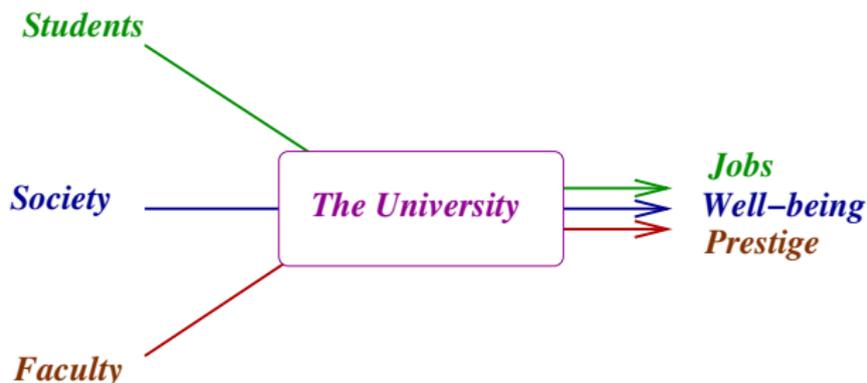
- ▶ thought leadership, the arts, long-term research, *destiny*
- ▶ *symbolic of what a society values!*

# Societal Outcomes

- Better nutrition for all, higher productivity in agriculture
- *sadak, bijlee, paani*
- More and cheaper buses, bridges.
- Better public transport, better sewage systems.
- Cheaper phones, better cars, less pollution.
- Quieter or more cultural *ganeshotsavs* .
- More authors, better books, more olympic medals.
- Indigenous helicopters, submarines.
- A more equal society. Well being for all!

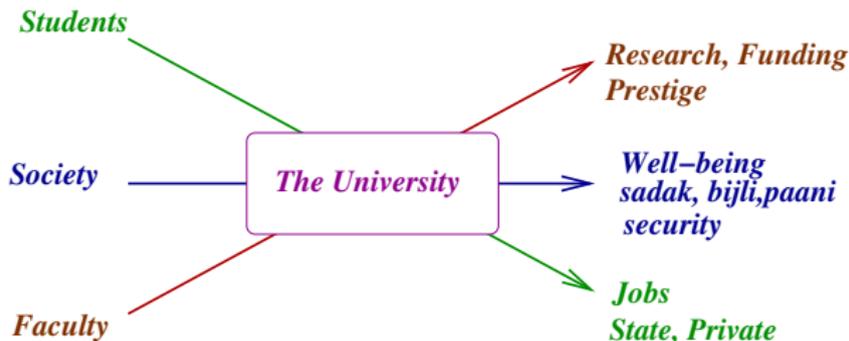
# Collaboration and Alignment

- Close collaboration between the Society, State, Industry and University.
- An alignment between faculty members, the students, and the design of the institution.



# However

However, It may happen that there is a *disconnect!*



## Two Questions?

- How are we doing?
- How do we get better?

# How is India doing *materially*?

How do you measure?

- Number of scientific instruments in schools.
- Number of buses per 1000 people.
- Number of liters of water per person per day?
- Number of factories. Number of manufacturing jobs.
- Length of roads per 1000 people.
- Units of electricity per person per year.

# Engineering in Sectors and employment

## Sector-wise GDP

India	Agriculture	Industry	Services	Per capita ( in USD)
GDP (2012) (%)	17.4	25.8	56.9	1.5K
Employment (%)	51.1	22.4	26.6	-
GDP China	10	44	46	6.8K
GDP S. Korea	3	40	57	25K
GDP Germany	1	28	71	43K

Low-income, un-industrialized trap?

