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FAO
Water-Enegy-Food Webinar Series
Session 5

Nexus & Sustainability in Theory and Practice:
Examples from Iran

Presenters: Bahram Taheri & Roya Zargarian

Date: March 30th, 2021

Know your water
establishing robust
water accounting
systems

WATER
Productivity
Efficiency, and
Sustainability
in the NENA countries

Food and Agriculture Organization
of the United Nations

Nexus & Sustainability in Concept, Theory and Practice

- Presenters:
  - Bahram Taheri **(Nexus & HSE Center, AmirKabir Univ. Foundation, NRI Nexus Center)**
  - Roya Zargarian **(Nexus & HSE Center, AmirKabir Univ. Foundation)**
  - Morteza Jalali and Mohammad Moradi **(NRI Nexus Center)**
- Moderators:
  - Annette Huber-Lee **(SEI)**
  - Francesco Fuso-Nerini **(KTH)**
- Closing
  - Domitille Vallee **(FAO)**
  - Jiro Ariyama **(FAO)**

  - **Tuesday, March 30th, 2021 1:00-2:30 p.m. Cairo Time**

Key topics: Nexus, Sustainability, Water, Energy, Food, Efficiency, Productivity, System of Systems, Institutionalization

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Webinar Schedule

Time	Content	Speaker
13:00-13:15	Nexus and sustainability in concept & theory	Bahram Taheri
13:15-13:25	Introduction to Sustainability Transition Pathways	Roya Zargarian
13:25-13:45	Existing Nexus simulation tools, examples from Khuzestan	Morteza Jalali & Mohammad Moradi, Bahram Taheri
13:45-14:05	Prospective hands-on nexus tools, nexus mind-maps & a few exercises to work on	Bahram Taheri
14:05-14:25	Discussion and Q&A	Annette Huber-Lee Francesco Fuso-Nerini
14:25-14:30	Closing	Domitille Vallee Jiro Ariyama

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Nexus and Sustainability
In
Concept and Theory

Bahram Taheri
13:00-13:15

“Nexus & Sustainability”, the elephant in the dark room

Rumi, the 13th Century Persian poet included it in his Masnavi, "The Elephant in the Dark",
Originally a Hindu parable,
The elephant, the dark room or the blind men

Rumi uses this story as an example of **the limits of individual perception**
and as a metaphor for the unknown:

The sensual eye is just like the palm of the hand.
The palm has not the means of covering the whole …
The eye of the Sea is one thing and the foam another.
Let the foam go, and gaze with the eye of the Sea.
Day and night foam-flecks are flung from the sea:
oh amazing! You behold the foam but not the Sea.
We are like boats dashing together;
our eyes are darkened, yet we are in clear water

If each had a candle and they went in together
the differences would disappear

An ukiyo-e print by Hanabusa Itchō (1652–1724).

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Institutionalization of Nexus & Sustainability

- Cognitive Phase
- Normative Phase
- Regulative and Organizational Phase

John Godfrey Saxe I (1816–1887)

That each by observation
Might satisfy his mind …..
Though each was partly in the right
And all were in the wrong! ……
And prate about an Elephant
Not one of them has seen!

Buddha (4th-5th Century BCE):

For, quarreling, each to his view they cling.
Such folk see only one side of a thing.

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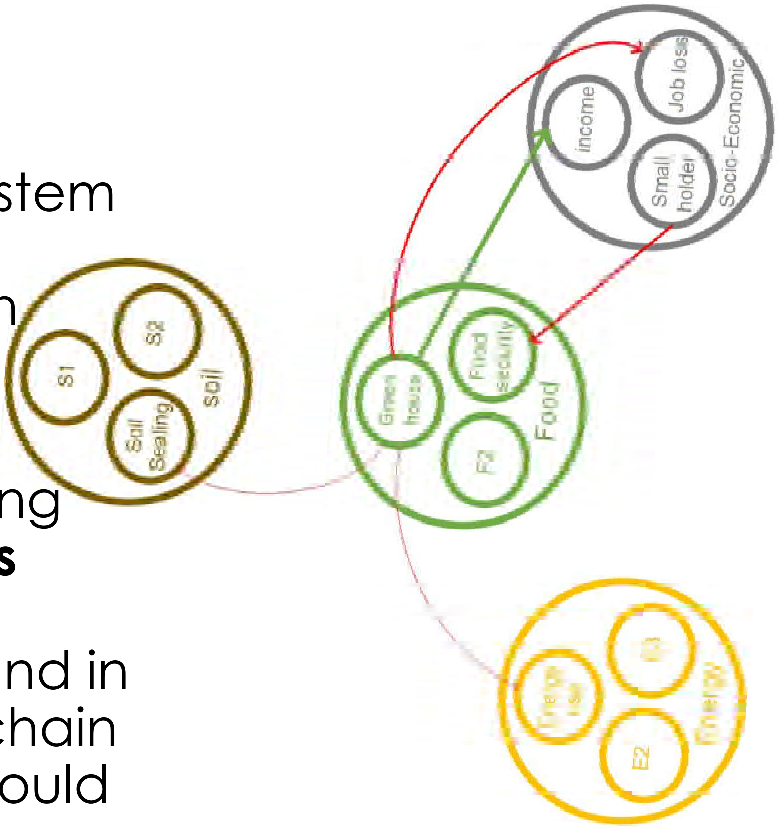
Nexus! What is it?



A “**System of Systems** (SOS)” in which each subsystem and its elements, acquire **additional qualities** or **capabilities** that they did not possess on their own **alone**.

It refers to the **paired, tripled or multilateral** interconnections/interactions between and among subsystems and the way this **quality of systemness** affects one element or a subsystem of the nexus’ response to a certain **input or action**, **differently** and in **such a scale**, quantitatively or qualitatively, in a chain of **back and forth impacts and reactions** that it would not have, if it was a lone responder to that certain input or action.

Ref. B. Taheri, Nexus Lecture in The World Academy of Sciences, TWAS, Trieste, Italy, Nov. 2017

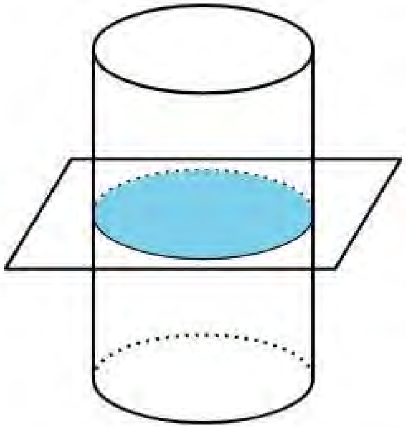
Nexus as a System of System (SOS)

- **Looking at Nexus as a System of systems** enables us to look at our problem at hand as a collection of task-oriented or dedicated **systems** that can combine their resources and capabilities together to create a new, more complex **system** which offers more **resilience**, more **homeostasis**, more **functionality** and higher **performance** than simply the sum of the constituent **systems**.
- In a Nexus SOS, we should adopt a **risk-based** approach, in which we identify **positive synergies** and use them, while understanding the negative synergies and **tradeoffs** and avoid them by managing and responding to those risks, hence increasing the **productivity** and **sustainability** of our activities and interactions with nature and society.

AmirKabir University Foundation’s First Nexus Center Logo

Why understanding of the dimensionality of nexus is so important?

- Let's look at a cylinder, a 3-D object and think of its possible intersections with a 2-D plate. That is exactly what happens when we reduce the number of dimensions in moving from one higher dimension of complexity of Nexus SOS to a lower level of nexus complexity! Noting that, this is reduction of a subsystem and not a single element from a subsystem!



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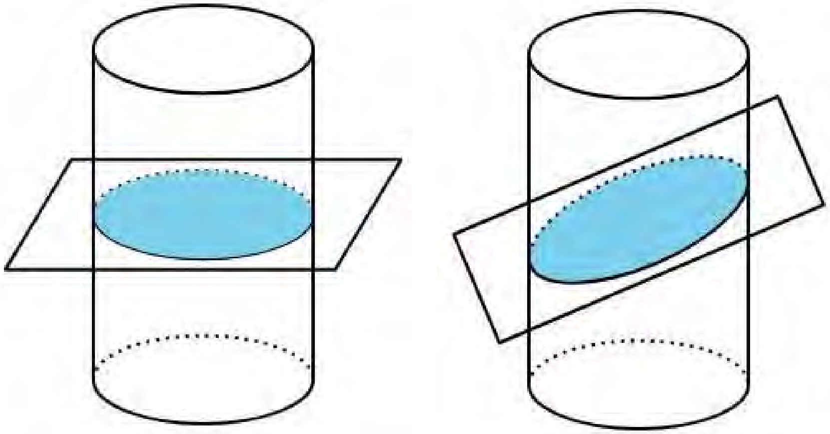

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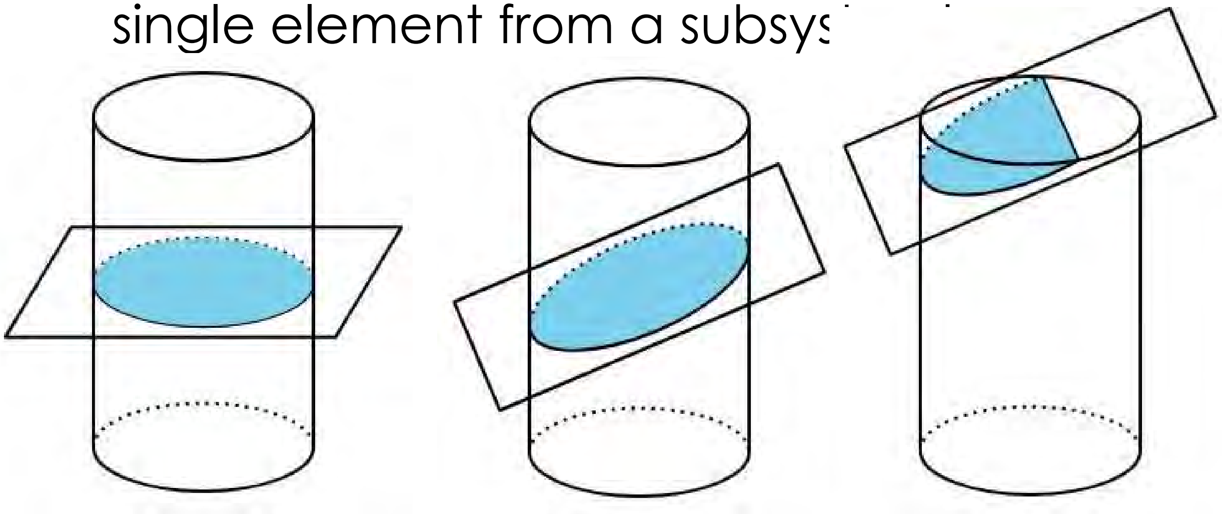

