TRINITY UNIVERSITY
Building on the Rock

QUALITATIVE COMPUTING EDUCATION AND THE AFRICAN DEVELOPMENT AGENDA

BEING A PRESENTATION AT THE 2ND TECHNOLOGY-ENHANCED LEARNING | COMPUTING EDUCATION FORUM

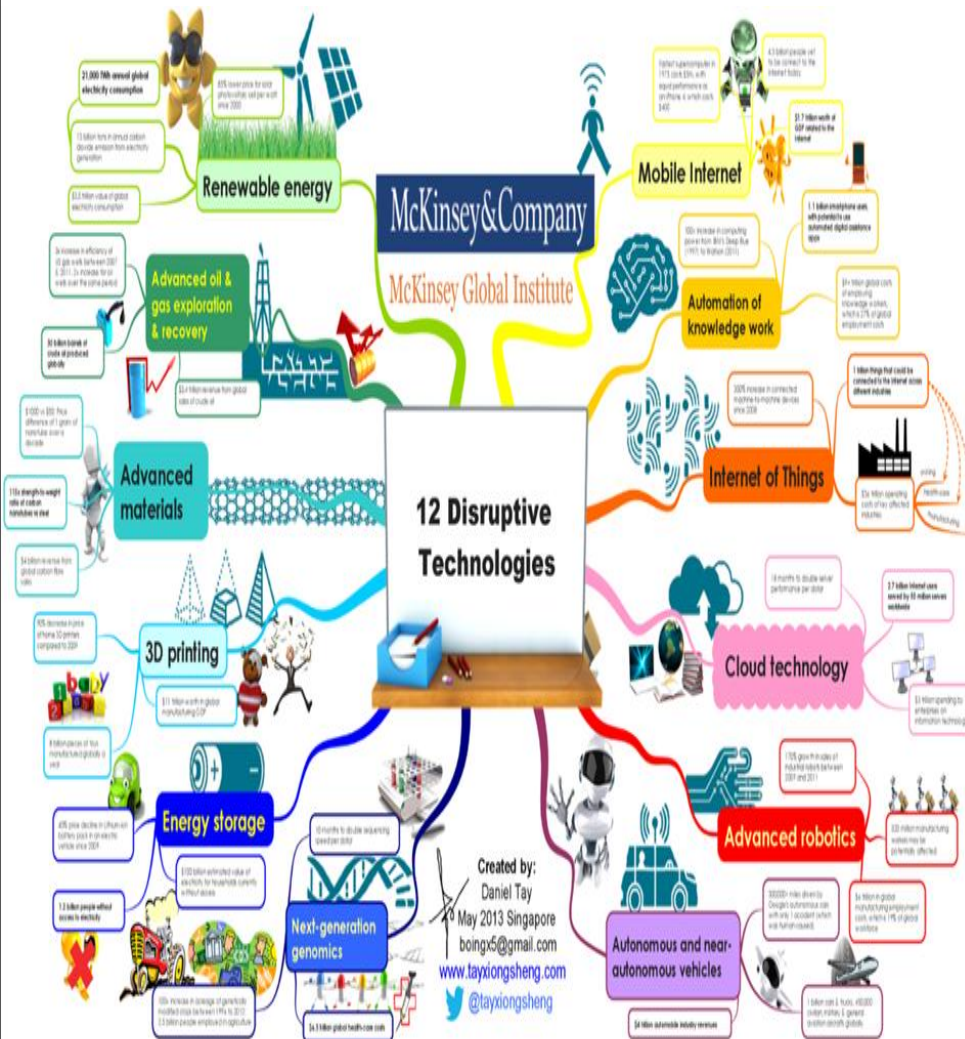Prof. Charles Ayo
Trinity University, Yaba, Lagos.

Alternate Title

INNOVATIVE ENTREPRENEURIAL COMPUTING

EDUCATION FOR AFRICA'S DEVELOPMENT

– THE CHINESE EXAMPLE

Lecture Outline

Appreciation & Acknowledgements

Review of Africa's Developmental Facts Sheet

Facts Sheet: Expenditure on Research (2014 – 2018)

University World News
Africa Edition

June 17th 2021 Edition

1. 80% of African countries invest less than 1% of GDP in scientific research.

2. Low number of Researchers, Scientific Publications & Patents (0.5%)

3. Active Tech Hubs and Incubators in Africa has more than doubled since 2016 to 744 in 2020.

Facts Sheet: Researchers (2014 – 2018)

1. Egypt had 687 researchers per million inhabitants in 2018.

2. South Africa that had a researcher density of 518 in 2018.

3. In terms of global shares of researchers by region, Sub-Saharan Africa had a density of 124 researchers per million inhabitants in 2018

Facts Sheet: Scientific Publications (2015 -2019)

1. Africa's contribution also increased from 61,236 to 92,133 publications.

2. Sub-Saharan Africa's quota increased from 30,805 to 47,374 publications.

3. Global scientific publications rose from 1.5 million to 1.7 million between 2015 and 2019.

Facts Sheet: Research Topics (2021)

1. According to the UNESCO Science Report 2021:

   a. 2012 and 2019, Sub-Saharan Africa more than spiked its research output in artificial intelligence and robotics.

   b. South Africa (3,774),

   c. Nigeria (1,600),

   d. Ethiopia (305) and

   e. Ghana (231)

   They contributed more than 50% of Sub-Saharan Africa's total output on artificial intelligence and robotics in that period.

   ▪ Thanks to ACE

Facts Sheet: Patents (2021)

1. Almost half of them are located in just five countries, namely:
   a. Nigeria (101),
   b. South Africa (91),
   c. Kenya (70),
   d. Egypt (55),
   e. Morocco (41).

3. As a result, only 17 000 patent applications were registered in Africa in 2018, equivalent to 0.5% of the global total.
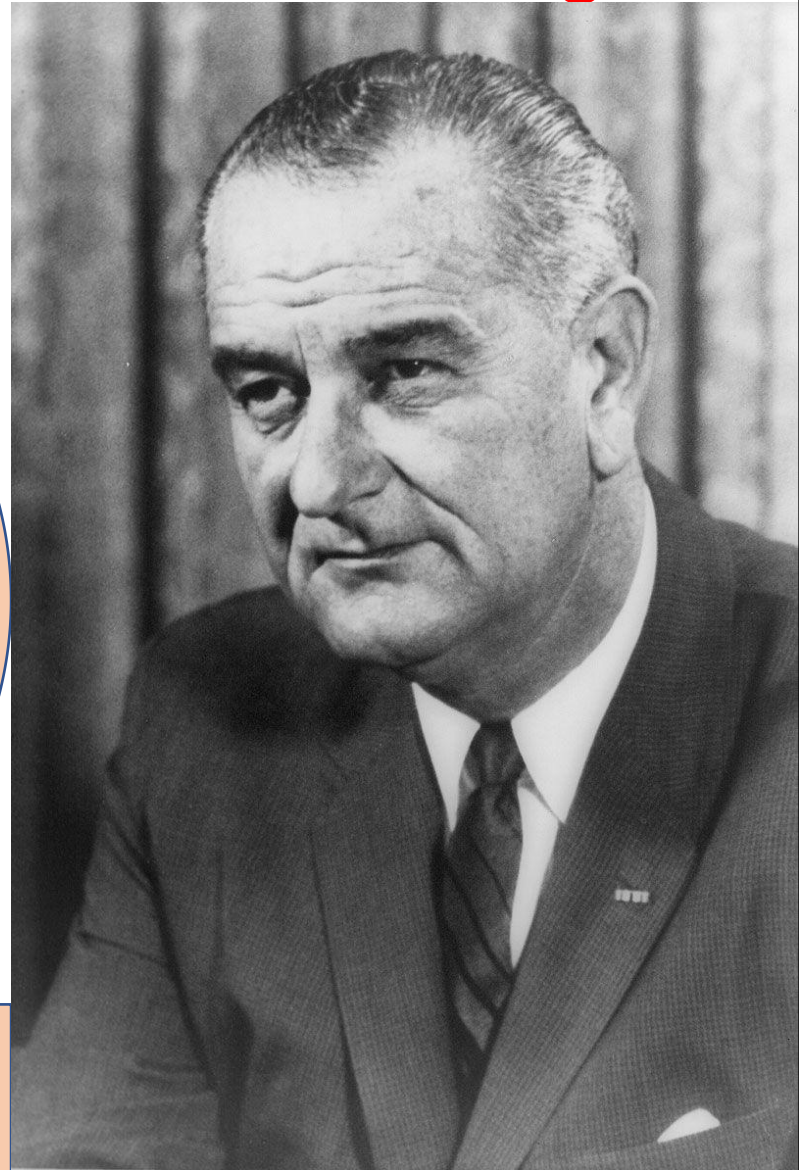
The African Education System and Nation Building

"At the desk where I sit, I have learned one great truth. The answer for all our national problems – the answer for all the problems of the world – come to a single word. That word is "**education**.""

- **Lyndon B. Johnson**

- Africa is well-endowed in both human and material resources, but lacked the wherewithal to transform them to finished goods.

- That the continent is still battling with the issues of underdevelopment pose a fundamental question about the:
  - quality of leadership,
  - quality of education and
  - gap between education and national development.

- Figures 1 to 6 show the abundant mineral resources all over the countries and regions in Africa but they lack the technical know-how to transform them from the crude forms to finished products.

- Thus, keeping the countries/countinent in perpetual poverty and import-dependent.

