

Towards a Material Society

*Development as Engineering*¹

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¹Based on manuscript "Making of India as an Engineering Society" 

Organization of the talk

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

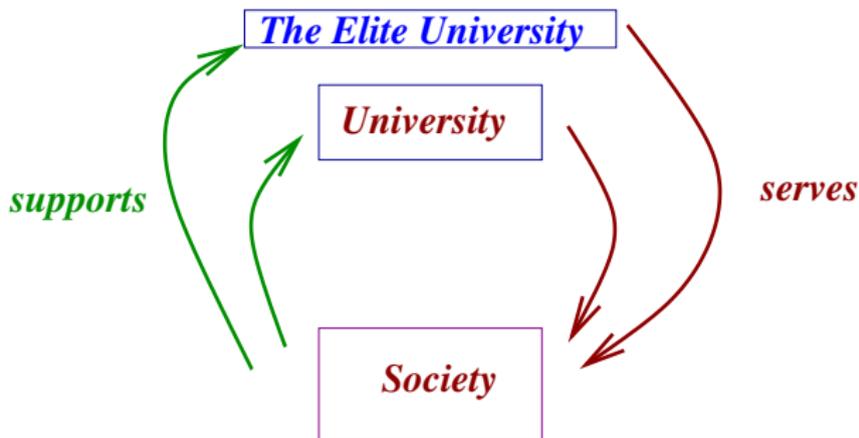
How and Why has the University failed?

- **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*



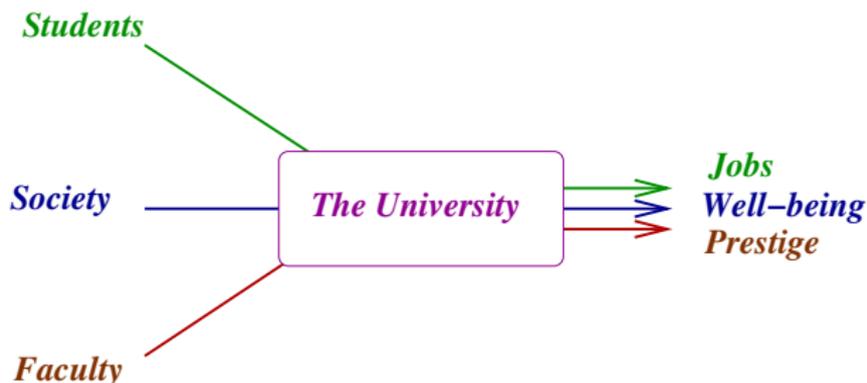
- **The University**
 - ▶ repository of knowledge and practices
 - ▶ training agents who deliver value
- **The Elite University**
 - ▶ thought leadership, the arts, long-term research, *destiny*
 - ▶ *symbolic of what a society values!*

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!

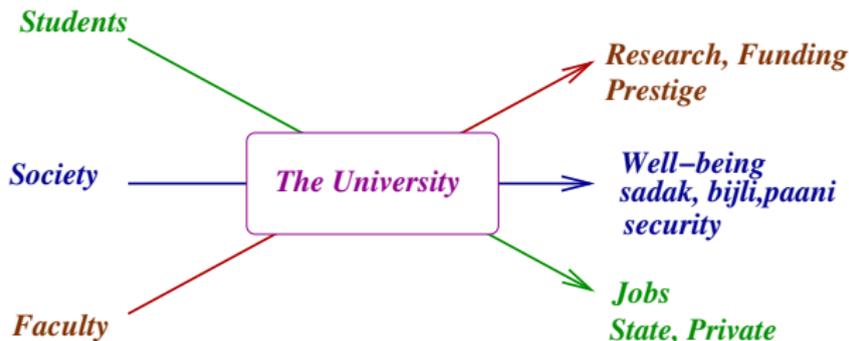
Collaboration and Alignment

- 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?