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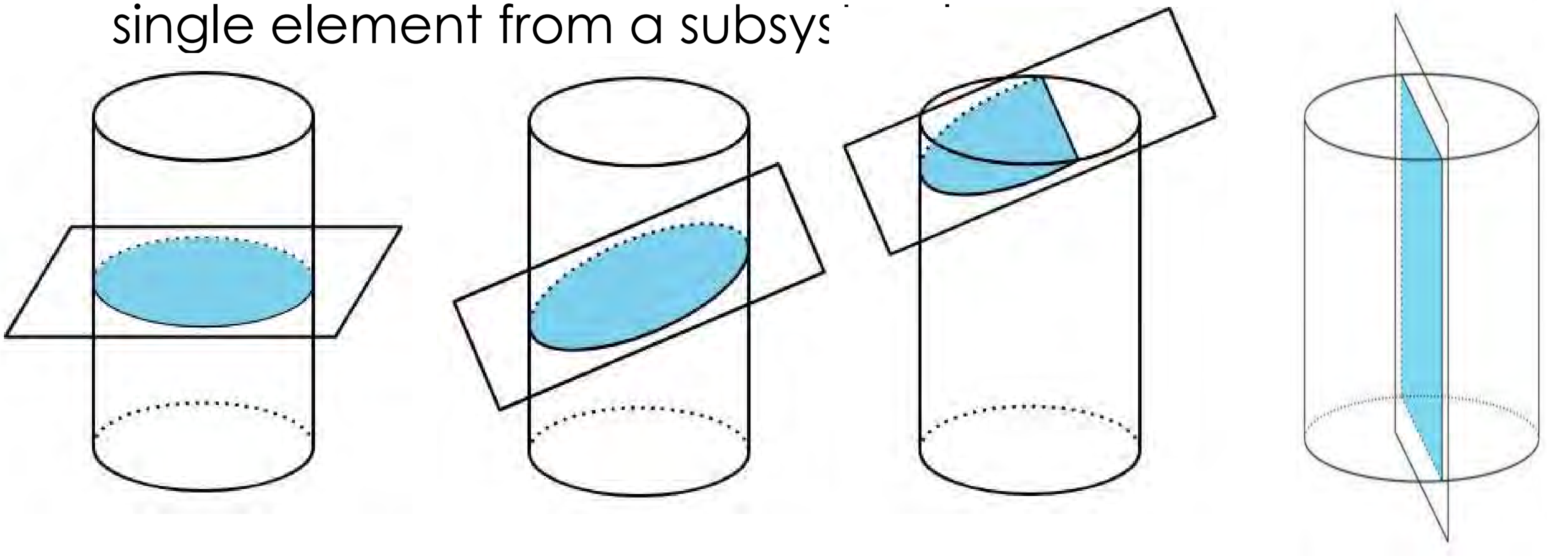
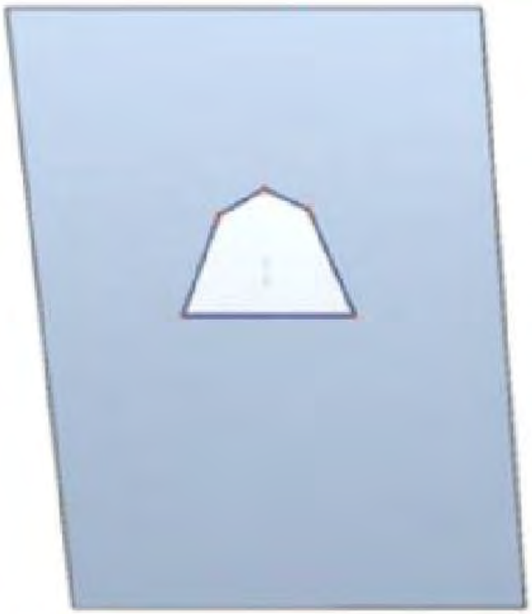


It's an Immensely Difficult Task, to get a Reliable Cognition about a World of Higher Dimensions, Higher Complexity and Larger Scale, from inside a World of Lower Dimensions, Lower Complexity and Lower Scale, while being Bound by the Limitations of the tools of the Second World!

Can we reconstruct
downward?
Do we know, the
angle of the vision
Which created the
2-D shape?
Do we know, the
boundaries of
expansion?



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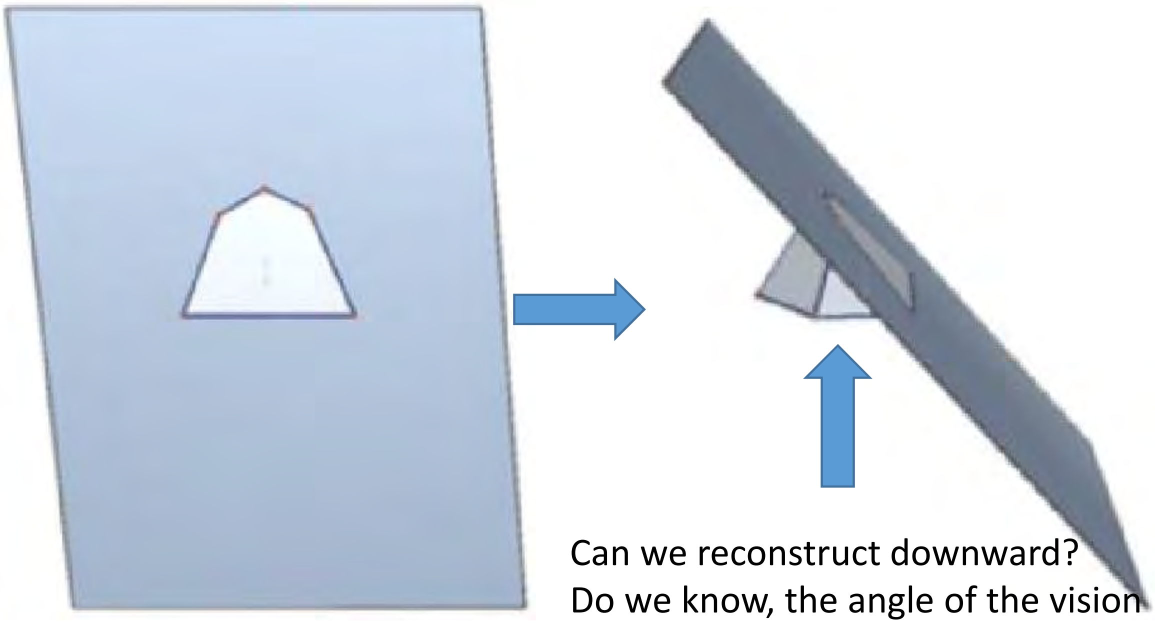

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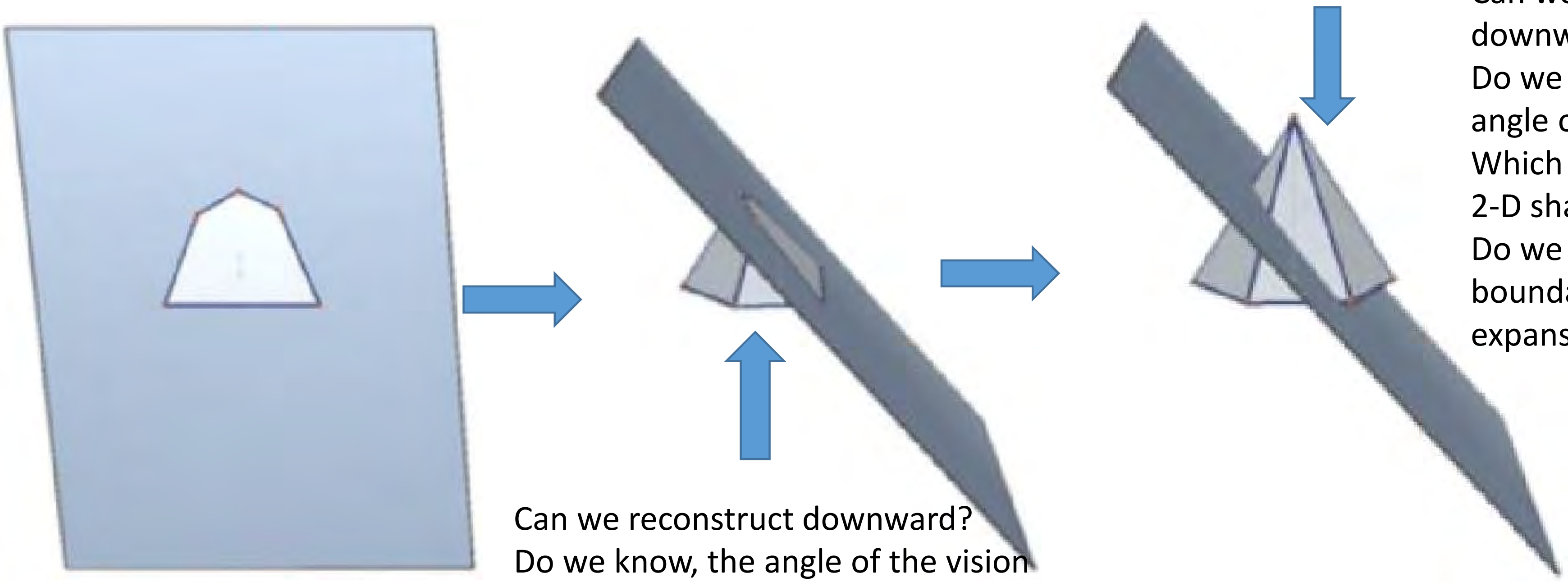

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What is a System?

If there is a system,
And you are of the belief that
you are on top of everything,
But, you have no cognition of
Or respect for the systemic relations

A group of parts combined in a way, through relations, that creates one or more emergent property or capabilities not possessed by the separate parts

Real System: Two or more elements interacting in physic space-time to create emergent properties, capabilities, functions or effects that the elements in isolation cannot achieve

Real systems: *Share the characteristics of "**viable system** and "living systems" exhibit homeostasis, resilience and ability to cope with unforeseen circumstances.*

Beware of Falling!

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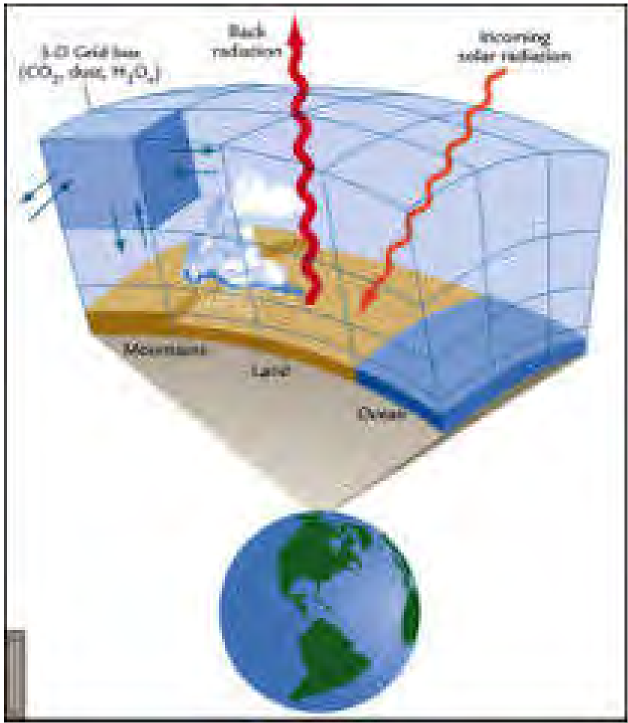
Models? What are they? Physical or Conceptual?

is a **representation of a system**, made of the **composition of concepts** which are used to help people **know, understand, or simulate a subject the model represents**.

Conceptual model may refer to models which are formed after a conceptualization or generalization process. Conceptual models **are often abstractions** of things in the **real world**, whether **physical or social**.