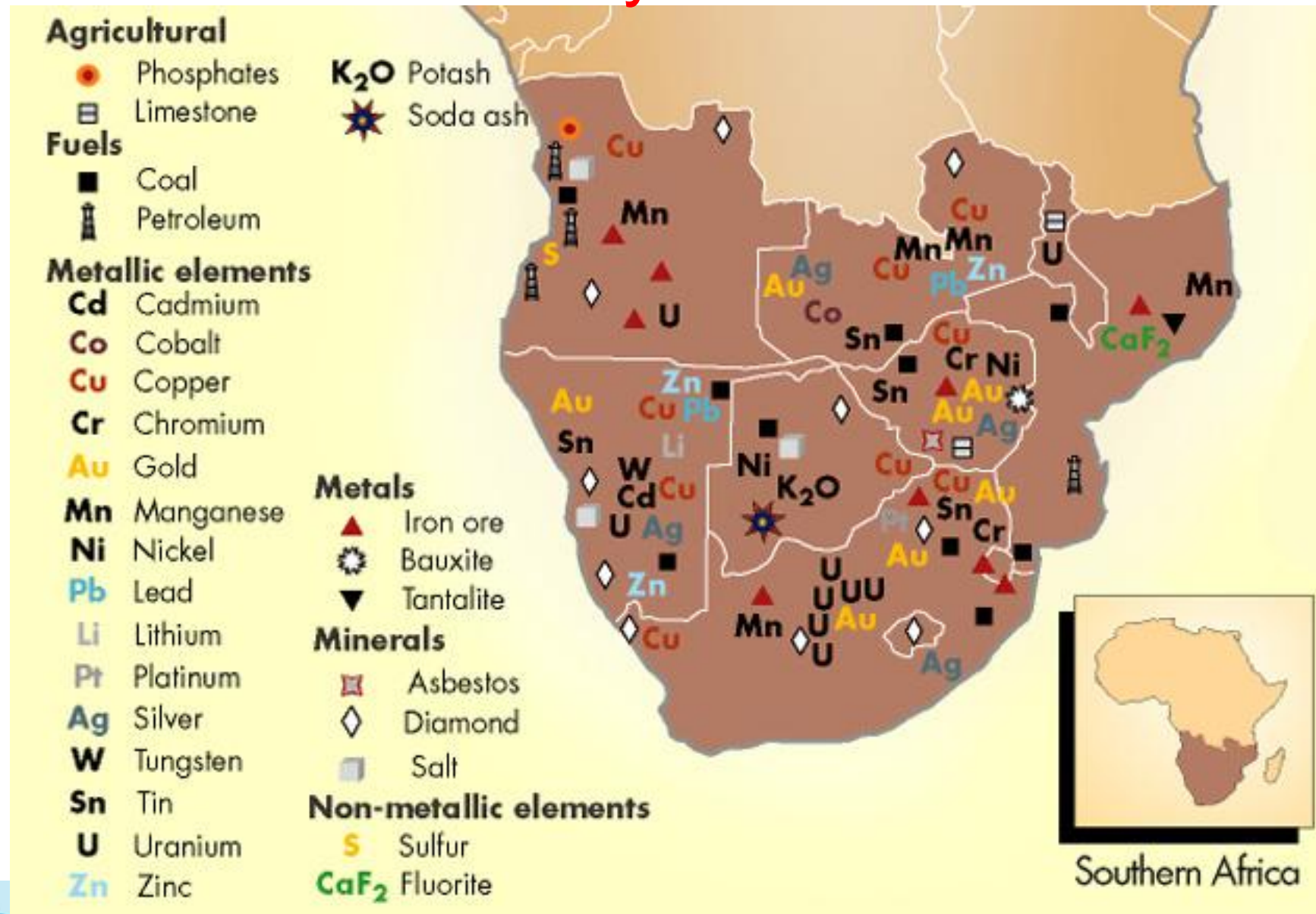Figure 1: Mineral Deposits in South Africa

Figure 2: Mineral Deposits in East Africa
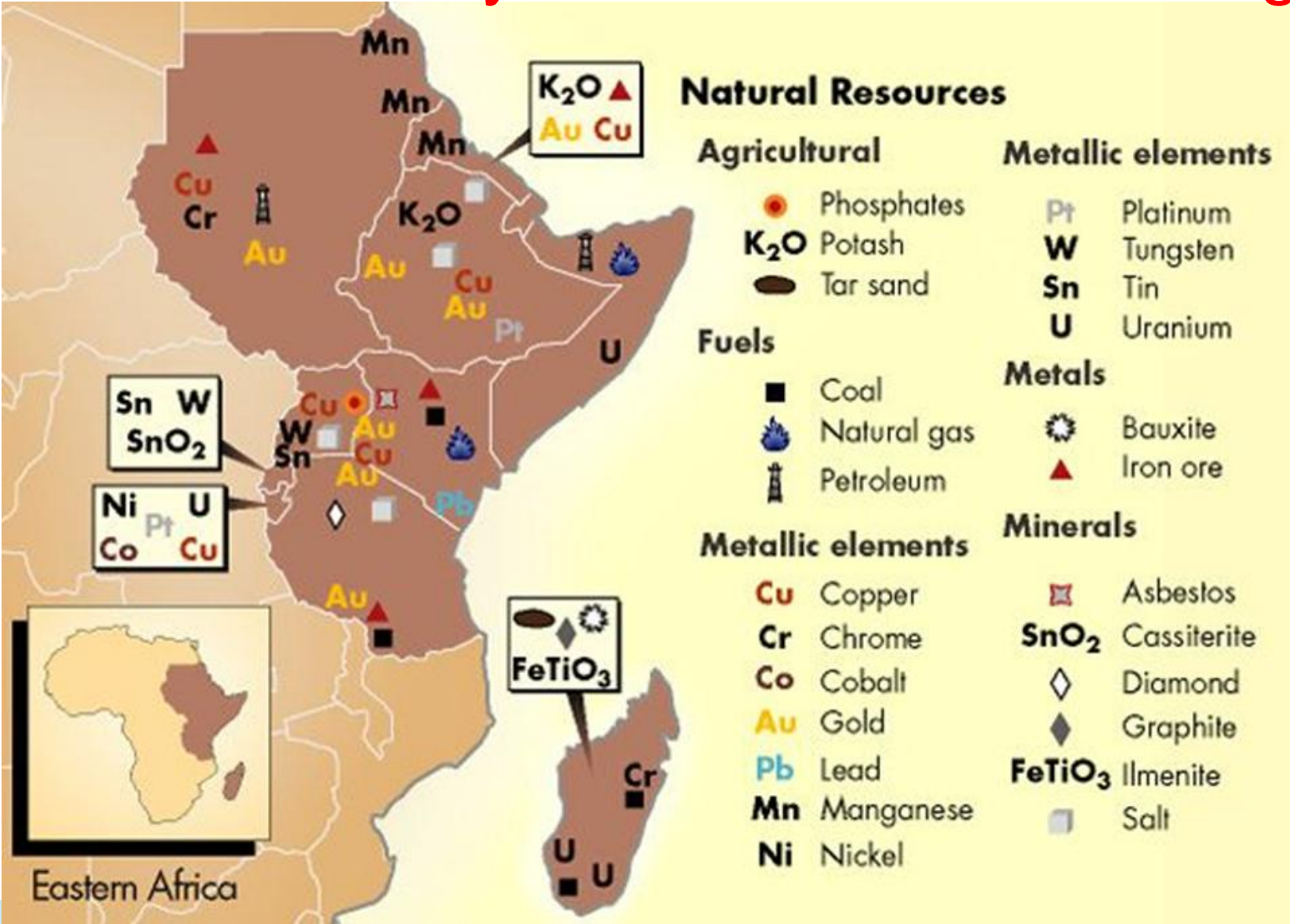
Figure 3: Mineral Deposits in West Africa
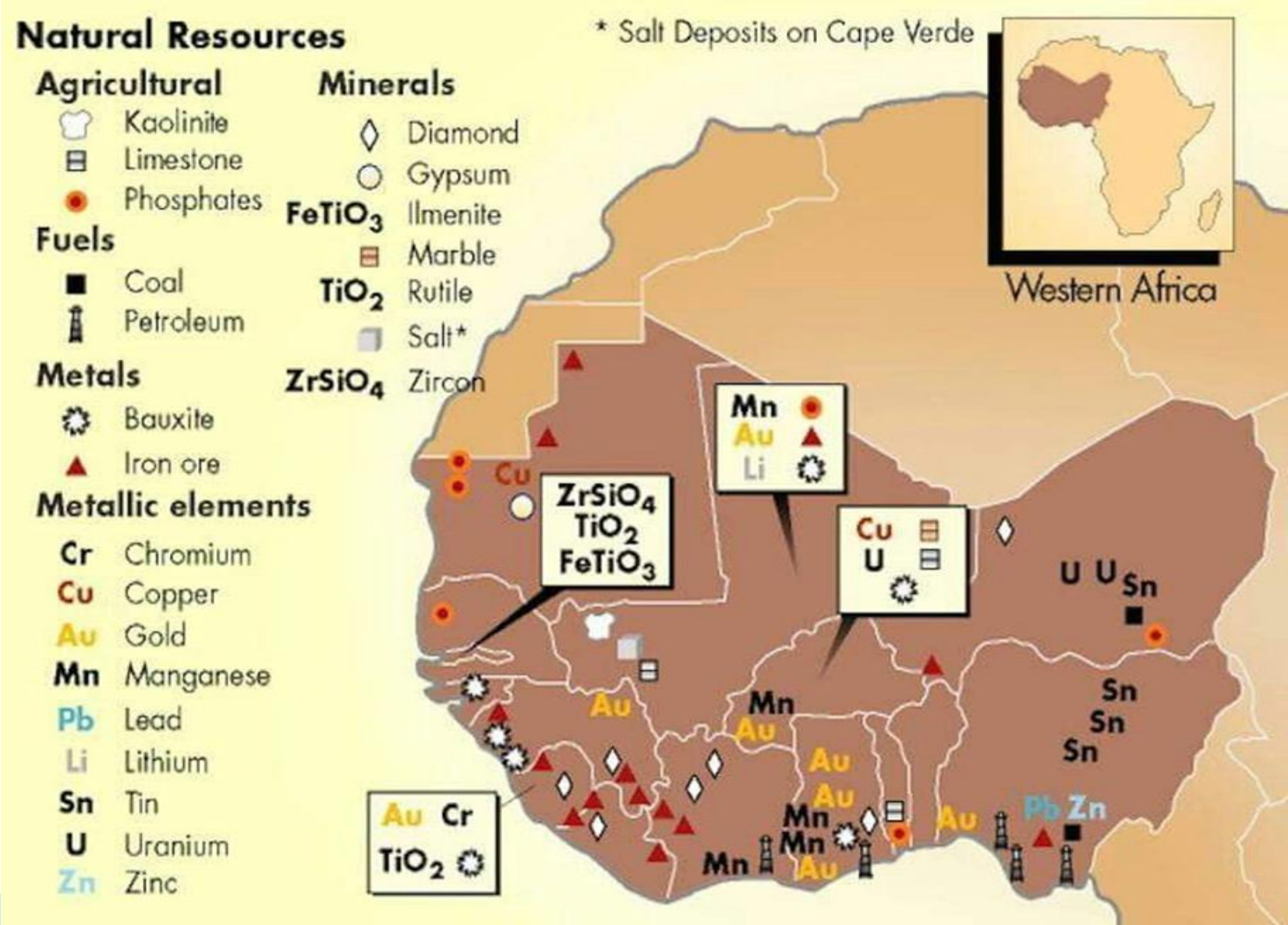
Figure 4: Mineral Deposits in Central Africa
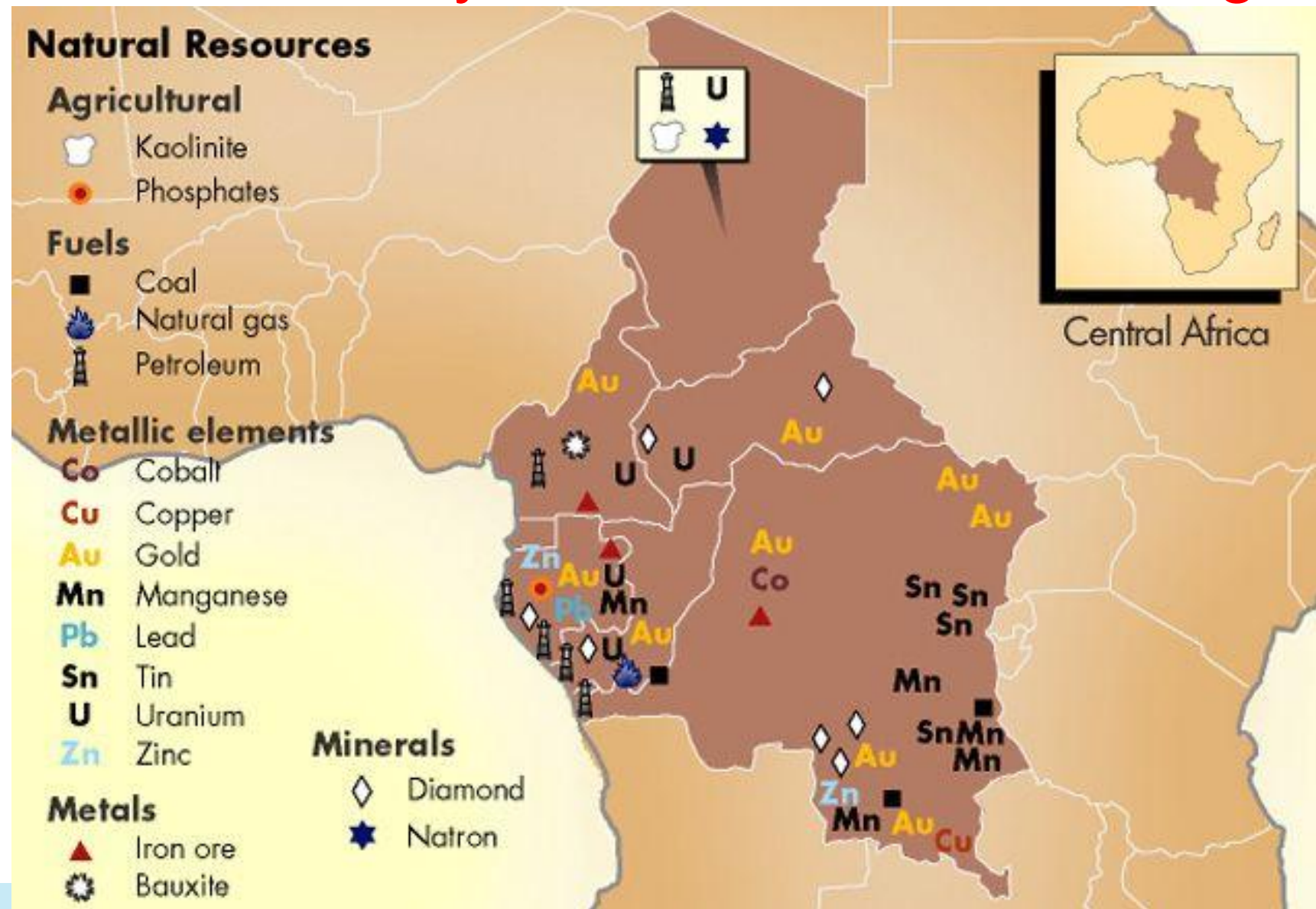
Figure 5: Mineral Deposits in Northern Africa
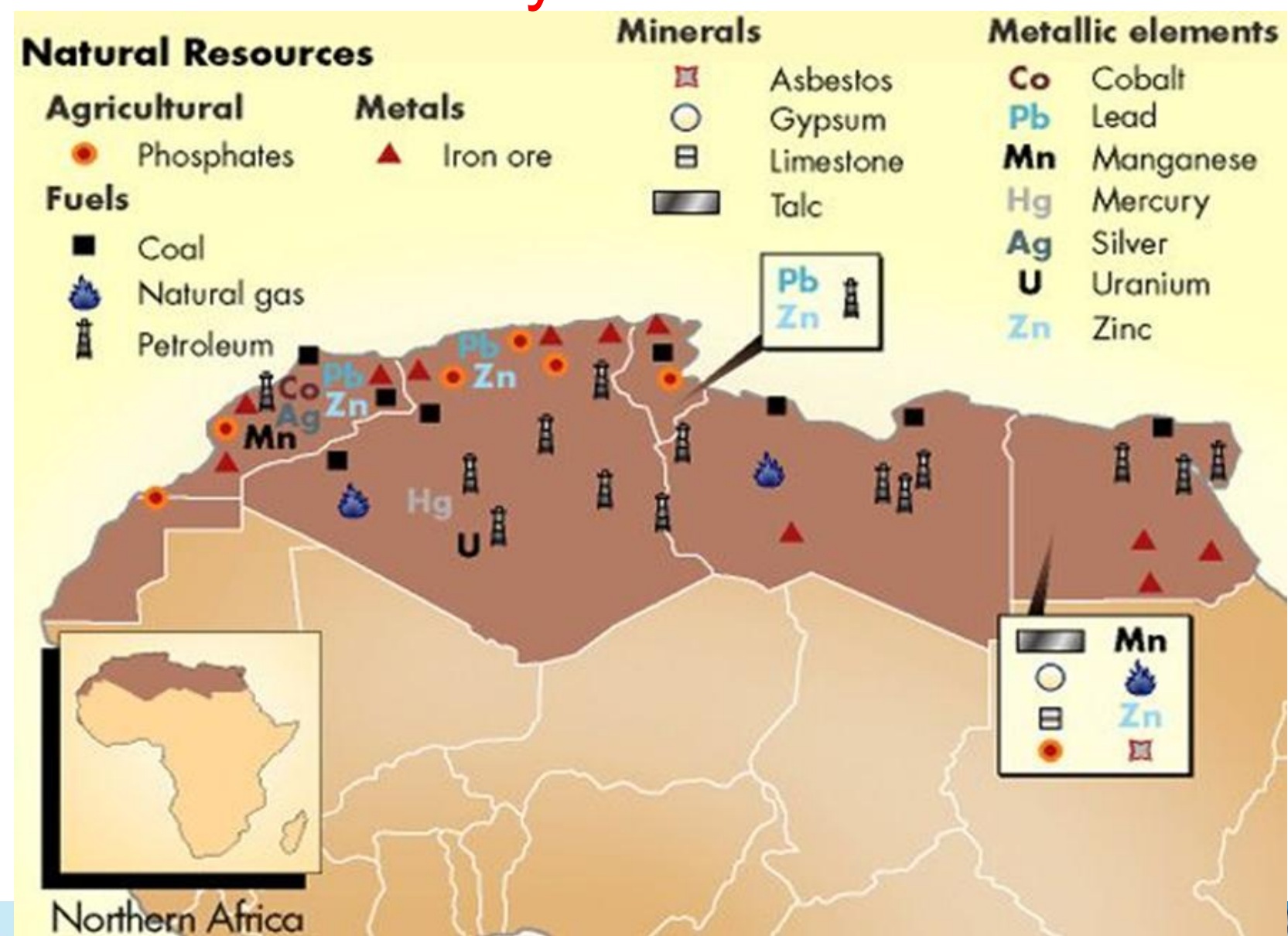
Rivers in Africa