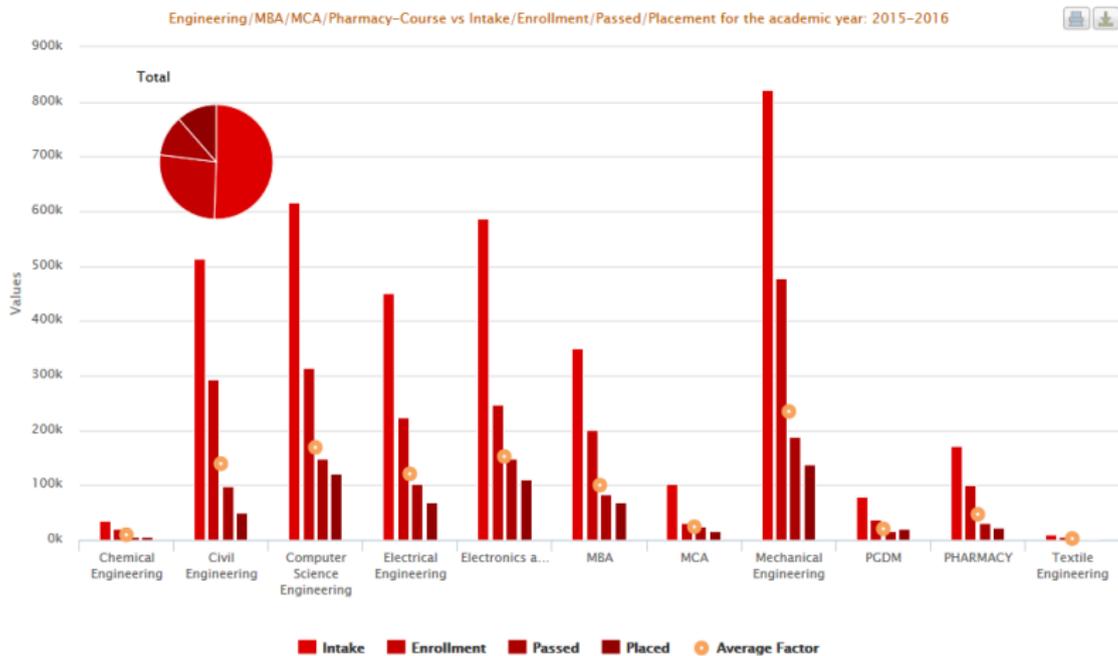
Top Formal Employers

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	745	931
2008	862	911

similarly about Milk, Electricity, Cooking Fuel.

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



Conclusion

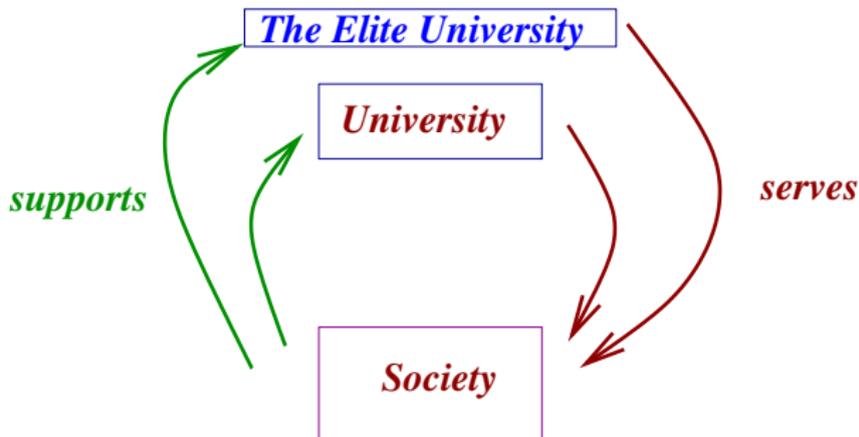
- Mis-allocation! Our engineers are not doing what they are supposed to do!
- But are they trained? And are there opportunities?
- Has our training changed as per changing situations?

Critical for the Material World

- Alignment between job-descriptions, values and education.



Revisit- Society and the University



- **The University**
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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

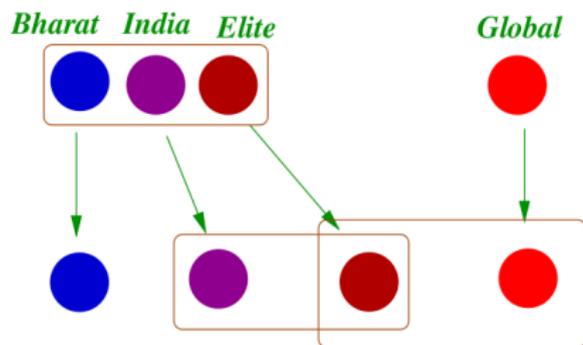
- **Important Role.** Central funding. Autonomy. Better salaries. Branding and networking. **Still trusted-somewhat.**
- **They define the discipline in India**-through JEE, GATE and other exams.
- **Problematic Design (on hind-sight):** Nehruvian modernity-*excellence and benevolence*. Uni-directional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

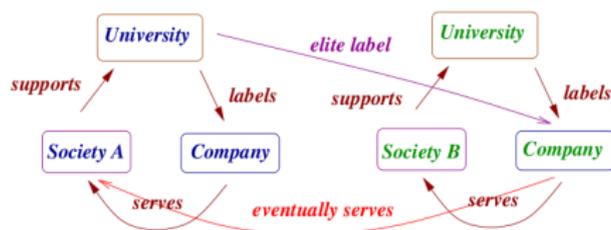
- Separation of disciplines and *physical removal* from society. No breadth or inter-disciplinarity, field or social.
- Largely abstract, textual, *urban and english*.
- *No synthetic content or engagement.*
- *Faculty: Enmeshed and entrapped as clients of global science.*
Graduates: Trained for and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