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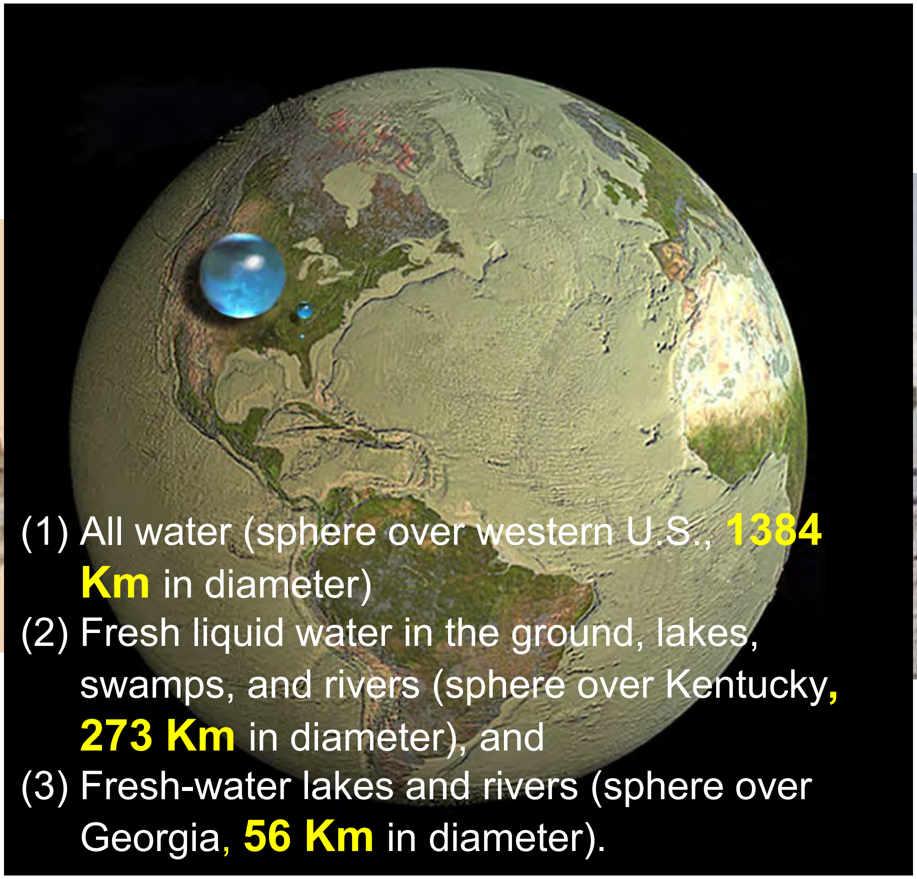
Cognition of Limitation of World Resources



(1) All water (sphere over western U.S., **1384 Km** in diameter)
(2) Fresh liquid water in the ground, lakes, swamps, and rivers (sphere over Kentucky, **273 Km** in diameter), and
(3) Fresh-water lakes and rivers (sphere over Georgia, **56 Km** in diameter).

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Cognition of Limitation of World Resources

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Energy, Water and Food

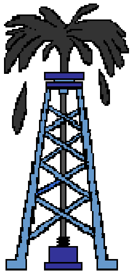
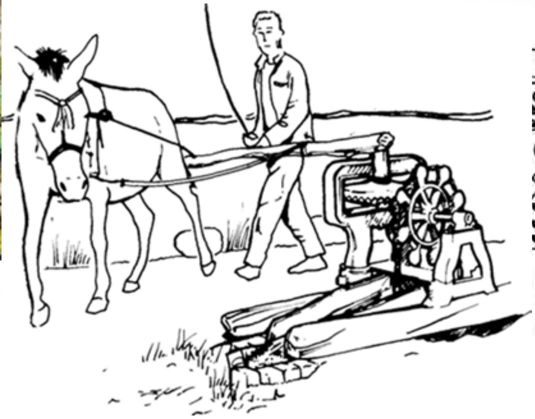
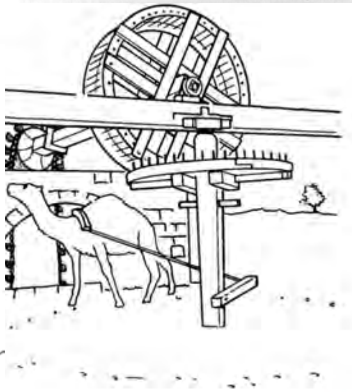


Fig. 349. — Batteuse Damey à manège direct placé sous la batteuse.





Next time that you estimate Water Yield in your farm. Also check the Energy Yield! It may be the time doing that!

	MJ/ha	MJ/ha	Energy
Produce	Energy Input	Energy Yield	Yield Ratio
Barley	**25656**	**49800**	**1.94**
Wheat	**32493**	**48517**	**1.49**

S.M. Ziaei, Et al, Jan. 2015

- 60 to 90% of energy use in today's world agriculture is from non-renewable sources
- In the case of Iran, it is 80%

What a man or a woman can do?
Popeye the Sailorman or Rosie the Riveter

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How much Energy do we get from food every day?
A comparison!

2500 Kcal, 2906 W.hr
A 121 Watt Lamp
321 CC of Fuel Oil

2000 Kcal, 2324 W.hr
A 97 Watt Lamp
256 CC of Fuel Oil

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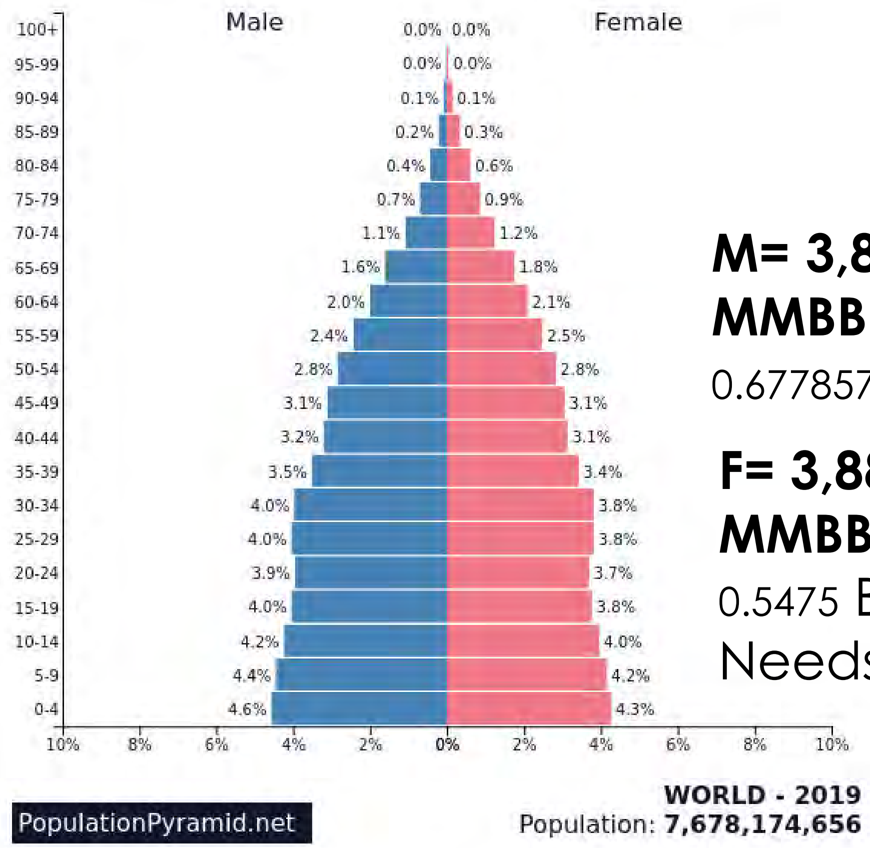
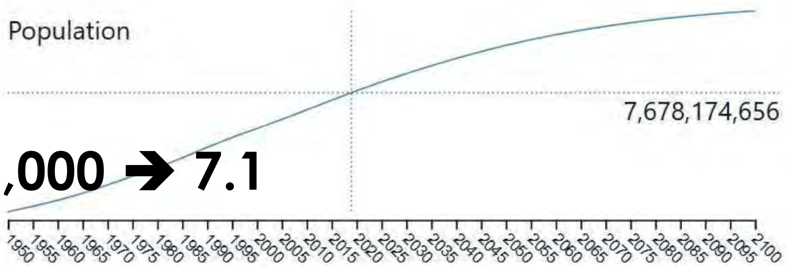
BBL eq. of Planet's Population's Food





M= 3,824,434,000 ➔ 7.1 MMBBL/Day

0.677857 BBl/Male/Year

F= 3,889,035,000 ➔ 5.83 MMBBL/Day

0.5475 BBL/Female/Day Calorific Needs

Ref: Salzburg Energy Forum,
2019, Bahram Taheri

Fossil Fuel Used in US Food System

In the USA approximately 1400 liters of oil equivalents are expended to feed each citizen; energy consumption is broken down:

- 31% manufacturing inorganic fertilizers
- 19% operation of field machinery
- 16% transportation
- 13% for irrigation
- 8% raising livestock [not feed lot feed]
- 5% crop drying
- 5% pesticide production
- 8% other inputs

Does not include energy costs of packaging, refrigeration, transport to outlets and energy for cooking

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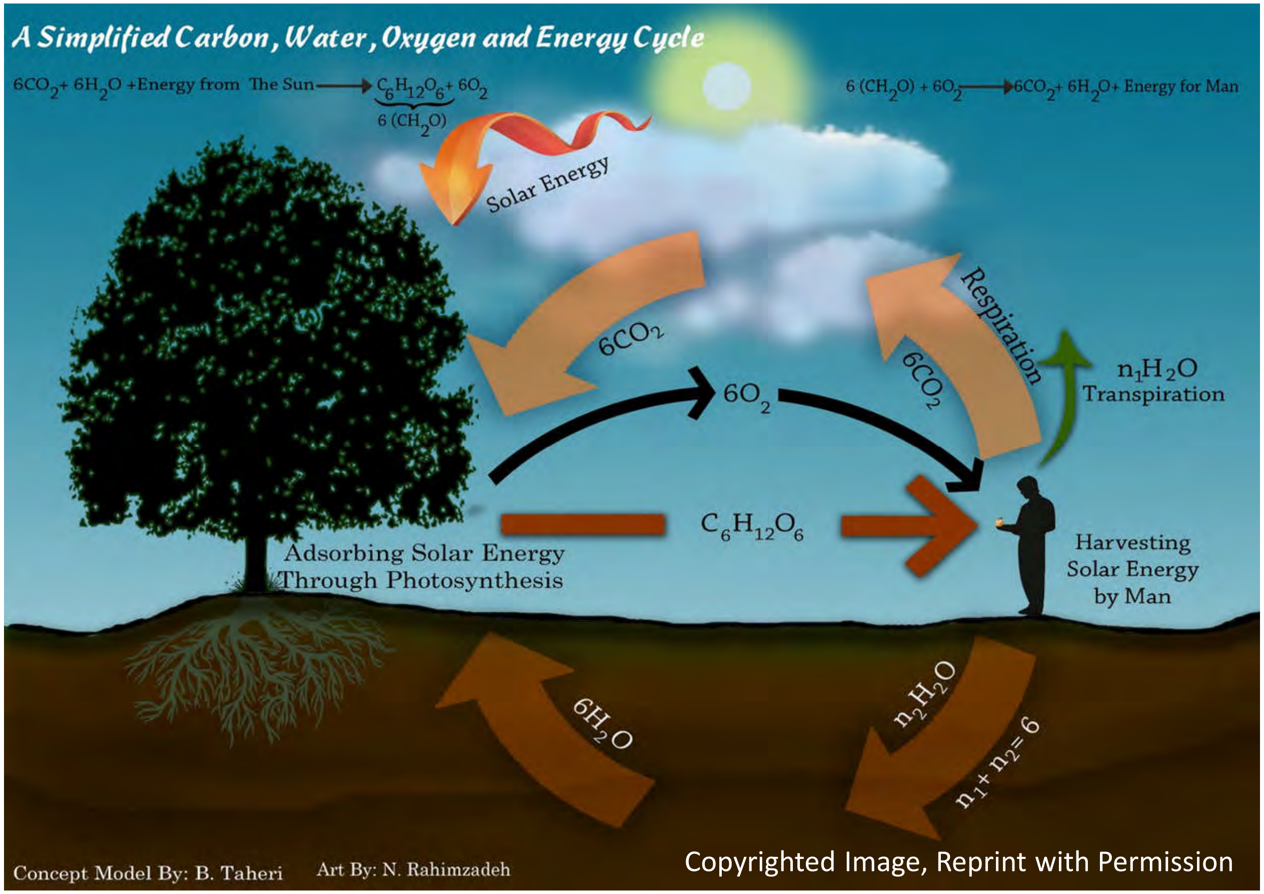
The DNA of Water, Soil, Energy, Food and Life Nexus