Figure 6: Network of Rivers in Africa

Network of Rivers in Africa

We have the challenge of:

- Pipe-borne water
- Food Security
  - Importation of Rice
  - Importation of Sugar
  - Importation of Wheat
  - Importation of Fish
  - Importation of Meat, etc
- Power Generation

Proposed Model of Education – Needs-based Education (4Ws)

1. **Where are we presently in our nationhood? (Situation)**

2. **Where do we desire to be? (Needs)**

3. **What do we have? (Available Resources)**

- -

4. **What do we do? (Reforms)**

Any education system that cannot transform the abundant mineral resources to finished goods is a MISFIT

DISRUPTIVE TECHNOLOGIES & 4IR

1. Cloud computing
2. Unmanned Aerial Vehicles – Drones
3. Internet of Things/Everything (IoT/E):
4. Blockchain Technology
5. 3-D Printing
6. AI
7. Big Data/ Data Science
8. Green/Renewable Energy
9. Quantum Computing
Etc.

Disruptive Technologies

- According to Stephane Kasriel, Upwork CEO and co-chair of the World Economic Forum's Council on the Future of Gender, Education and Work (2018), he stated that:
  - "The future of work won't be about college degrees, it will be about job skills."

- New non-traditional education options are proliferating.
  - There are arrays of online certification institutes such as Stanford LEAD, Udemy, Alison, Google Digital Garage, edX, Coursera, Khan Academy, Udacity, Skillshare, FutureLearn, Codeacademy, etc.

Disruptive Technologies

- Increasingly, more companies including tech giants such as:
  - Apple, IBM and Google no longer require a degree,
  - Well-paying jobs are offered to those with non-traditional education or a high-school diploma.

- What's the implication of this?
  - We close shops?
  - We change our approach?
  - We incorporate Skill Acquisition into HEIs Curricula?
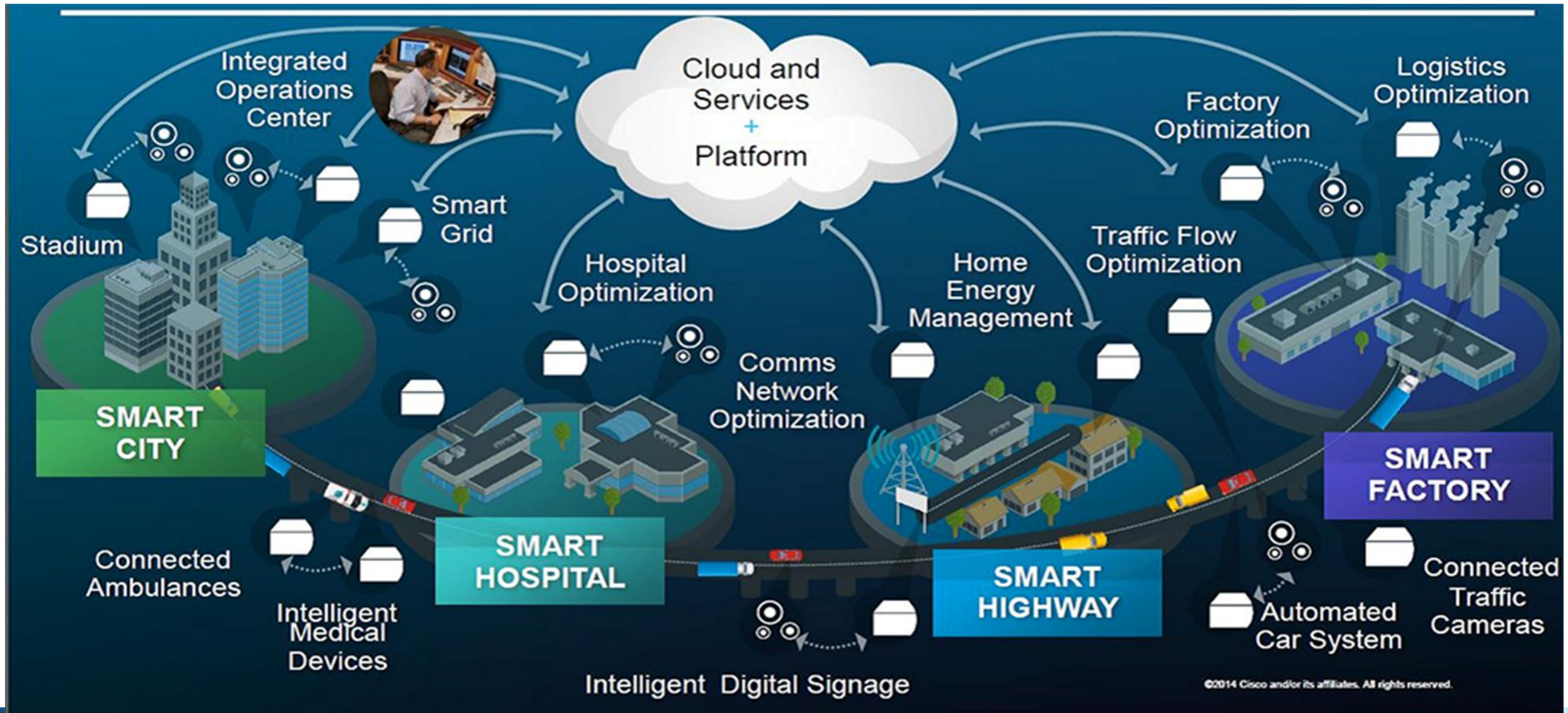
THE 4IR AND PROFESSIONAL PRACTICE

The 4IR and Professional Practice

- The entire sectors/industries are affected by this digital revolution

1. Smart City

A complex system that uses digital and communications infrastructure to manage systems such as:

- adequate water supply,
- assured electricity supply,
- sanitation, including solid waste management,
- efficient urban mobility and public transport,
- affordable housing, especially for the poor, etc.