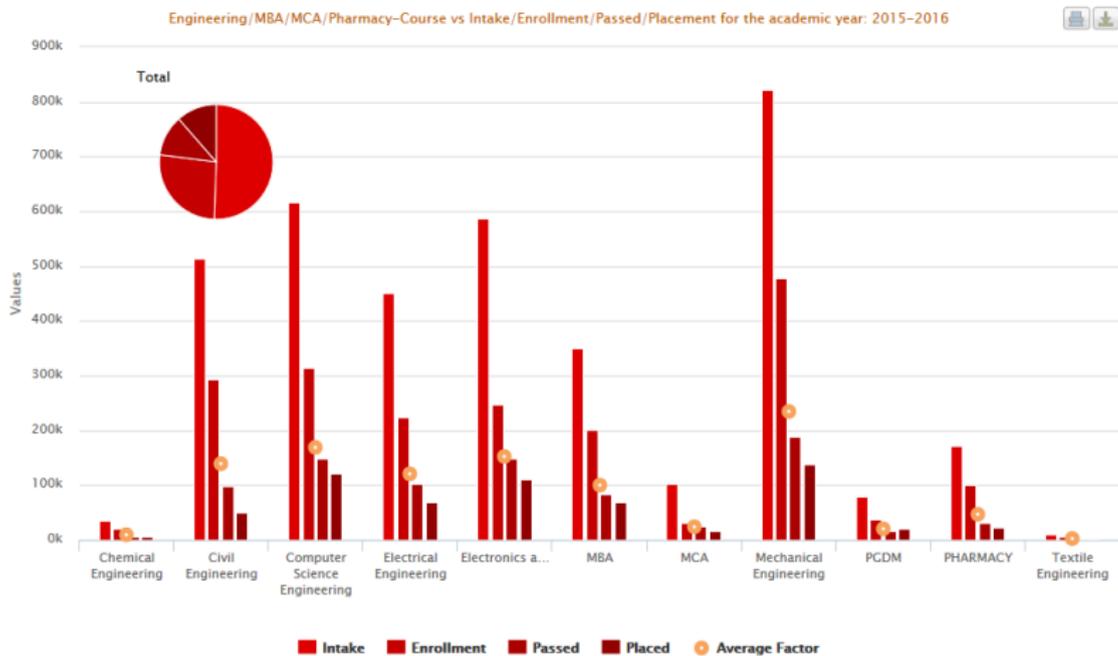
## Top Formal Employers

Industry	Food	Textiles	Metals	Apparel	Non-metals
Wages (Rs. lakhs)	0.70	0.80	1.35	0.67	0.69

### Formal vs. Informal: various definitions.

- About 75% workforce in informal sector.
- In manufacturing, the rule of 80%-20%.

# The supply-side



- 90,000 for USA vs. 10,00,000 for India!
- Considerable expense-Rs. 2 lakh p.a., and yet "unemployable".

at the IITs

## Engineering Placements 2013 (IIT Bombay)

Sector	Engg.	Finance	Consulting	IT
Super-GG	25 (27.7)	10 (35.0)	8 (49.6)	41 (52.1)
GG	116 (7.9)	82 (11.7)	110 (9.6)	102 (10.0)
IG	52 (6.5)	19 (7.2)	11 (5.8)	28 (7.2)
GI	24 (9.3)	10 (14.2)	10 (5.2)	5 (9.3)
II	64 (6.5)	13 (9.5)	8 (5.8)	22 (7.9)

Table : Numbers by sector and profile and average annual salary in Rs. lakhs

So, why are our graduates not doing engineering?

# Knowledge

**Table 4:** Number of papers with phrase in the title, with at least one author from India (Scopus)

Topic (Phrase)	All years preceding 2003	2003-2009 (TEQIP I)	2010 onwards (TEQIP II)
<i>Water Supply</i>	84	74	87
<i>Sanitation</i>	30	51	63
<i>Groundwater Models</i>	11	29	70
<i>Public Transport</i>	5	15	25
<i>Power Grid</i>	12	56	288

**Table 3:** Number of papers with phrase in the title, with at least one author from India (Scopus)

Topic (Phrase)	All years preceding 2003	2003-2009 (TEQIP I)	2010 onwards (TEQIP II)
Neural Network	692	1818	2467
Fuzzy Logic	110	327	759
Wavelets	96	905	1846
Genetic Algorithms	262	989	1373

- Do we even know enough?