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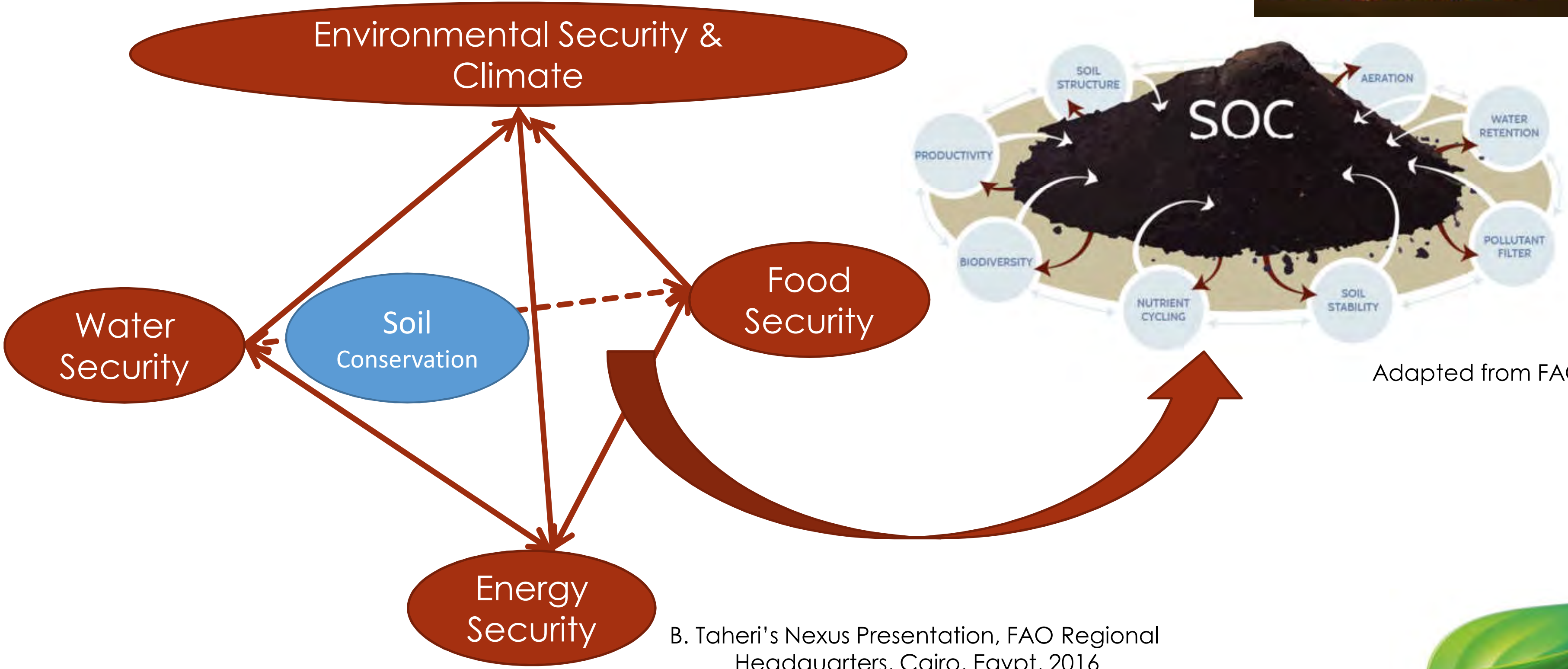
A 5-Dimensional Nexus

Photo: Taken by B. Taheri, Cairo, 2016



Adapted from FAO, VGSSM

B. Taheri's Nexus Presentation, FAO Regional Headquarters, Cairo, Egypt, 2016

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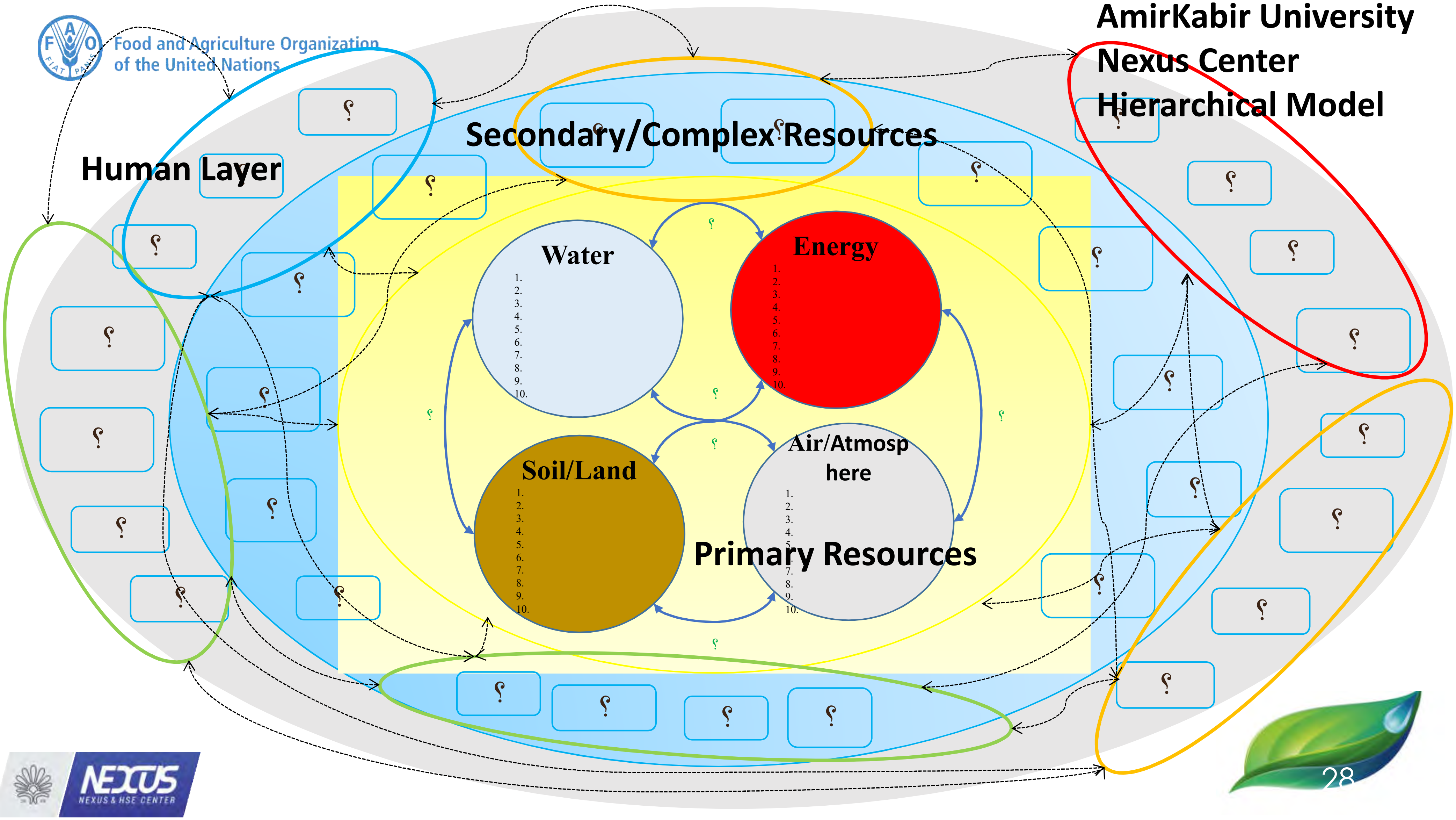
AmirKabir University Nexus Center Hierarchical Model



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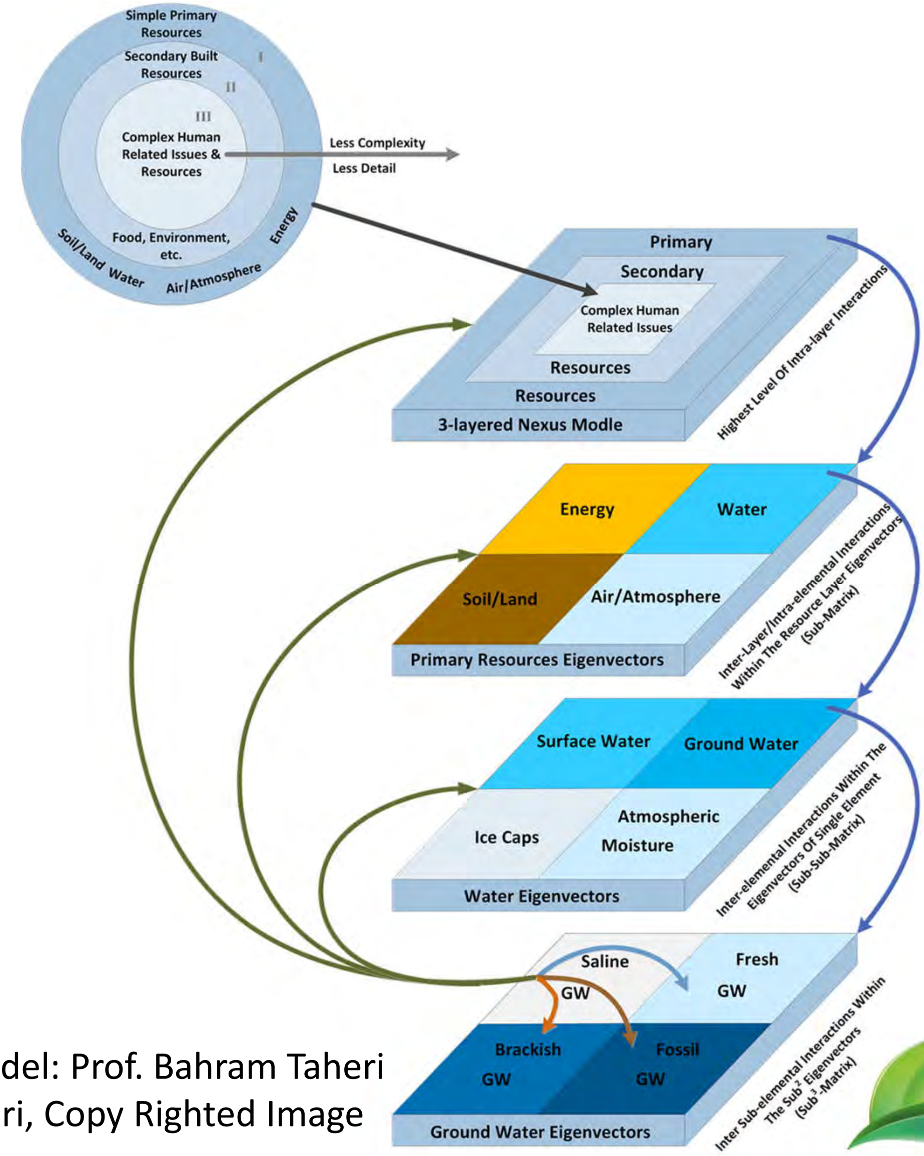
AKUF Nexus Center Multi-Layered System of Systems Nexus Model