CLEAN MOBILITY INSTEAD OF DIRTY TRAFFIC
Some action fields on the road to a smart and sustainable city

© ENERGY ATLAS 2018 / STOCKMAR

solar rooftops for local energy generation

battery research and production facility

demand-driven traffic control

attractive traffic routes for bikes and pedestrians

tramways and electric buses

self-driving cars extended public transport

charging stations for individual vehicles
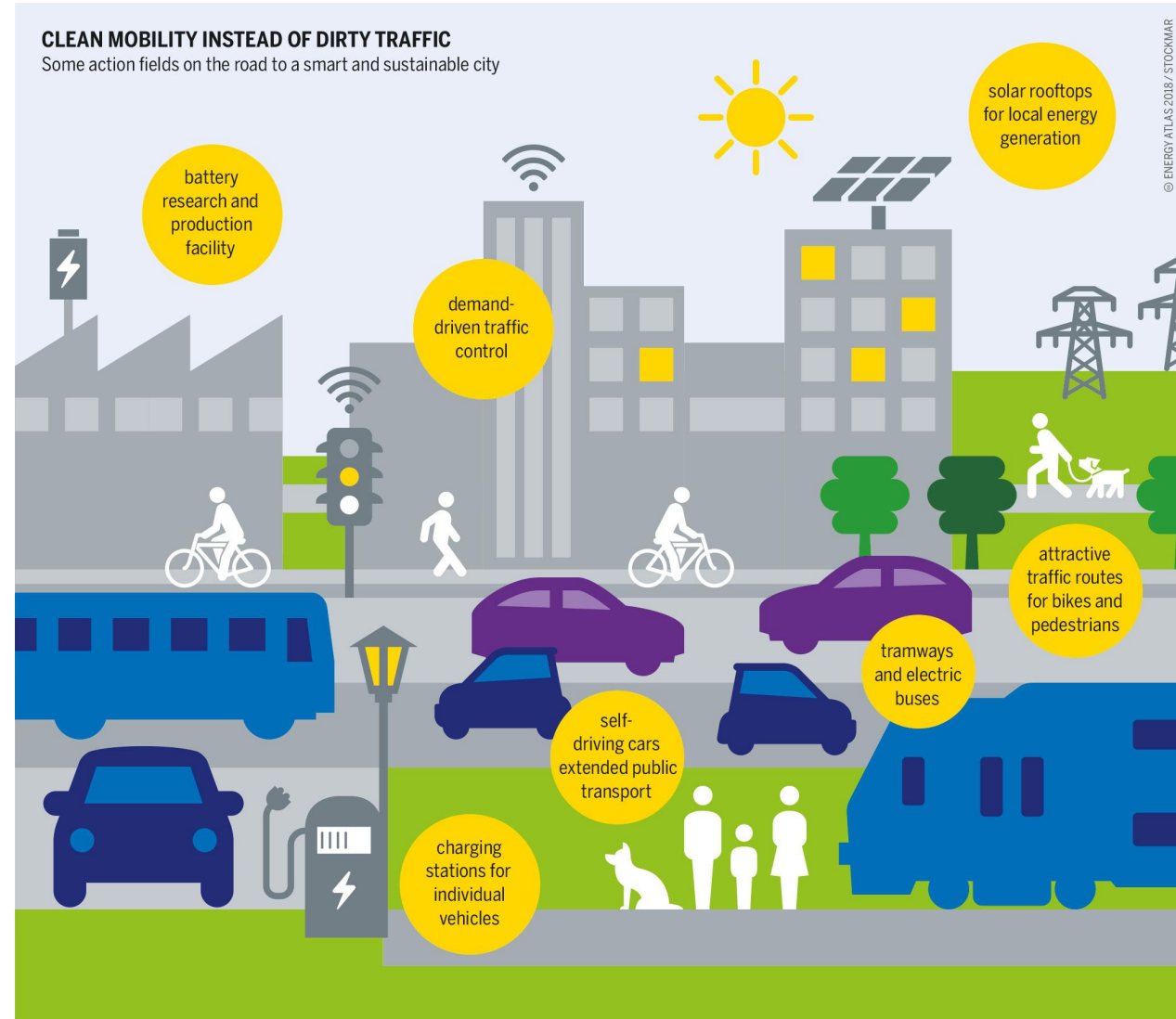
2. Smart Hospital

- The smart technologies used in smart hospital are:
  - WiFi, active RFID, sensors, integration platforms,
  - mobile apps, wearables, big data and cloud technologies and various dashboards.
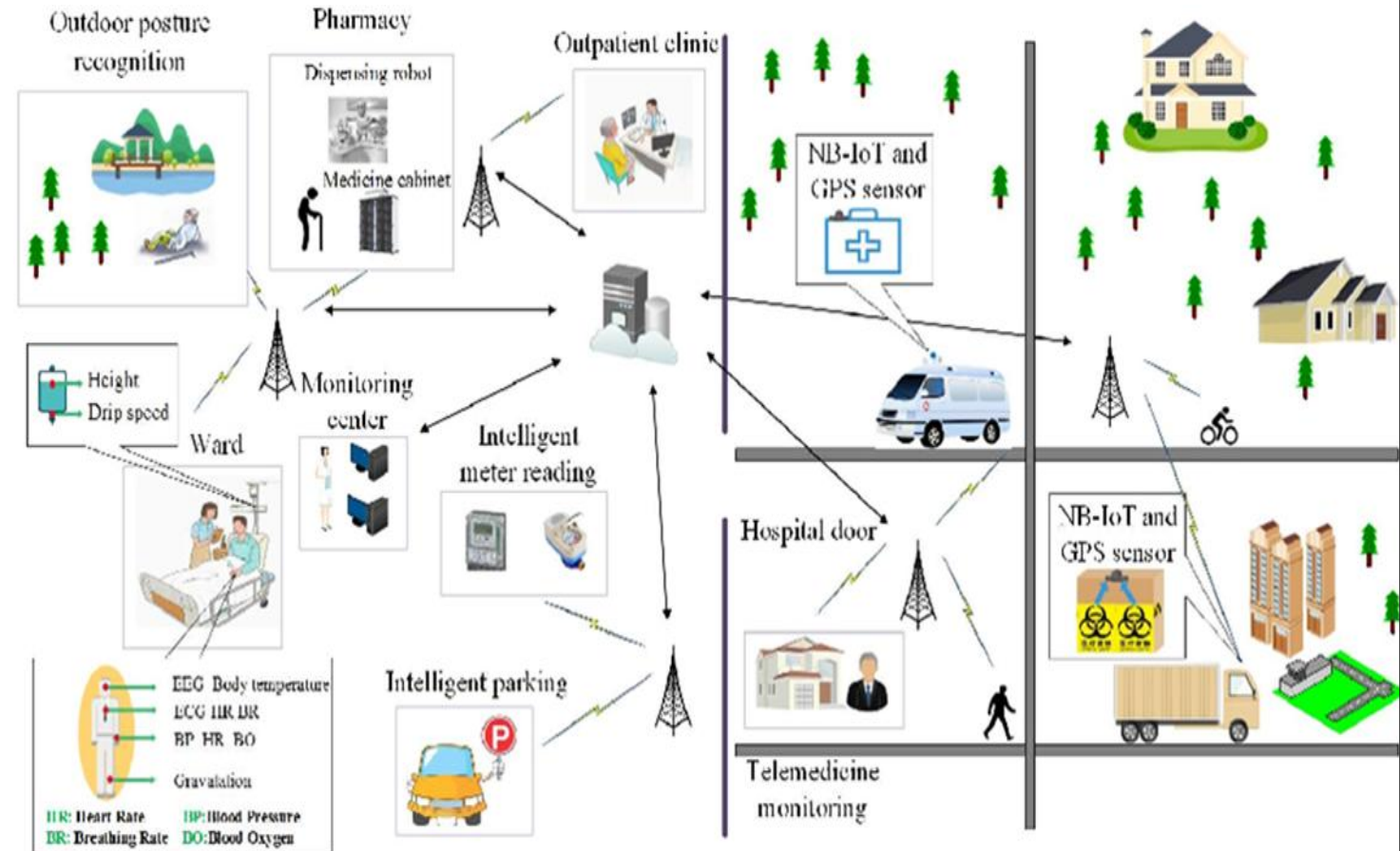
3. Smart Agriculture/Farming

Smart Farming (3rd Green Revolution)

- A combined application of ICT solutions such as precision equipment, the Internet of Things (IoT), sensors and actuators, geo-positioning systems, Big Data, Unmanned Aerial Vehicles (UAVs, drones), robotics, etc.