# Effects!

Steel consumption. Points to few business models, e.g., *Railways*.

India	57	China	477
Other Asia	69	Japan	506
Egypt	95	USA	306
UK	145	Netherlands	200

Year-round drinking water availability. Points to bad practices.

Year	Rural	Urban
2012 (69th NSSO), per 1000	858	896
Maharashtra	<b>745</b>	931
2008	862	911

similarly about Milk, Electricity, Cooking Fuel.

And this is how our basic engineering/social/gender services are ...

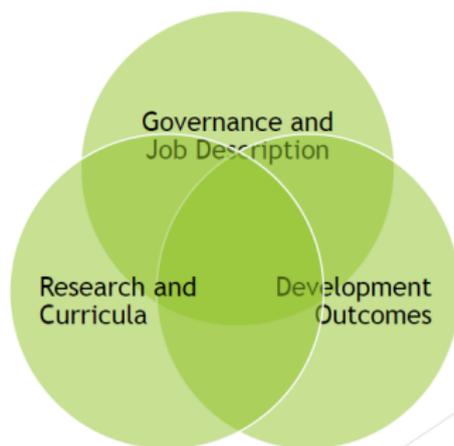


# Conclusion

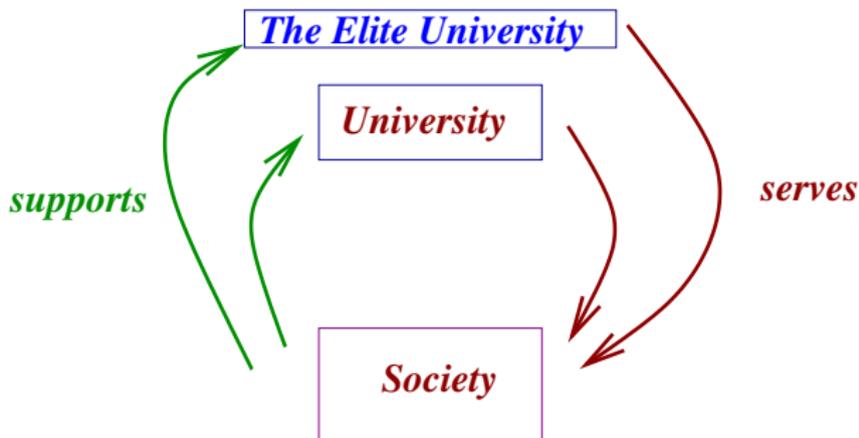
- Mis-allocation! Our engineers are not doing what they are supposed to do!
- But are they trained? And are there opportunities?
- Has our training changed as per changing situations?

## Critical for the Material World

- Alignment between job-descriptions, values and education.



# Revisit- Society and the University



- **The University**
  - ▶ repository of knowledge and practices
  - ▶ training agents who deliver value
- **The Elite University**
  - ▶ thought leadership, the arts, long-term research, *destiny*
  - ▶ *symbolic of what a society values!*

# Society and the University-*Expectations*

## Knowledge Provisioning!

- **Methods.** How to do things. Processes and procedures. Empirics. Skills of description, analysis and argumentation. Design of experiments. *What is amenable to systematic analysis?*
- **Useful Knowledge.** Groundwater. Sanitation. Tanks and Submarines. Railways. Low-cost housing. Better steels, better machines. Cooperatives. Agricultural markets. *How to bring better societal outcomes?*
- **Blue-sky research.** Astronomy. History. Natural History. Sustainability. The humanities. *How to bring conviviality and culture?*

Lets see them one-by-one

# The Methods-*Scientific Temper*

Whis is the best *chulha* in the village?