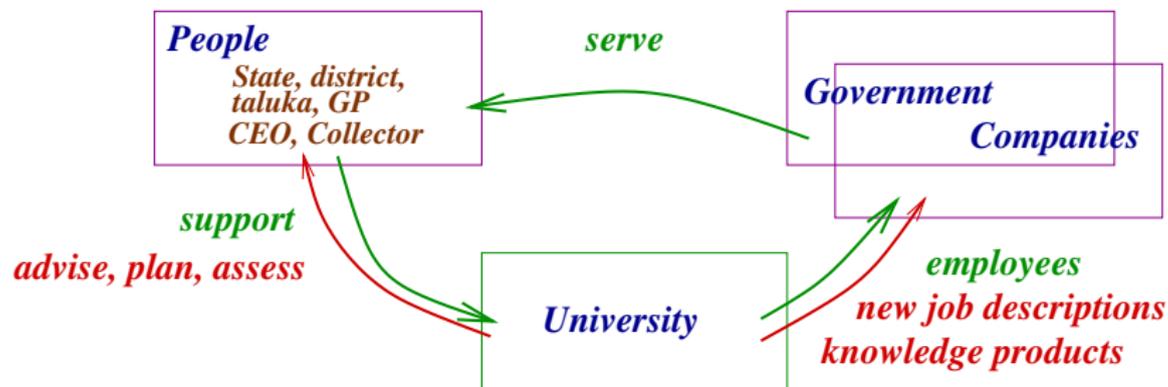
Optimizing Irrigation in Shahpur, Thane



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

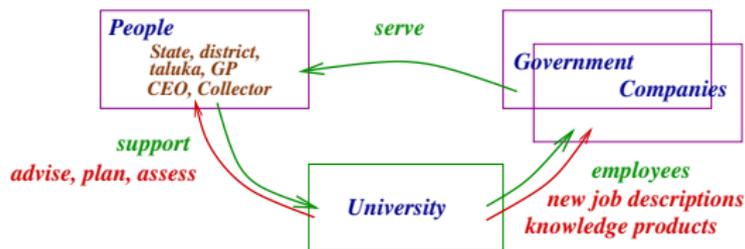
- Prepare students through an inter-disciplinary *Development Engineering*.
- Use elite status and create linkages within state agencies.
- Bring formality and rigour. Improve outcomes.
- Legitimize the case-study and transfer to regional colleges.

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.

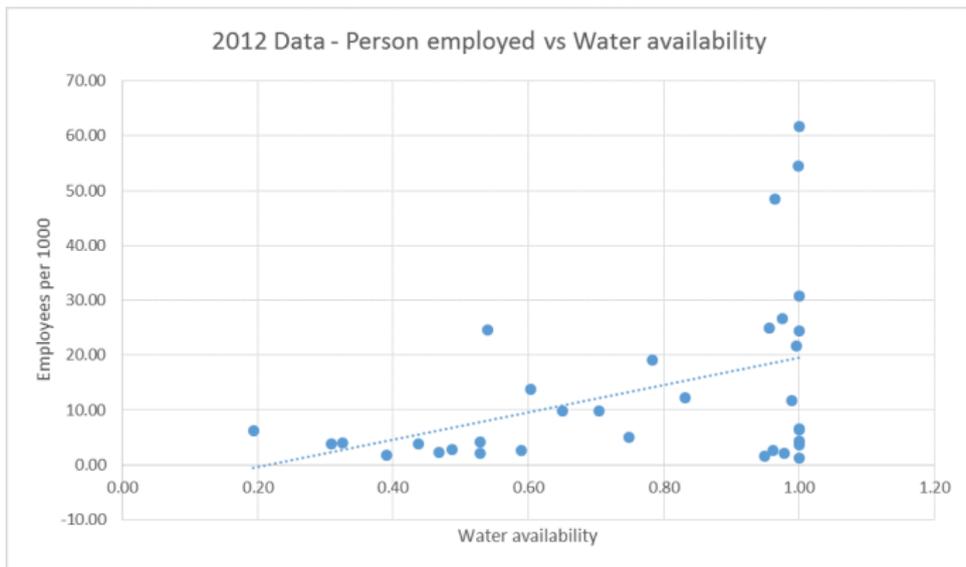
- The shrinking state and its causes.
- Sites for good practices, their codification and adaptability.
- Jobs, new professions and job descriptions and institutional capacity.

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.

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J. Wilkinson and R. Rocha

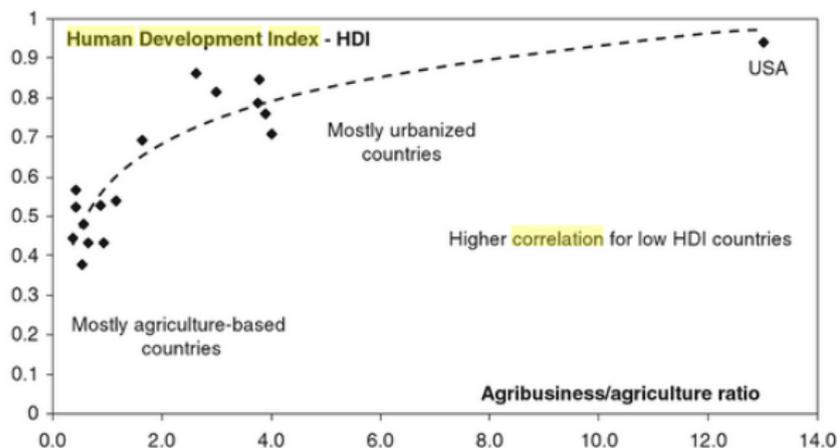


Figure 1. Correlation between human development and the agribusiness/agriculture ratio.

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