Combine Harvester

Security Bot

Farm Drone

Farm Data

SMART FARMING

Self-driving Tractor

Field Sensor

Watering System

Agricultural APP
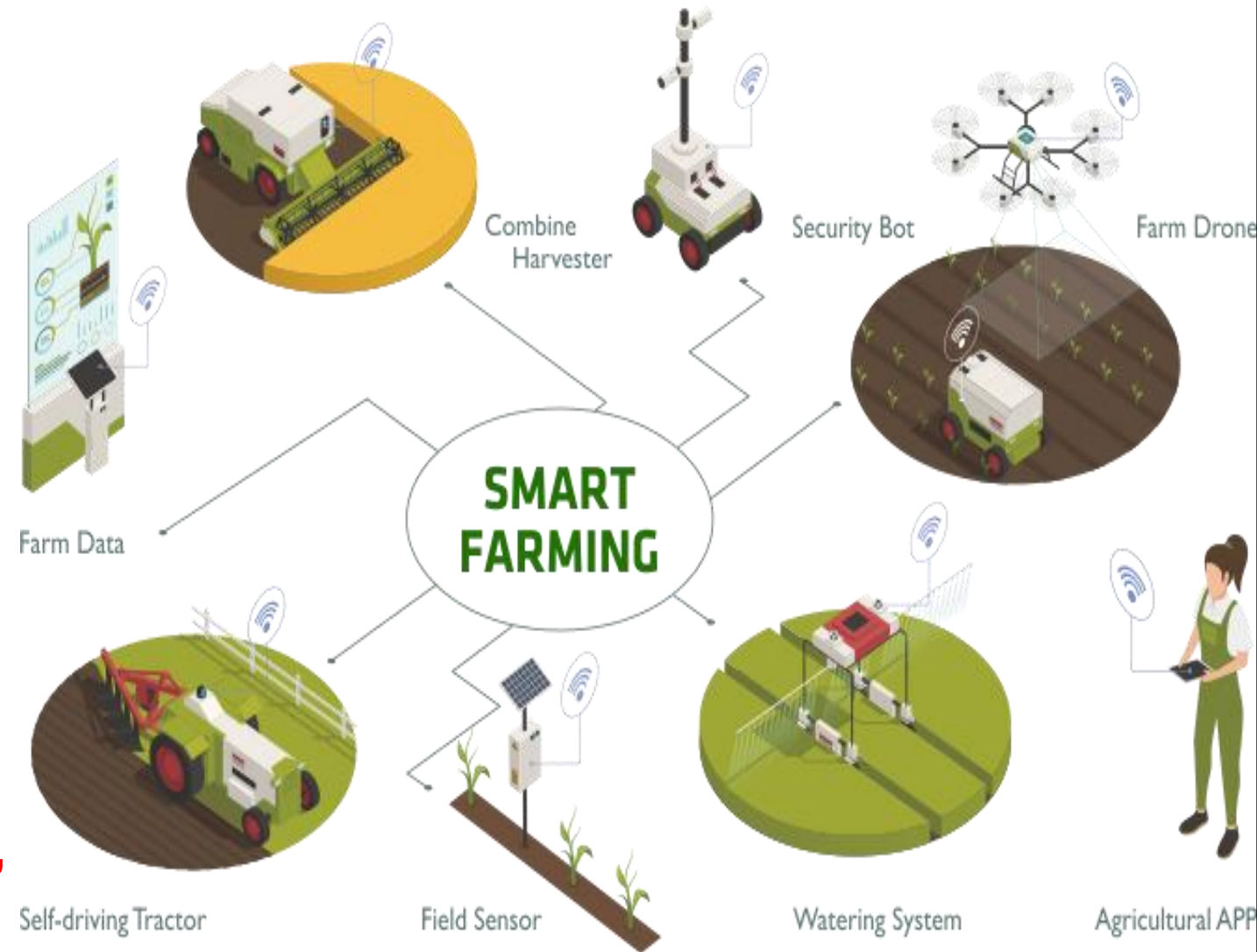
4 Smart Transportation

- The concept of "smart" involves:

  - integration of networks of sensors into infrastructure and vehicles

  - accomplishing remote management and control, safety, and efficiency.

4 Smart Education

- A technology driven learning system that enhances:
  - the capability of the educators;
  - the ability of learners to learn more efficiently, effectively, comfortably, and flexibly; and
  - the graduates to meet the needs for the work and life in the 21st century.
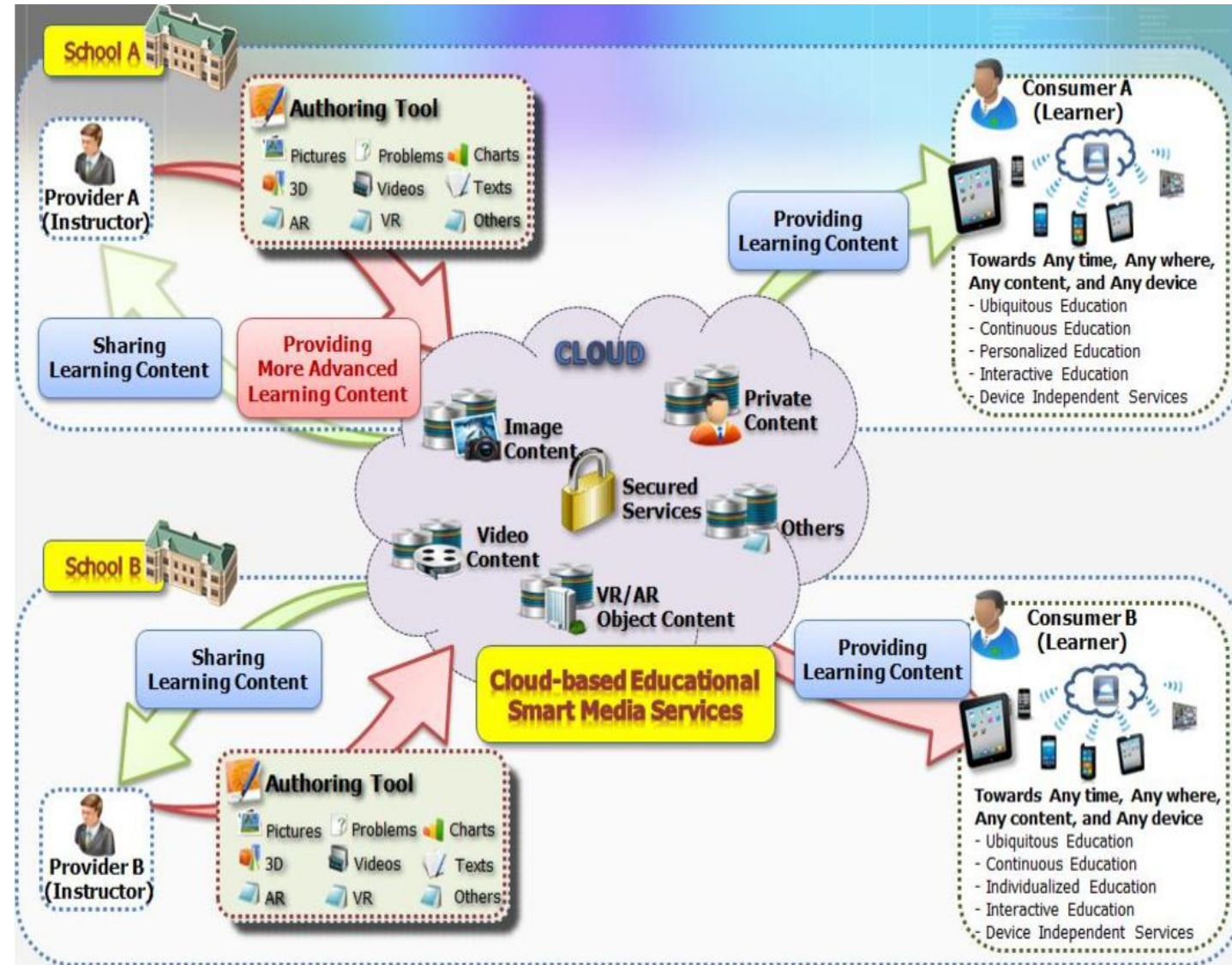
5. Smart/Open Government

- The use of:
  - innovative policies,
  - business models, and
  - technology

- To enhance SMARRT Government:
  - Simplicity, Morality, Accountable, Reduced paper work, Responsible and Transparent
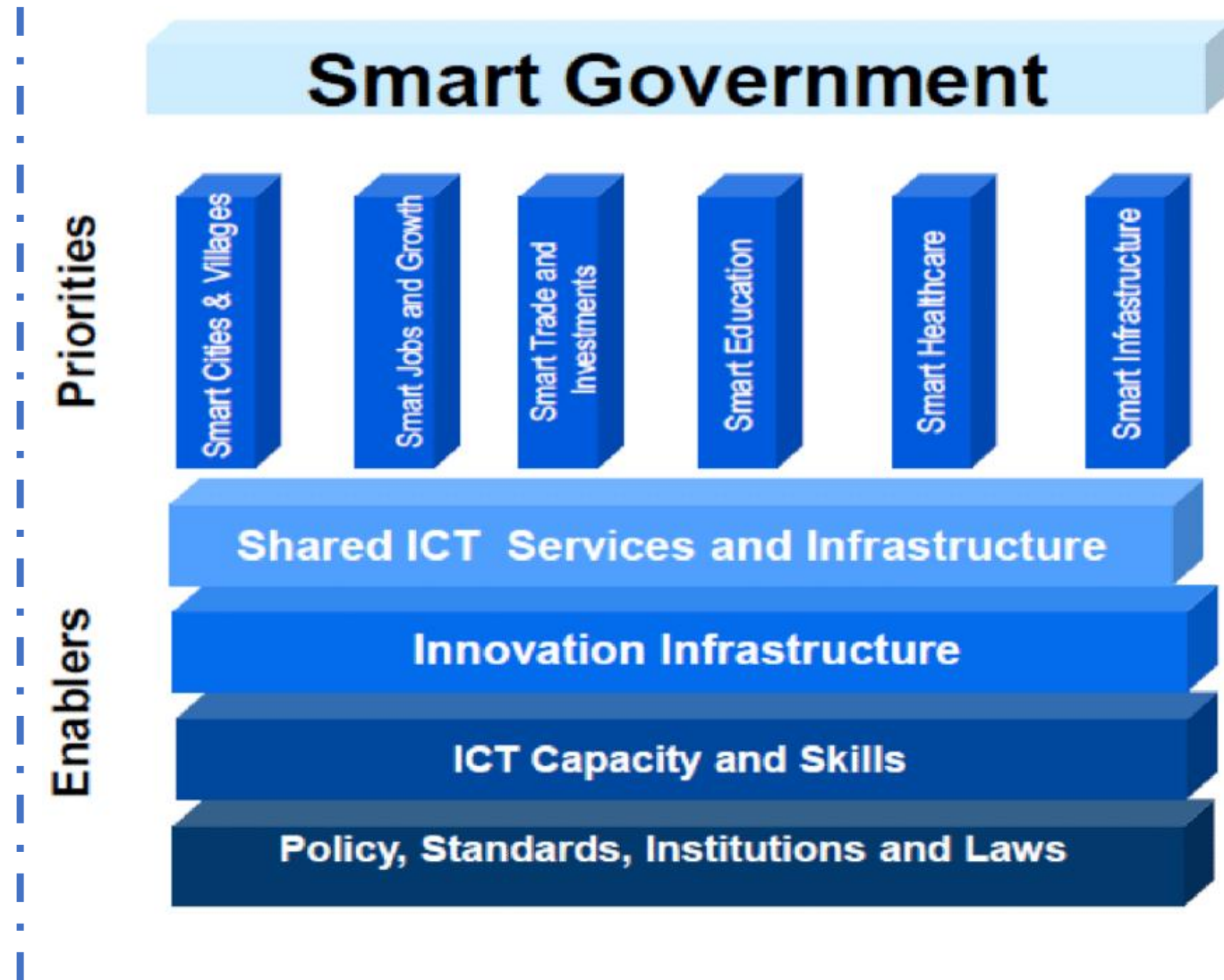
IMPACT OF DISRUPTIVE TECHNOLOGIES ON HEIs

The impact is 3-fold:

1. Impact on Curriculum

2. Impact on Employment

3. Impact on Institution:

   o Staff

   o Students

   o Infrastructure

Curriculum Mapping for Student Employability

Coursera provides a wide selection of job-relevant content that can supplement existing curricula. As a result, the following academic disciplines and skills emphasis combinations are also possible by leveraging content currently offered on our platform.