- 2-3 types. Designing a test. Documentation. Arguments. Awards and recognition.
- **New role-models.**  
Chulha as a scientific and cultural object!  
Girls at the fore-front.



- Where is my water? Where is my land? How late is the bus and how frequently? What constitutes a drought?
- *Cultural and political salience poorly understood.*

# Where do we stand on scientific temper?

- Proximate and concrete. Ideal vehicle for *methods and temper*.

## But for us:

Global  $\xRightarrow{\text{Research}}$  Elite  $\xRightarrow{\text{Curricula}}$  Regional  $\xRightarrow{\text{Tests}}$  School

- Merit goes the other way!. Aspirational dysfunction. Deliverance for the top 2-5%. No outcomes for the next 30%. Science as the way out and not a better life within!

## Competitive Exams: The rogue elephant *in the room*.

- Highly iniquitous and under-analysed. Doubtful legality.

"maintain standards:"  $\nrightarrow$  rank students

- Multiple-choice *objective* science. Cultural skills of description, argumentation and design - neither tested nor taught.

# Useful Knowledge

## Both sector knowledge and agents.

- Groundwater and groundwater professionals.
- Protocols which deliver value.

## But we have:



- Little new knowledge in groundwater, railways, chulhas, cooperatives, milk-coolers.
- Old practices in state and private sectors. Same job-descriptions which are now defunct. **No new jobs!**
- Engineers going to IT and IITians delivering cabs.
- **Missing:** The synthetic role of inter-disciplinary training.

# Blue-sky research

- Why are my hills barren? Were they forested in the past?
- What are the colours and pigments used at *Hampi*?
- What is the history of Manmad railway junction?

## Culturally Crucial

Makes our ordinary lives interesting.

Gives confidence. Creates new role-models.

However, we have:

- Particle physics. Protein folding. . . And lots of fake ones.
- "Successful" collaborations on *global* problems.
- Borrowed *frontier*. Borrowed narratives. Borrowed rigour - journals and textbooks. and a submission to *global science*.

# The Elite University

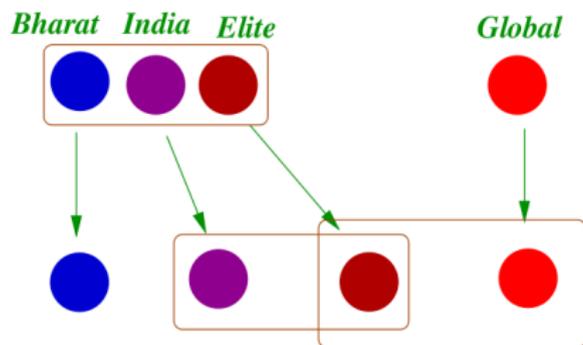
- **Important Role.** Central funding. Autonomy. Better salaries. Branding and networking. **Still trusted-somewhat.**
- **They define the discipline in India**-through JEE, GATE and other exams.
- **Problematic Design (on hind-sight):** Nehruvian modernity-*excellence and benevolence*. Uni-directional flow:

**Scientists** (well-meaning)  $\Rightarrow$  **Agents** (mal-performing)  $\Rightarrow$  **Beneficiaries** (poor, helpless)

- However, no accountability to region and location. No connection with regional institutions and the vernacular.
- **Separation of knowledge from the "provincial" administrations.** Perhaps a fear of "*political interference*".
  - ▶ **Misplaced.** Science is the best tool against despots and wayward politicians.

# The elite university...

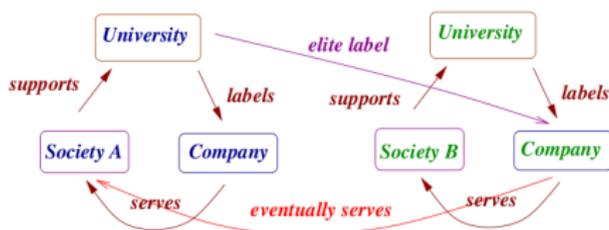
- Separation of disciplines and *physical removal* from society. No breadth or inter-disciplinarity, field or social.
- Largely abstract, textual, *urban and english*.
- *No synthetic content or engagement.*
- *Faculty: Enmeshed and entrapped as clients of global science.*  
*Graduates: Trained for and aspire to serve the global society..*



# Global Science

An instrument of the global economy-*beliefs and methods*.