Conceptual Model: Prof. Bahram Taheri
Art: Zahra Nazeri, Copy Righted Image

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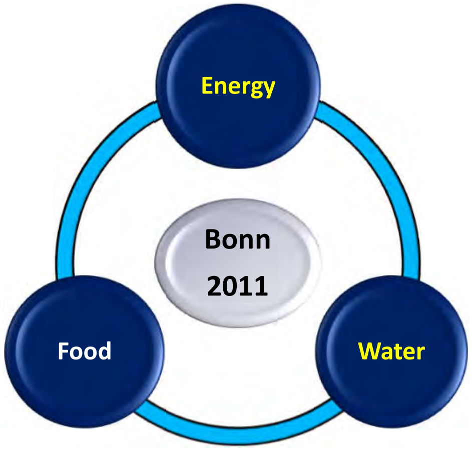
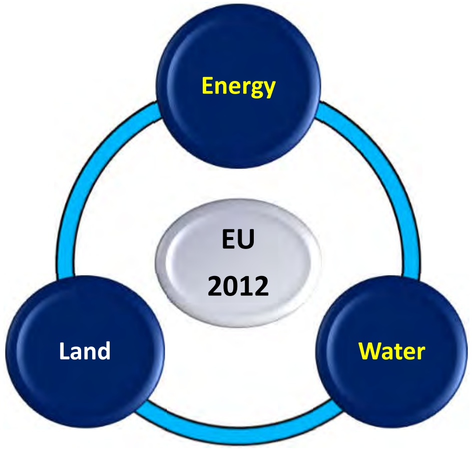
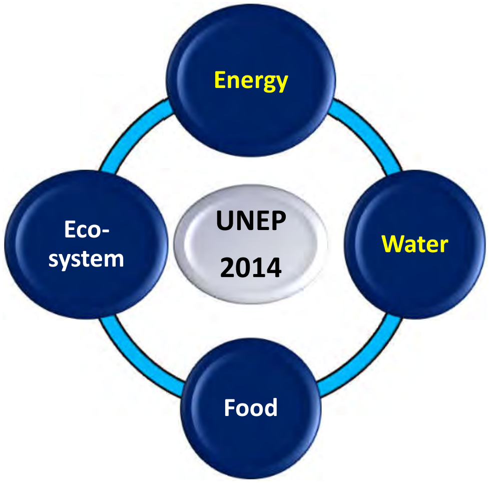
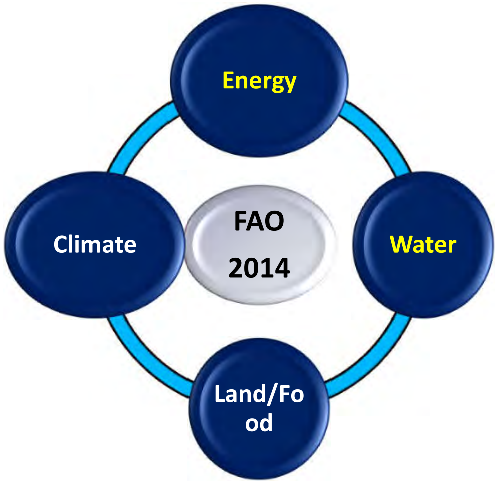
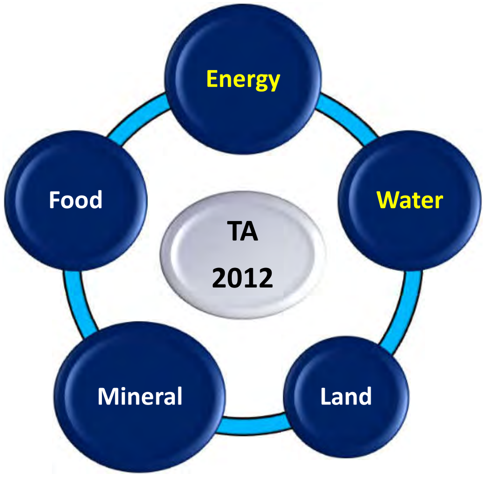
Conceptual Frameworks for Resource Nexuses


Energy
Bonn
2011
Food
Water


Energy
EU
2012
Land
Water


Energy
Eco-system
UNEP
2014
Water
Food


Energy
Climate
FAO
2014
Water
Land/Food


Energy
Food
Water
TA
2012
Mineral
Land


Fiber
Energy
Feed
WBCSD
2013
Food
Bio-materials
Water

A Nexus View Of the SDGs In Three Layers

Sustain resource availability

Strengthen institutions for collaborations

Reduce impacts on terrestrial biodiversity

Lower inequalities

Build partnerships

Diminish impacts on aquatic biodiversity

Elevate food security

Enhance water security

Reduce poverty

Create new industry and jobs

Stimulate innovative industry and green infrastructure

Curtail CO_2 emissions

Increase energy security

Provide educational material

Boost equal gender access to resources

Lower consumption and production cost

Enhance health and well-being

Nexus Energy Indicators (An example for other resources)

- Water use/ Energy unit (snap or lifecycle)
- Energy use/ Water unit (snap or lifecycle)
- Energy/water/farming
- Energy/water/food (Lifecycle)
- Energy/CC/Soil
- Soil/Energy/CC
- Soil/CC/Energy
- Energy lifecycle/Environment per GDP, Per Sector, Per Subsector
- Etc.

Nexus
Sustainability
Sustainability Transition Pathways

Roya Zargarian

13:15-13:25

Sustainability

Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs (Brundtland, 1987).

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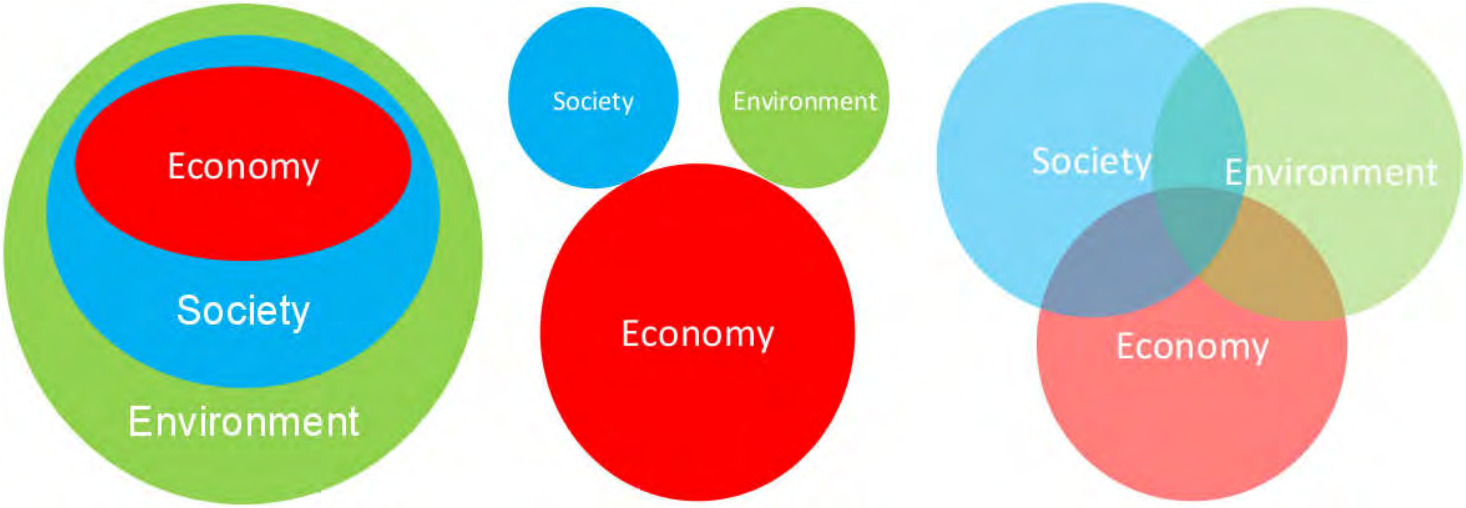
Sustainable development theory



Sustainability models consisting of three pillars economy, society and environment. The embedded model (left), the Mickey Mouse model(middle) and the TBL model(right).

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Sustainable development goals(SDGs)

- In 2015, the world's leaders adopted 17 Sustainable Development Goals (SDGs) that aim to 'free humanity from poverty, secure a healthy planet for future generations, and build peaceful, inclusive societies as a foundation for ensuring lives of dignity for all . These 17 goals are supported by 169 targets with over 200 indicators. All countries, regardless of their income-levels, agreed to aim to achieve the SDGs by the year 2030.
- **However, five years in, the outlook on the SDGs is bleak: recent assessments show that inequality is widening, hunger is on the rise, ecosystems are eroding at an alarming rate, and climate change threatens the entire SDG agenda.**

Issues

- Global population projected to exceed 9 billion
- Per capita buying power expected to more than double by 2050
- Major threats, such as climate change and its likely social, political and economic consequences compound the challenges and add further interlinkages

⬇

- Global challenges such as reducing food insecurity, water scarcity and fossil energy use, as well as improving human health and protecting the environment, are increasingly pressing and deeply interconnected

Issues

- **The world is not on track to achieve the 17 SDGs by 2030**. A dominant emphasis on economic development threatens achievement of social, and especially environmental SDGs. Economies are aggregations of numerous, widely diverse economic activities. And individual economic activities vary widely in terms of the SDGs that they impact, both positively and negatively.

Why Nexus?

- Achieving the SDGs requires all relevant stakeholders to work together and manage the synergies and trade-offs among different management or governance sectors (for example, food, health, water and energy).

- The water–energy–food nexus has become central to discussions regarding the development and subsequent monitoring of the SDGs.

Why Nexus?