Engineering

ACADEMIC DISCIPLINE	SKILLS EMPHASIS
Biochemical Engineering	Bioinformatics
Biomedical Engineering	Precision Medicine
Chemical Engineering	Battery Technology
Civil Engineering	Smart Cities
Electrical Engineering	IoT and Embedded Sensors
Mechanical Engineering	Digital Manufacturing
Textile Engineering	Nanotechnology

Business

ACADEMIC DISCIPLINE	SKILLS EMPHASIS
Master of Business Administration	Digital Marketing
Bachelor of Business Administration	AI/ML
Bachelor of Business Administration	Entrepreneurship

Other

ACADEMIC DISCIPLINE	SKILLS EMPHASIS
Architecture	Urban Design
Nursing	Healthcare Tech & Analytics
English	Digital Marketing

Coursera for Campus (2021)

Impact of Disruptive Technologies on HEIs Cont'd

List of Relevant IT Certifications & Salaries

S/N	Certification	Salary		Certification	Salary ($)
1	Big Data Engineer:	$166,500	16	Google Certified Professional Cloud Architect	40,000 to 175,000
2	DevOps Engineer:	$120,000	17	AWS Certified Solutions Architect	114,000 to 149,000
3	Information Systems Security Manager:	$149,000	18	Certified Information Security Manager (CISM)	132,000 to 149,000
4	Mobile Apps Developer:	$135,750	19	Certified in Risk and Inf Systems Control (CRISC)	About 146,000
5	Applications Architect:	$144,500	20	Project Management Professional (PMP)	About 144,000
6	Data Architect:	$145,500	21	Certified Info. System Security Prof (CISSP)	About 141,000
7	Database Manager:	$137,500	22	Certified ScrumMaster (CSM)	About 135,000
8	Data Security Analyst:	$134,000	23	AWS Certified Solution Architect (Professional)	About 135,000

Impact of Disruptive Technologies on HEIs Cont'd

List of Relevant IT Certifications & Salaries

S/N	Certification	Salary		Certification	Salary($)
9	Data Scientist:	$129,000	24	Microsoft Certified: Azure Solutions Architect Expert	About 135,000
10	Network/Cloud Architect:	$146,000	25	Certified Information Systems Auditor (CISA)	About 132,000
11	Network/Cloud Engineer:	$115,250	26	AWS Certified Cloud Practitioner – Foundational	113,000 to 131,000
12	Senior Web Developer:	$124,750	27	VMware Certified Prof 6 – Data Center Virtualization (VCP6-DCV)	About 130,000
13	Site Reliability Engineer:	$123,250	28	Info. Tech. Infrastructure Library (ITIL) Foundation	About 129,000
14	Systems Engineer:	$107,000	29	Microsoft Certified: Azure Fundamentals	126,000
15	Software Engineer:	$123,250	30	Citrix Certified Associate – Networking (CCA-N)	About 125,000

China Leads US in Global Tech Race:

- China leads in 37 of 44 technologies tracked in a year-long project by thinktank the Australian Strategic Policy Institute (ASPI).

- The fields include:

  – Electric batteries, hypersonic and advanced radio-frequency communications such as 5G and 6G

- China emerged world's leader in science and technology superpower through:

  – high-impact research across the majority of critical and emerging technology domains.

China Leads US in Global Tech Race:

- China houses the world's top 10 leading research institutions
- They collectively generate nine times more high-impact research papers than the second-ranked country (US).

Impact of Disruptive Technologies on HEIs Cont'd

Autonomous systems operation technology flow of talent

Top 25%

UNDERGRADUATE

POSTGRADUATE

EMPLOYMENT

UNDERGRADUATE:
- 25.3% China
- Germany
- 7.8% India
- Italy
- 40.7% GROUP Other Countries
- South Korea
- United Kingdom
- 9.6% United States

POSTGRADUATE:
- 12.3% China
- Germany
- India
- Italy
- 38.3% GROUP Other Countries
- South Korea
- 9.5% United Kingdom
- 24.7% United States

EMPLOYMENT:
- 17.2% China
- Germany
- India
- Italy
- 40.6% GROUP Other Countries
- 5.8% South Korea
- 8.0% United Kingdom
- 19.2% United States
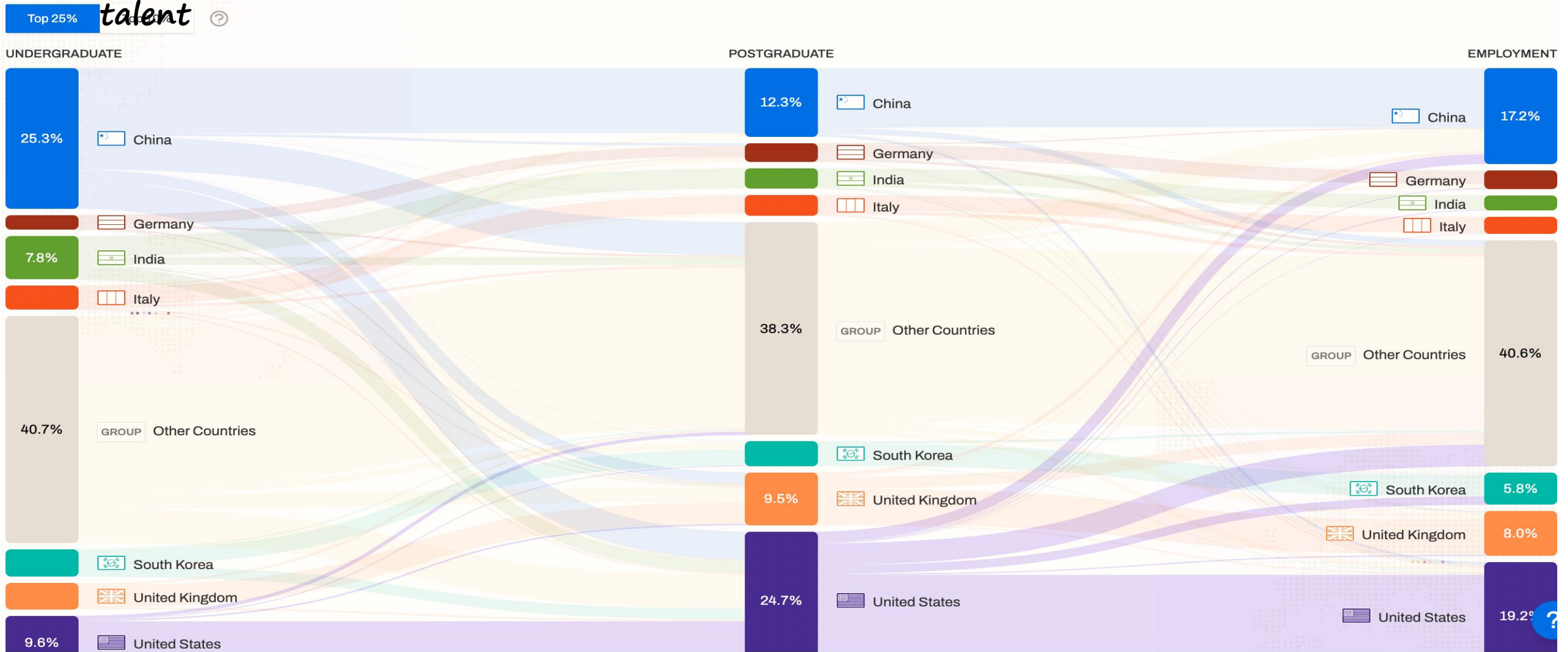
Who produces the best quality research?
Within Autonomous systems operation technology

Countries ranked by highest H-index		
United States	1st	83.0
China	2nd	78.0
Germany	3rd	46.0
United Kingdom	4th	46.0
Canada	5th	37.0
Australia	6th	35.0
South Korea	7th	34.0
Italy	8th	33.0
Switzerland	9th	33.0
India	10th	29.0
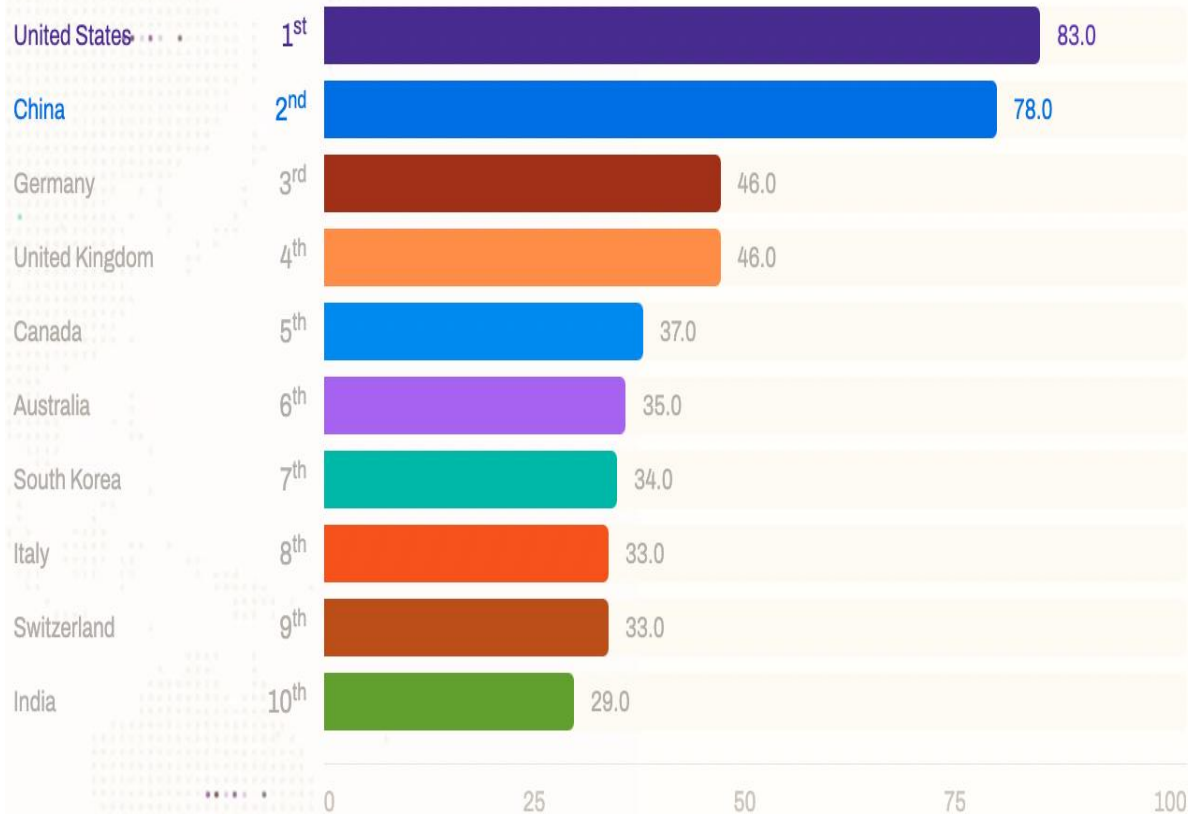
Proportion of publications in top 10%		
China	1st	26.2%
United States	2nd	21.0%
United Kingdom	3rd	5.3%
Germany	4th	5.1%
South Korea	5th	3.5%
Australia	6th	3.2%
Canada	7th	3.1%
Italy	8th	2.9%
India	9th	2.4%
Spain	10th	2.0%