- Coalition of iconic scientists, universities, multi-lateral agencies and companies building a better world.
- Widely applicable laws proven with great effort and rigour.
  - ▶ Practically unfalsifiable with limited resources or case-studies.
- *Development Economics, Development Engineering*: to supervise knowledge production in the developing world.



# What is to be done and who is to do it?

- **How do we dis-entangle from this mess?**
- Where do we start? From the regional or the elite? **Elite, of course, for they define the conduct of higher education.**
- How and what will persuade them? And yet keep their autonomy and the modicum of trust that still exists.
- What should be the pedagogy and sectors?
- What is the role for the regional?
- How do we re-legitimize the regional institutions?
- What should the relationships between the elite and the regional institutions?
- **And how will we take it through the great Indian bureaucracy of MHRD, AICTE, IIT Council, CABE and so on?**
- **Is there a way out?** Ideal design task for Ph.D. students!

# What is to be done?

## Foremost

- Re-imagine the university. Refine the loop.
- Re-imagine knowledge as tapestry of local and accessible knowledge, describing a wide variety of situations and performed by a variety of actors.
- How to save/re-tool elite science?-give them the *power* of falsifiability and accountability.

*How can engineers deliver better value?*

## *New Areas*

- *What sectors which are likely to be important?*

## *New job profiles*

- *New processes, products and protocols which deliver value.*
- *New engagements between the state, the university and the private sector.*

# The areas of the future

- **SME and Informal Enterprises.** Bringing the benefits of technology, increasing efficiency, improving market access.
- **City and District Administration.** Improving planning, transport, infrastructure, logistics, optimization.
- **Core Sectors.** Water supply and sanitation, Electricity grid, Solar, Food, supply chains.

This would in turn create the demand for new instruments, gadgets, machines, tools for analysis and design, simulators ⇒ **better engineering, better efficiency, better value**

# Solar-steam based *Istry* in Parbhani



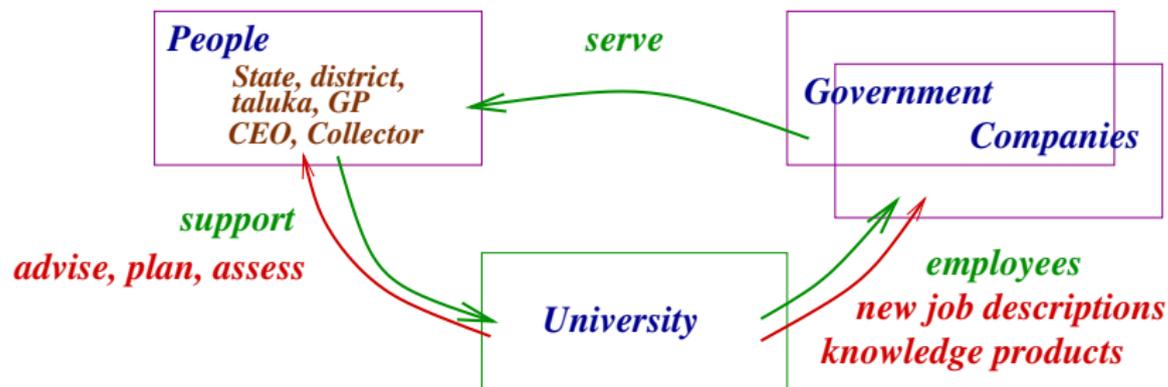
# Optimizing Irrigation in Shahpur, Thane