- Numerous approaches have been developed to help address these issues, including the concepts of natural capital and ecosystem services , quantification of environmental footprints and planetary boundaries, integrated water resource management and ‘soft path’ approaches to improve water use efficiency, multifunctional landscapes and integrated ecosystem management. Each of these concepts has multiple dimensions and is valuable for addressing some of the SDGs, and they can be extended to address synergies and trade-offs among sectors
- The nexus concept builds on many of these approaches by emphasizing the importance of understanding connections, synergies and trade-offs

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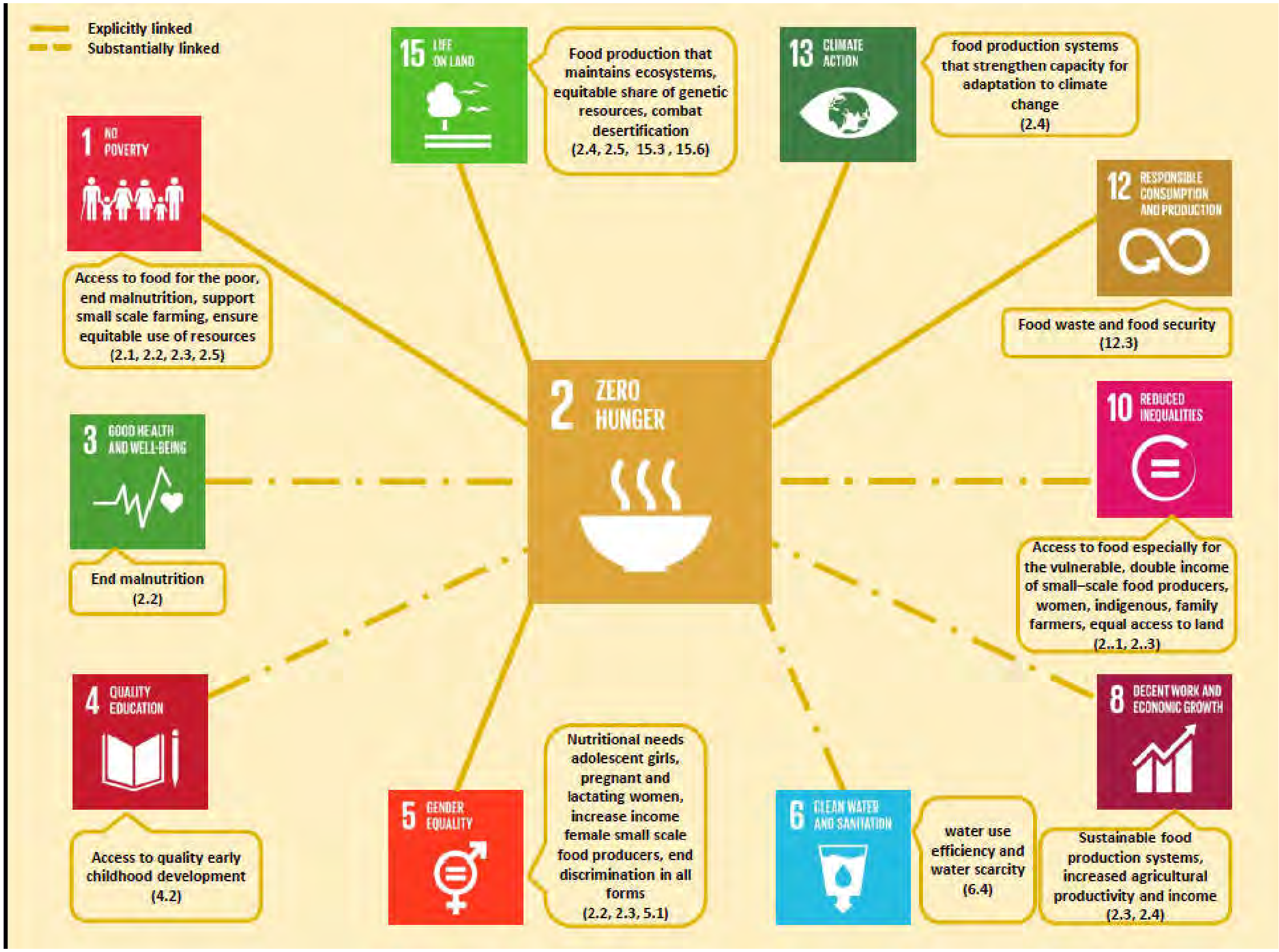

▬ Explicitly linked
▬ ▬ Substantially linked

Access to food for the poor, end malnutrition, support small scale farming, ensure equitable use of resources (2.1, 2.2, 2.3, 2.5)

Food production that maintains ecosystems, equitable share of genetic resources, combat desertification (2.4, 2.5, 15.3 , 15.6)

food production systems that strengthen capacity for adaptation to climate change (2.4)

Food waste and food security (12.3)

End malnutrition (2.2)

Access to food especially for the vulnerable, double income of small–scale food producers, women, indigenous, family farmers, equal access to land (2..1, 2..3)

Access to quality early childhood development (4.2)

Nutritional needs adolescent girls, pregnant and lactating women, increase income female small scale food producers, end discrimination in all forms (2.2, 2.3, 5.1)

water use efficiency and water scarcity (6.4)

Sustainable food production systems, increased agricultural productivity and income (2.3, 2.4)

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Protect and restore water-related ecosystems (6.6)

Improve water quality by reducing pollution (6.3)

Increase recycling and safe reuse of water, reduce release of chemicals and waste into water, reduce waste generation (6.3, 12.4, 12.5)

access to drinking water (6.1)

water use efficiency and water scarcity (6.4)

Assure access to drinking water (6.1)

sanitation and hygiene, improved water quality (6.2, 6.3)

Improve sanitation and hygiene with special attention to the needs of women and girls (6.2)

integrated water resource management, quality, reliable, sustainable and resilient infrastructure (6.5, 9.1)

Equitable access to drinking water, access to adequate and equitable sanitation and hygiene (6.1, 6.2)

(United Nation, 2018)

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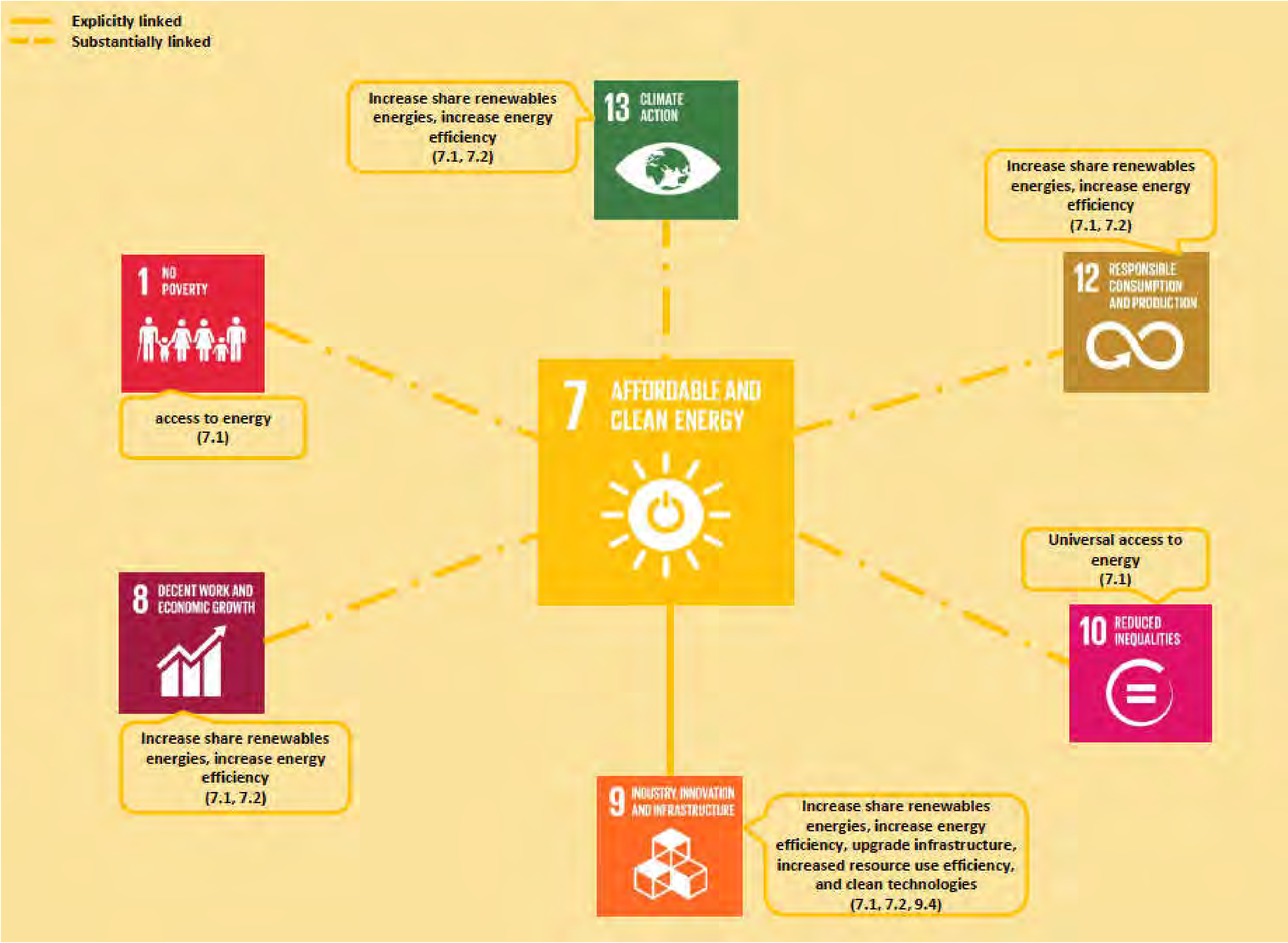

Increase share renewables energies, increase energy efficiency (7.1, 7.2)

Increase share renewables energies, increase energy efficiency (7.1, 7.2)

access to energy (7.1)

Universal access to energy (7.1)

Increase share renewables energies, increase energy efficiency (7.1, 7.2)

Increase share renewables energies, increase energy efficiency, upgrade infrastructure, increased resource use efficiency, and clean technologies (7.1, 7.2, 9.4)

Urban nexus approach

- The urban nexus approach examines interlinkages among urban sectors including water, energy, food, and waste management.
- involves identifying, understanding and acting on interrelationships to capture synergies and minimize trade-offs .
- It also guides stakeholders as to how to integrate management to increase resource efficiency, as well as how to turn waste and wastewater into resources that can contribute to solving the challenges of urban waste management.
- When the urban nexus approach is applied from the early planning stage onwards, it holds great potential for making urban systems resource efficient, cost effective, and environmentally friendly and also

Urban Nexus

- The Urban Nexus approach examines the interdependencies between water, energy and food/land and the synergies and competing uses of these resources, requiring a shift from a sectoral to a cross sectoral, integrated approach. It challenges existing structures, sector policies and procedures to promote the protection and use of water, energy and food/land in a balanced manner, countering traditional silo thinking and divided responsibilities that often result in poorly coordinated investments, increased costs and underutilized infrastructure and facilities.

Urban Nexus

- **The Urban Nexus approach is an action-oriented guiding principle within the vision of a circular economy, where waste is viewed as a resource**. Multi-sectoral and multilevel approaches which integrate resources contribute to improved resource efficiency. With many project cities identifying wastewater and solid waste management as their most pressing problems, the Urban Nexus approach emphasizes how wastewater and waste can be converted into sources of energy and useful byproducts, such as fertilizer”.