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Impact of Disruptive Technologies on HEIs Cont'd

Quantity | Quality

China 26.2%

United States 21.0%

Other Countries 5.4%

United Kingdom 5.3%

Germany 5.1%

South Korea 3.5%

Australia 3.2%

India 2.4%

Switzerland 1.7%

Netherlands 1.5%

Canada 3.1%

Spain 2.0%

France 1.9%

Italy 2.9%

Singapore 1.9%

Impact of Disruptive Technologies on HEIs Cont'd
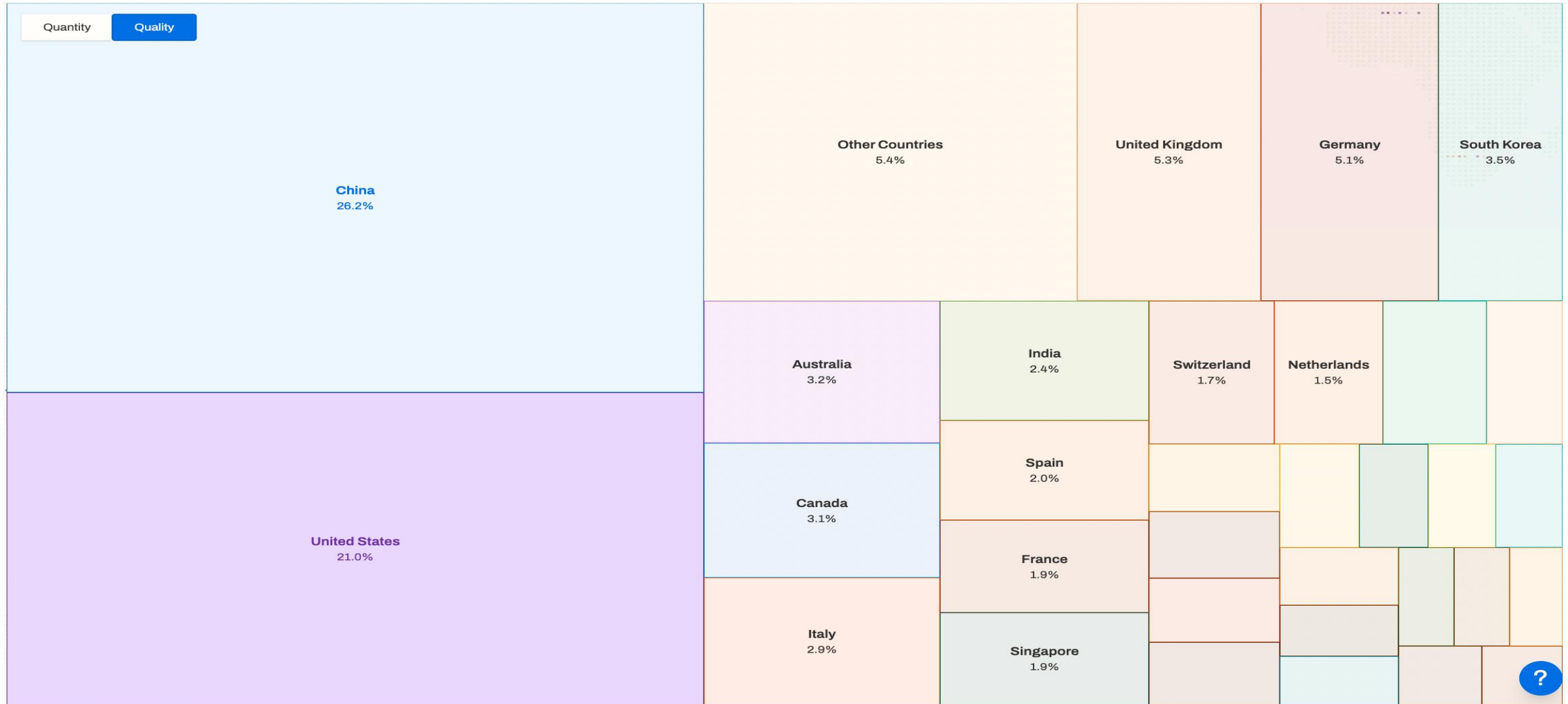
Impact of Disruptive Technologies on HEIs Cont'd
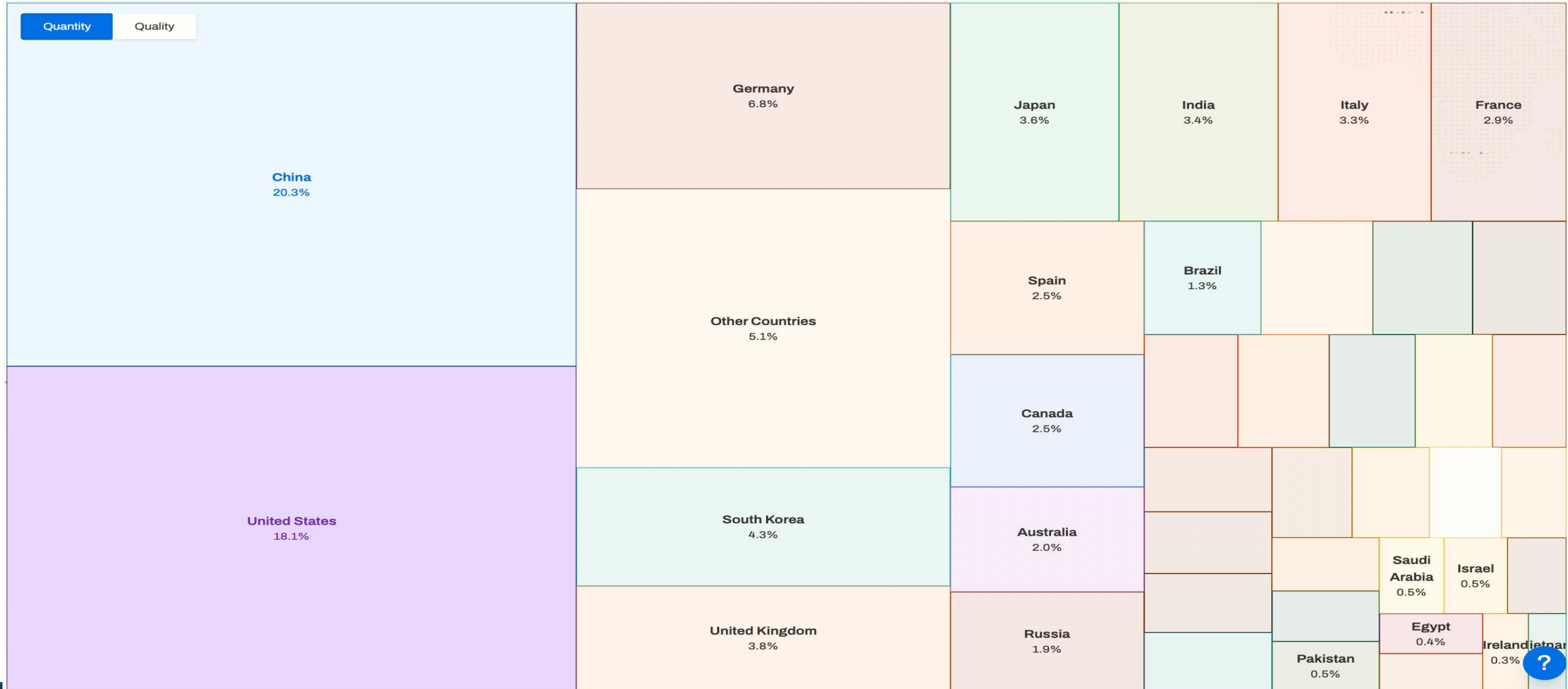
Global Patent Applications

WORLD patent applications — 100% 3,401,100 applications — China, US, Japan, Republic of Korea, EPO*
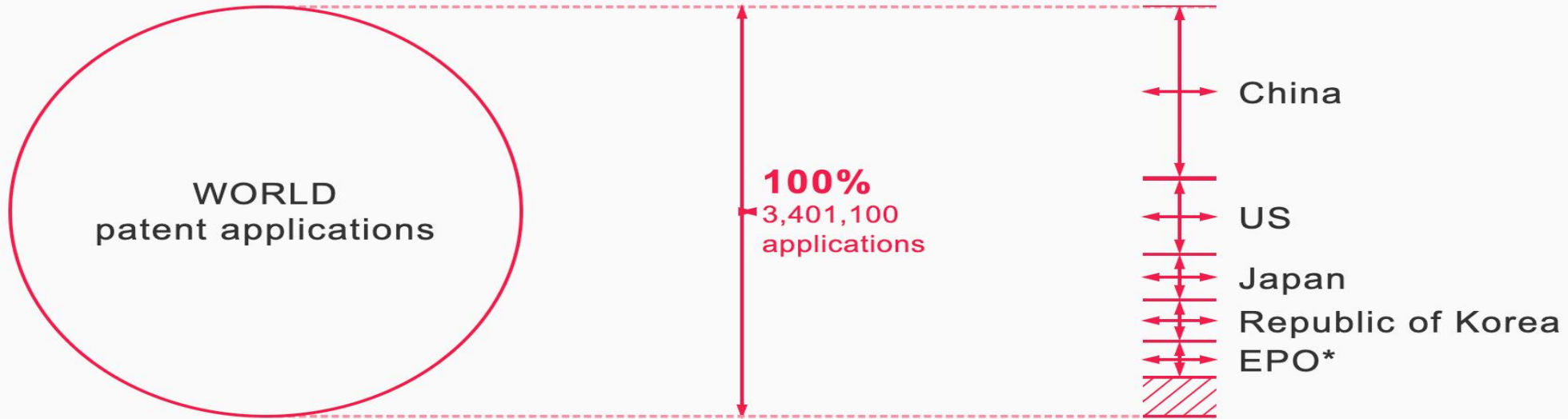
More than 85% of all patent filings in 2021 occurred in the IP offices of China, the US, Japan, the Republic of Korea and the EPO. China accounted for 46.6% of the world total.