# Processes at Ganapaty Factory in Pen



# The New Institution and new job profiles!



## New jobs!

- Energy expert. Drinking Water consultant.
- District Public Transport Manager. Taluka-level planner.
- **New research. New definition of rigour!**
- **Research which is accessible by society!.**

# Regional Engineering

- Each department in each IIT/NIT/IISER identify key areas and develop these through field-work and **case-studies**. *Start elective courses and project topics.*

Electrical	Rural electricity, Energy efficiency at SME
Civil	Low-cost housing, Watersheds, Drinking water
Mechanical	SMEs, cooking energy, agricultural machinery
CSE	Logistics of public transport, GIS and planning,
Sciences	Groundwater, Bio-digestion, water quality

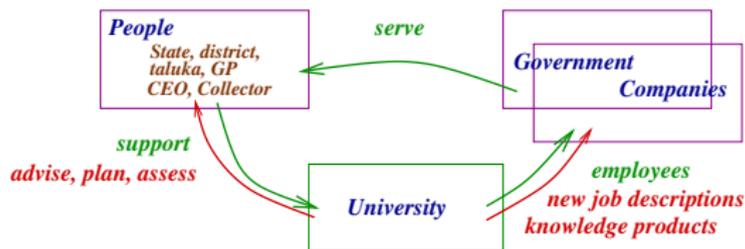
- Prepare students through an inter-disciplinary *Development Engineering*.
- Use elite status and create linkages within state agencies.
- Bring formality and rigour. Improve outcomes.
- Legitimize the case-study and transfer to regional colleges.

# Development Engineering

2-semester course (approved by IIT Bombay) to prepare students for Regional Engineering.

- **Designed to be teachable by ordinary-mortal teachers for ordinary mortal students at an ordinary-mortal college.**
- **Applied Social Science**-development and its metrics, elementary structure of society, basic data-sets and GRs.
- **Analysis**-GIS and planning perspective, census data, cost-benefit analysis.
- **Local Engineering Practice**-creation of value, stakeholders, design and outcomes.
- **Sector**. Key attributes of a sector. Government programs. Reading a case-study and a GR.
- **Field-Work**. Semester-long Case-Study on a specific problem/location/stake-holder. Reportable to stake-holders.

# The Unit Step



## The Mechanism: The Engineering Case-Study

- End-user defined, quickly usable and deployable.
- Concrete context and clear processes and protocols.
- *Rigorous!* Repeated case-studies in different situations.
- *International-quality Research!!* Innovation in practices. *New job definitions.*
- *The agency and wide access to useful knowledge.*

# The Case Study



# What to do?-As Thinkers-The Research Agenda

## Global Knowledge-its culture and politics.

- The Social Imagination of natural and social sciences.
- One-science, The Science loop as a political process. Advanced science.
- The global knowledge elite, One-Science and its linkages with the global economy.

## Philosophy of Modern Knowledge.

- Cultural views and cultural diversity and the "world-class" syndrome.
- The Question of Rigour- Global rigour vs. a plural and democratic science.
- Practical Rigour and its features.

## The Indian knowledge bureaucracy.

- The input, the output and the conduct of research.
- The situation of the university.
- Elite institutions and their impact.
- MHRD, UGC, DST and other bodies. Accreditation.

## The Competitive Exam

- The social imagination of knowledge
- The definition of basic sciences and social sciences.
- The race to the bottom. The gender, the urban-rural divide.
- The impact on wider knowledge formation.