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Nexus

The success of the Sustainable Development Goals (SDGs) depends on solving the ‘nexus’ challenge: how can positive interactions between SDGs be optimised, and negative interactions minimised, in order to create co-benefits and reduce trade-offs?

Nexus Benefits

- **Uncovering synergies and co-benefits**. Nexus approaches can identify synergistic effects and co-benefits that might otherwise be missed in complex production systems and supply chains. This is particularly important in densely populated urban areas where the benefits of more efficient resource consumption are high
- **Detecting harmful trade-offs**. Nexus approaches can help detect and minimize harmful trade-offs. For example, trade-offs occur in drier regions where farmers choose between multiple types of crops that have different water and energy demands
- **Unveiling unexpected consequences**. Nexus approaches can assist in identifying unexpected consequences. For example, biofuels were proposed as part of the solution to increased CO2 emissions from burning fossil fuels, but unexpected side effects occurred.

Why sustainable transition pathways?

- **Governance**: The food price crisis increased the number of hungry by 75 million in 2008 and a further 70 million people were pushed into extreme poverty in 2010-11. In 2011, 900 million people were undernourished in the world, although enough food is produced for the Earth's population.
- **Social**: Nutrition-related diseases such as cancer, cardio-vascular and liver diseases are on the rise. In particular, Type 2 diabetes will double in developing countries by 2030 and triple in North America by 2050, resulting in challenging heath care and societal costs.

Why sustainable transition pathways?

- **Economy**: The financial and economic crisis resulted in 18-51 million more people unemployed and the poor increased by at least 110 million in 2008; today, economic stagnation continues.
- **Environment**: The most severe environmental crisis of our modern times is climate change, representing a global security issue due to displacements and turbulence. It also puts food systems at risk by worsening growing natural resources scarcity and price volatility

Sustainability transition pathways

- Today, over 900 million people still suffer from hunger. Poor populations worldwide, especially in rural areas, are among those most vulnerable to the food, climate, financial, economic, social and energy crises and threats the world faces today.
- We cannot call development sustainable while this situation persists, while nearly one out of every seven men, women and children are left behind, victims of undernourishment.
- The transition to a sustainable future also requires fundamental changes in the governance of food and agriculture and an equitable sharing of the transition costs and benefits.

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Sustainable agriculture

- Sustainable agriculture lies at the core of the 2030 Agenda. Six out of the 17 Sustainable Development Goals concentrate on sustainable agriculture, namely SDG 2 on hunger, nutrition and sustainable agriculture, SDG 6 on water use efficiency, SDG 12 on responsible production and consumption, SDG 13 on combating climate change, SDG 14 on conserving marine resources, and SDG 15 on terrestrial ecosystems, land restoration and biodiversity.

Green economy

- Due to the multiple environmental, economic and social crisis, policy-makers worldwide are searching for sustainable development pathways. One solution proposed is the **green economy**.
- There are different interpretations of the green economy but overall it is about achieving more (socio-economic development) with less (ecological impact).

Greening economy with agriculture

- Greening the Economy with Agriculture (GEA) refers to ensuring the right to adequate food, as well as food and nutrition security – in terms of food availability, access, stability and utilization – and contributing to the quality of rural livelihoods, while efficiently managing natural resources and improving resilience and equity throughout the food supply chain, taking into account countries' individual circumstances.

Greening economy with agriculture

- Current agricultural systems are the result of unsustainable farming practices that have squandered our natural resources, leaving our current and future generations with the additional task of addressing land degradation, water scarcity and pollution, eroded agro-biodiversity and climate change. Today, there are still too many regions in the world where agricultural productivity is extremely low, and where farmers, pastoralists, and other rural dwellers struggle to survive and make a decent living.

Agroecology

- Agroecology can support the achievement of multiple objectives – economic, environmental, social, nutritional, health and cultural – holistically.
- It is an approach that contributes directly to the achievement of thirteen of the Sustainable Development Goals, while significantly increasing the resilience of both people and the environment, mitigating climate change, and sustainably using and conserving natural resources and biodiversity.
- A systemic approach, involving relevant agricultural and food sectors and stakeholders in the broad adoption of agroecology, has the potential to greatly accelerate the transition to sustainable and resilient food systems, in line with the various international commitments made by member nations.

The cost of transitioning to sustainability

- Experience has shown that there are often trade-offs between achieving development, food security and environmental objectives.
- In some cases, the development of agriculture and the transformation of food systems can generate unintended environmental damage, while environmental protection policies can have negative impacts on the poor.
- Often these trade-offs are triggered or exacerbated by inappropriate policies and weak institutions. Identifying and reducing policy-driven trade-offs is fundamental to improving the sustainability of consumption and production systems, and that will require better alignment of agriculture, food security and environmental policies.

Summary and conclusion

- **Recent quantitative studies have revealed that nexus approaches can uncover synergies and detect trade-offs among sectors. If well implemented, nexus approaches have the potential to reduce negative surprises and promote integrated planning, management and governance**. However, application and implementation of nexus approaches are in their infancy. No studies have explicitly quantified the contributions of nexus approaches to progress toward meeting the Sustainable Development Goals.
- The world's landscape is changing and we cannot rely on our past successes for future gains. Hence adapting to climate change and finding ways to ensure food security and nutrition is what needs to be planned for whilst we need to consider that sustainable food and agriculture is one where food is nutritious and accessible for everyone and one where natural resources are managed in a way that maintain ecosystem functions to support current as well as future human needs.

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Existing Nexus Simulation Tools
Examples from Iran

Morteza Jalali
Mohammad Moradi
Bahram Taheri
13:25-13:45

0- Nexus Simulation in Khuzestan (Some Existing Tools)
1- Conservation Agriculture (Prof. Gorji, Univ. of Tehran)
2- SiahBisheh Pump & Storage Dam, a Water-Battery (Mr. Naghavi, et al, IWPRD Co.))
3- South Tehran Wastewater Company (Dr. Barati, Ms. Ekhtiarzadeh)
4- Carbon Capture from Energy & Petrochemical Industry (Mr. Salimi, Ms. Karimi)
5-Development of Iran's South Coastal Area (Dr. Amini, et al, IWPRD Co.)

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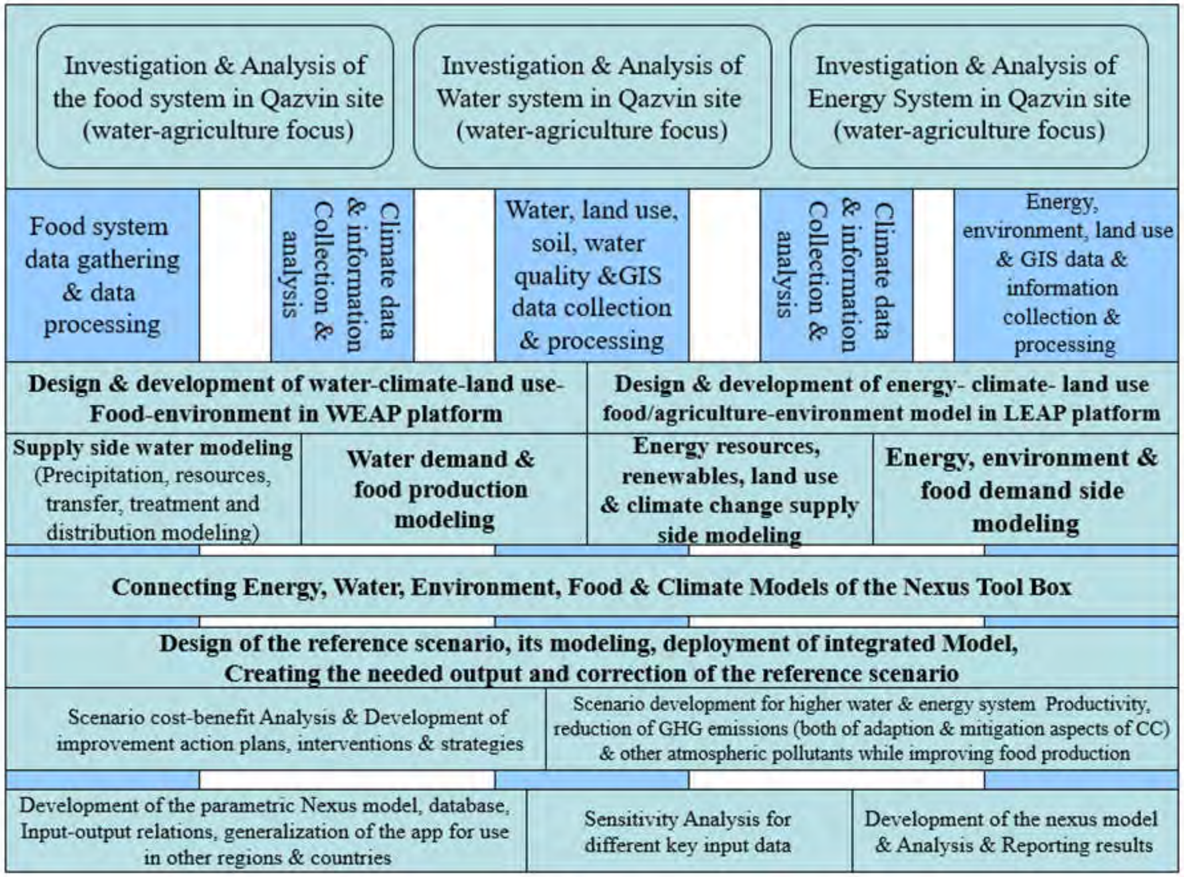
Model Generated to Apply WEAP-LEAP to Qazvin Pilot Site under SIDA Regional Project



Investigation & Analysis of the food system in Qazvin site (water-agriculture focus)

Investigation & Analysis of Water system in Qazvin site (water-agriculture focus)

Investigation & Analysis of Energy System in Qazvin site (water-agriculture focus)

Food system data gathering & data processing

Climate data & information Collection & analysis

Water, land use, soil, water quality &GIS data collection & processing

Climate data & information Collection & analysis

Energy, environment, land use & GIS data & information collection & processing

Design & development of water-climate-land use-Food-environment in WEAP platform

Design & development of energy- climate- land use food/agriculture-environment model in LEAP platform

Supply side water modeling (Precipitation, resources, transfer, treatment and distribution modeling)

Water demand & food production modeling

Energy resources, renewables, land use & climate change supply side modeling

Energy, environment & food demand side modeling

Connecting Energy, Water, Environment, Food & Climate Models of the Nexus Tool Box

Design of the reference scenario, its modeling, deployment of integrated Model, Creating the needed output and correction of the reference scenario

Scenario cost-benefit Analysis & Development of improvement action plans, interventions & strategies

Scenario development for higher water & energy system Productivity, reduction of GHG emissions (both of adaption & mitigation aspects of CC) & other atmospheric pollutants while improving food production

Development of the parametric Nexus model, database, Input-output relations, generalization of the app for use in other regions & countries