Note: * EPO is the European Patent Office

Source: WIPO Statistics Database, February 2023

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Global Trademarks Filing

WORLD trademark filing activity

100%
18,145,100 filings

China

US
Iran (Islamic Republic of)
EUIPO*
India
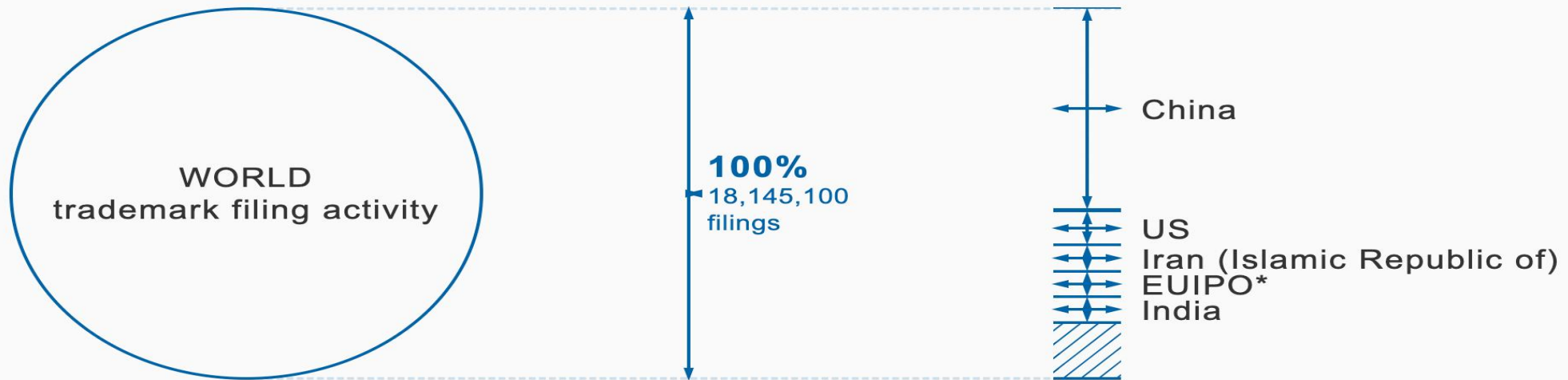
In 2021, 65.4% of all trademark filing activity — measured in class counts — occurred at the IP offices of China, the US, Iran, the EUIPO and India. China alone accounted for more than 52.1% of global trademark filing activity, primarily from Chinese residents.

Note: For trademarks, filings refer to the number of classes specified in applications.
* EUIPO is the European Union Intellectual Property Office

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Source: WIPO Statistics Database, February 2023

Technology	Top 5 countries					Technology monopoly risk
Nanoscale materials and manufacturing	China 58.35%	USA 6.73%	India 4.90%	South Korea 4.06%	Iran 3.84%	10/10 8.67 high
Coatings	China 58.47%	USA 7.34%	India 5.97%	South Korea 3.22%	Iran 2.84%	8/10 7.96 high
Smart materials	China 42.57%	India 8.13%	USA 6.96%	Iran 6.69%	UK 3.27%	7/10 5.24 medium
Advanced composite materials	China 40.82%	India 14.03%	USA 7.30%	South Korea 4.04%	Iran 3.93%	8/10 2.91 medium
Novel metamaterials	China 45.56%	USA 16.90%	South Korea 4.01%	Singapore 3.89%	Australia 3.01%	7/10 2.70 medium
High-specification machining processes	China 36.21%	India 13.84%	USA 11.75%	UK 3.59%	Germany 2.85%	8/10 2.62 medium
Advanced explosives and energetic materials	China 47.10%	USA 21.31%	India 4.88%	Germany 3.96%	Russia 3.23%	5/10 2.21 medium
Critical minerals extraction and processing	China 36.68%	USA 13.39%	India 4.47%	Australia 2.79%	Canada 2.68%	4/10 2.74 low

Source: India Today (March 2023)

Computing Programmes in India

VIT University – A 3-year programme

- Admission directly from the Secondary School.

- Very Comprehensive and Specialized Programmes.

- Detailed Core Courses

- Detailed and Extensive Programme and University Electives

- The Programme is industry focused with lots of Industry certifications.

- ALTSCHOOL - Adewale Yusuf (https://www.altschoolafrica.com/)
  - Building the biggest (ICT) University in Africa (IT Skills-based)
  - Target 10m graduates over 10 years
  - Students from over 17 countries
  - Tuition is $30/month for 12 months
    - School of Engineering – F/End Engng, B/End Engng, and Cloud Engng
    - School of Product – Prdt. Design, Prdt. Management and Prdt. Marketn
    - School of Data -…….
  - Lecturers drawn from the industry – Tesla, Google, etc.
  - Graduates readily employed abroad ($70k - $80k)
  - Current Enrolment is about 3,000 Globally.

INNOVATIVE & ENTREPRENEURIAL COMPUTING

Innovative & Entrepreneurial Computing

- ## Innovative **entrepreneurship**:

  - The technique of establishing and creating new business concepts to make profits, support the community, and accomplish corporate goals such as growth, expansion, etc.

INVENTION	VS	INNOVATION
Creating a new product out of scientific skills		Adding value to something already existing to meet societal needs
Limited to R & D Dept.		Spread across the organization

Innovation= Invention × Commercialization

Innovation-Driven Entrepreneurship is focused on global markets or supermarkets

Innovative & Entrepreneurial Computing

✓ The lessons to learn from Stanford University, USA, that housed the *numero uno D*epartment of Computer Science in the world.

- In terms of incubation centre (Tech-Hub), the Silicon Valley, is the economic epicenter of San Francisco and the USA in general.

- Silicon Valley was founded by Frederick Terman, the legendary Dean of Stanford Engineering School during the 1940s and 1950s.

- He created the tradition of Stanford Faculty starting their own companies.

Innovative & Entrepreneurial Computing Cont'd

➢ Today, it is home to many of the world's largest technology companies including:

➢ Apple, Cisco, Google, Yahoo, LinkedIn, eBay, HP, Intel and Oracle, Adobe, Tesla...and the list goes on and on ad infinitum.

➢ Other Tech-hubs in the US are:

➢ Silicon Beach

➢ Silicon Alley

➤ China is fast emerging as the Economic Leadership of the world through her Tech-hubs and are innovating at faster speed.

➤ The hubs are based in:

  ➤ Shanghai

  ➤ Shenzhen

  ➤ Hangzhou

➤ China, aptly captioned, "*From copiers to originators, Chinese tech titans showing the way forward with leading-edge advances that rivals the west*" – Rebecca Fannin

➢ AI – Baidu/Tesla

➢ Retail Commerce – Alibaba/Amazon

➢ Mobile payment – WeChat Pay and Alipay already exceeds US Credit/Debit Cards (Apple Pay and Google Pay) etc.

➢ At the fore front of China's Tech boom are (BAT):

> ➢ Baidu (Robin Li)
>
> ➢ Alibaba (Jack Ma)
>
> ➢ Tencent (Ma Huateng)

➢Areas of Research include:

> ➢AI, Biotech, Green Energy, Robotics, Drones, A/VR, Smart Technologies – Cars, Deliveries, etc

➢WeChat is super innovative.

➢It combines functions of:

> ➢ FB, Twitter, Skype, WhatsApp, Instagram and Amazon

➢China is at war with the US Technology wise.

S/N	NAME	INVENTION	NO USERS	PERS./WORTH	COMP./WORTH
1.	BILL GATES @20	MICRSOFT	2.1Bn	$103Bn	$1,791.2Bn
2.	LARRY ELLISON @33	ORACLE	OVER 70M	$111.1Bn	$235.25Bn
3.	STEV JOBS @21	APPLE	1.2Bn	$10.3Bn	$2,183.34Bn
4.	MARK ZUCKERBERG @20	FACEBOOK	OVER 3.59BN	$51.8Bn	$369.55Bn
5.	EVANS SPIEGEL @21	SNAPCHAT	OVER 363M	$2.6Bn	$15.59Bn
6.	ZHANG YIMING @	TIKTOK	1.3BN	$49.5Bn	$65Bn
7.	JACK MA @	ALIBABA	1.18Bn	$26.1Bn	S317.41Bn
8.	ROBIN LI @	BAIDU	OVER 544M	$7.9Bn	$46.91Bn
9.	MA HUATENG @	WECHAT	1.2Bn	$41.6Bn	$482.46Bn
10.	………………………	………….	…………	………………	…………………..

Innovative & Entrepreneurial Computing Cont'd

S/N	NAME	INVENTION	NO USERS	PERS./WORTH	COMP./WORTH
1.	LARRY PAGE @25	GOOGLE	1.5Bn	$84Bn	$1,415Bn
2.	JERRY YANG @27	YAHOO	OVER 225M	$2.7Bn	$48.08Bn
3.	STEV JOBS @21	APPLE	1.2Bn	$10.3Bn	$2,183.34Bn
	THE RICHEST MAN IN AFRICA				
	ALIKO DANGOTE	MANUFACTURING		$13.5Bn	
	THE RICHEST MAN IN THE WORLD				
	BERNARD ARNAULT	MOËT HENNESSY LOUIS VUITTON		$212.4Bn	
	ELON MUSK	TESLA (E-CARS)		$186.9Bn	

RECOMMENDATIONS AND CONCLUSION

- Lessons Learnt From China and US:
  - Active involvement in:
    - Research Publications, Patents, Science & Tech, R & D
  - Contributing sizeable % of GDP to R&D
  - Innovative and Entrepreneurial Computing
  - Developing Technologies & Software for Continental consumption at least.
    - Consider Zoom, MS Teams, FB, Twitter, UBER, etc.

Every Faculty/Department of Computing should:

✓Create Research Clusters focusing on each of the Disruptive Innovations/ Technologies. (The CU Example)

✓Develop Capacities through Training and Industrial Partnership. (PG Students and Staff Internship – (The CU Example)

✓Without University Degrees, we can turn the teeming youths population in Africa to an asset through a diploma program in Computing

Dangers Ahead

- According to the United Nations statistics, Africa has the largest concentration of young people in the world:
  - 19 of the world's 20 youngest countries are in Africa.
  - 77 per cent of the population in Sub Saharan Africa is below 35 years (three quarters of Africa's population).
  - 34 per cent is between 15-35 years.
  - 433 million youths are either unemployed or in precarious employment situation across SSA.

Dangers Ahead

- 60 per cent of the 10 million students graduating from Africa's HEIs yearly remain unemployed 5 years after graduation.
- 25 million jobs must be created yearly in Africa over 5 years to impact youths.
- Two thirds of non-student youths are unemployed or vulnerably employed.

Digital technology skills Opportunities

- Africa has only 700K developers compared to Latin America 2.2M.
- Most of Africa's 21st Century jobs will come from digital technology skills.
- Establishment of Tech-hubs/Startups in HEIs.
- Monumental Economic benefits from Innovation and Cyberpreneurship.
- Monumental contributions to Nation Building.

Thank You