## Public Sector and its practices.

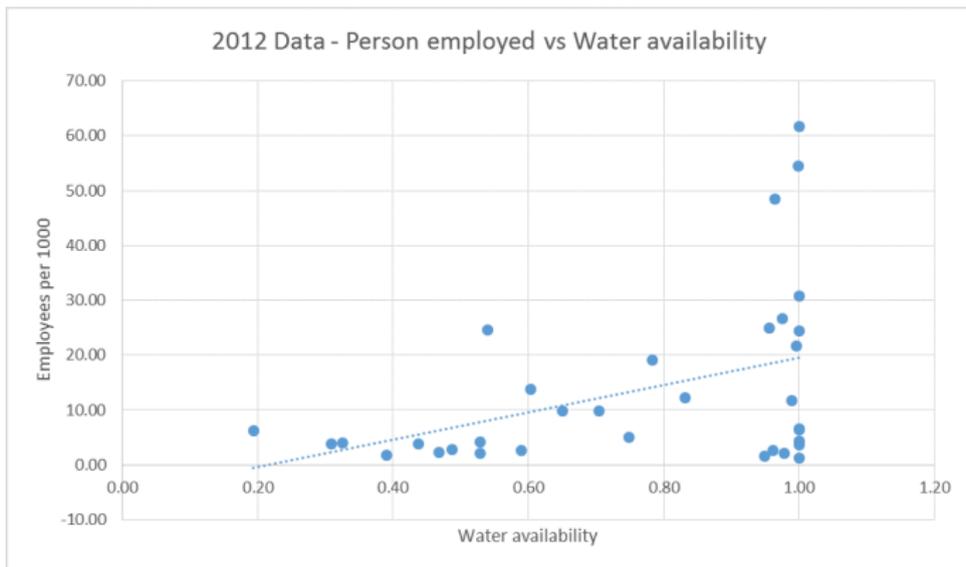
- The shrinking state and its causes.
- Sites for good practices, their codification and adaptability.
- Jobs, new professions and job descriptions and institutional capacity.

# Several Questions

- And what about the abstract and the intellectual? Or critique and dissent? Is there no longer any room for that at the university? *Yes, there is! Lots of it and at more places... It only gets better 😊.*
- **Can there not be a few purely intellectual institutions?** Need they be elite? Need they be centrally funded? Must they hold national exams and admit 2%? Must they tell us what science "really" means?
  - ▶ **Can we do this after we have something nice for the next 20%?**
- What about the traditional focus on the formal economy and big industry? Or are we all become Luddites or Plumbers?

# Development Engineering

**Better Engineering Services:** A pre-requisite to industrial growth.



# The small, medium and rural

The SME and agro-industry: Precursor to industrialization.

52

J. Wilkinson and R. Rocha

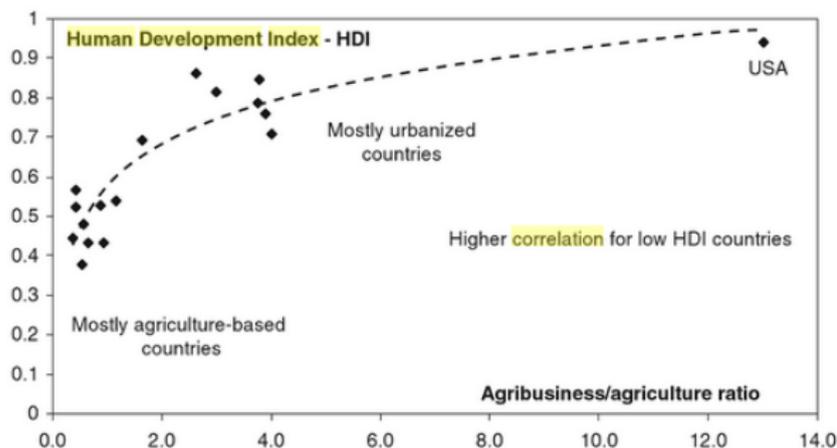


Figure 1. Correlation between human development and the agribusiness/agriculture ratio.

# Finally

*Freedom is the recognition of necessity.*

*Science is the cognition of necessity.*

**Scientific temper is the comprehension of needs.**

Development needs a different Science:

- A **culture** which documents, argues, describes and engages with the immediate neighborhood.
- A **platform** to bring all parties to a common accountability and which offers wide access and agency.

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# Thanks