Sensitivity Analysis for different key input data

Development of the nexus model & Analysis & Reporting results

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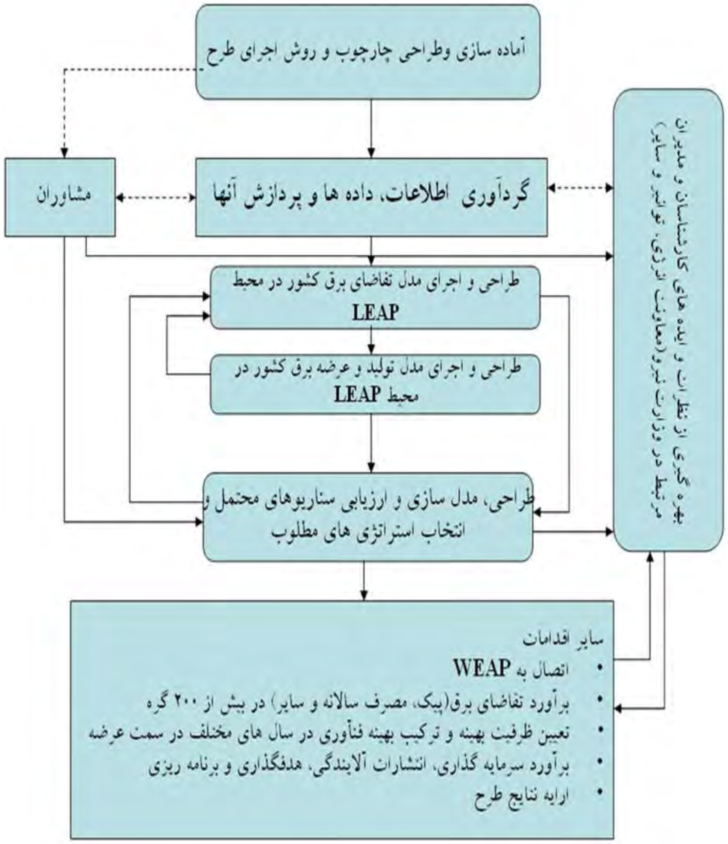
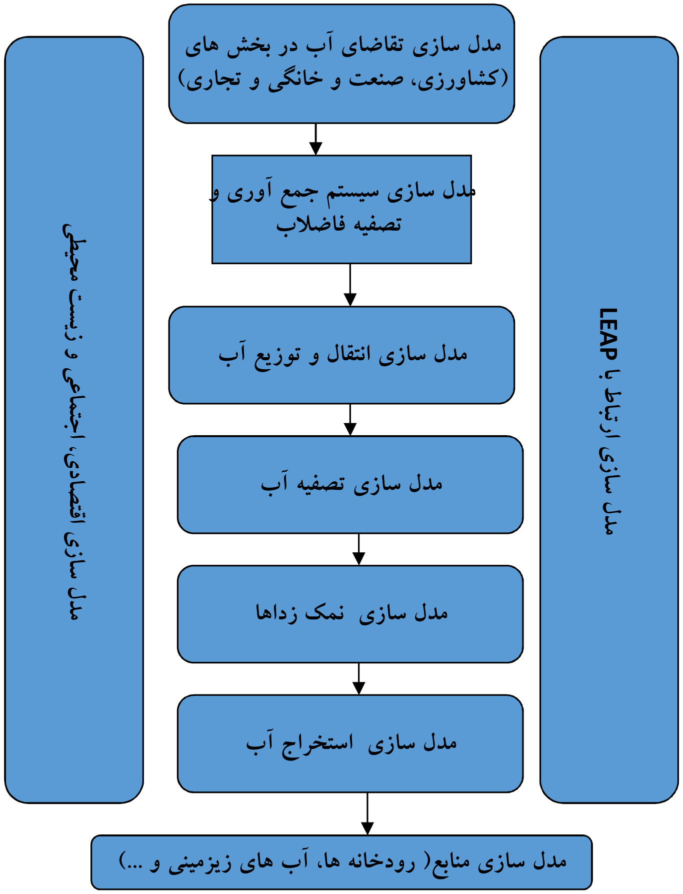
Water-Energy Interactions

Methodology of Modeling and Analysis





مدل سازی ارتباط با LEAP

مدل سازی تقاضای آب در بخش های (کشاورزی، صنعت و خانگی و تجاری)

مدل سازی سیستم جمع آوری و تصفیه فاضلاب

مدل سازی انتقال و توزیع آب

مدل سازی تصفیه آب

مدل سازی نمک زداها

مدل سازی استخراج آب

مدل سازی اقتصادی، اجتماعی و زیست محیطی

مدل سازی منابع(رودخانه ها، آب های زیرزمینی و ...)

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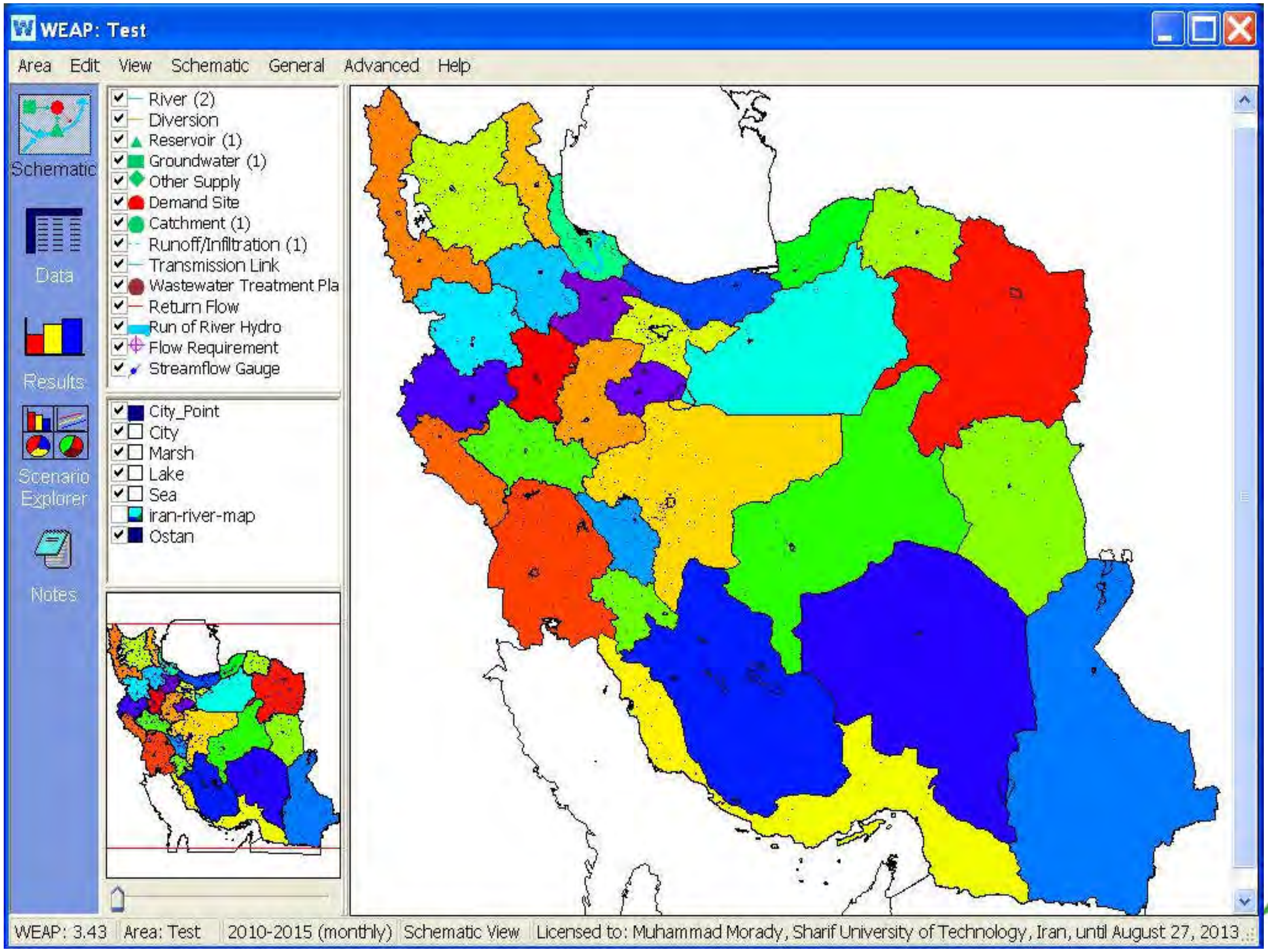
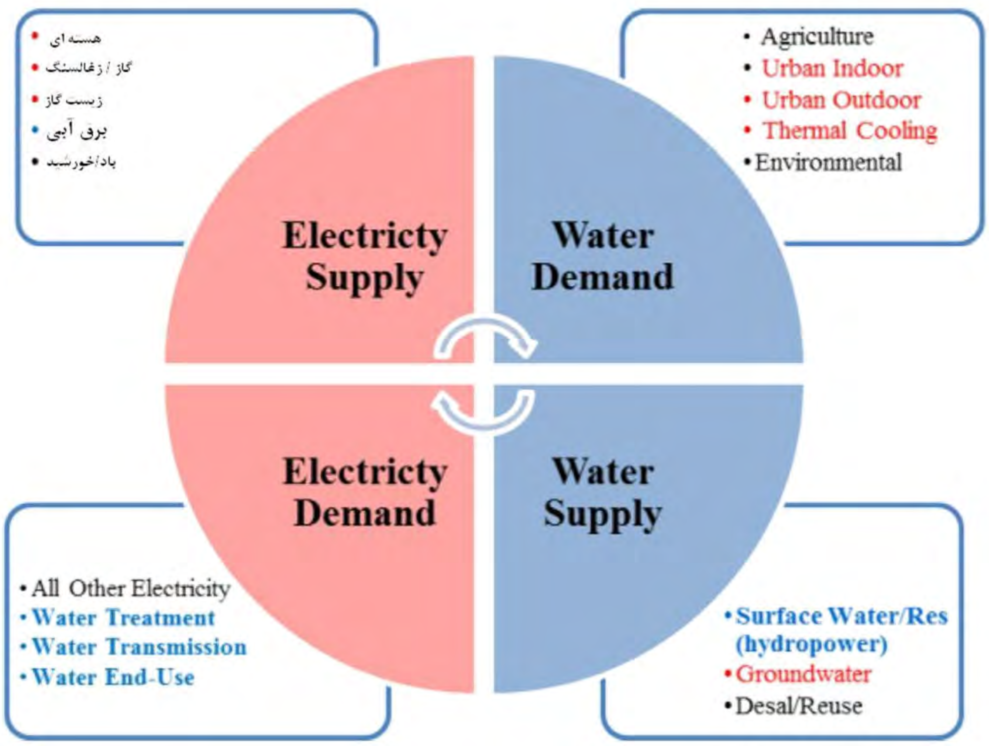


WEAP: Test

WEAP: 3.43 | Area: Test | 2010-2015 (monthly) | Schematic View | Licensed to: Muhammad Morady, Sharif University of Technology, Iran, until August 27, 2013

Interactions Between Water and Power Subsystems



- هسته ای
- گاز / زغالسنگ
- زیست گاز
- برق آبی
- باد/خورشید

Electricty Supply

- Agriculture
- Urban Indoor
- Urban Outdoor
- Thermal Cooling
- Environmental

Water Demand

Electricty Demand

- All Other Electricity
- **Water Treatment**
- **Water Transmission**
- **Water End-Use**

Water Supply

- **Surface Water/Res (hydropower)**
- Groundwater
- Desal/Reuse

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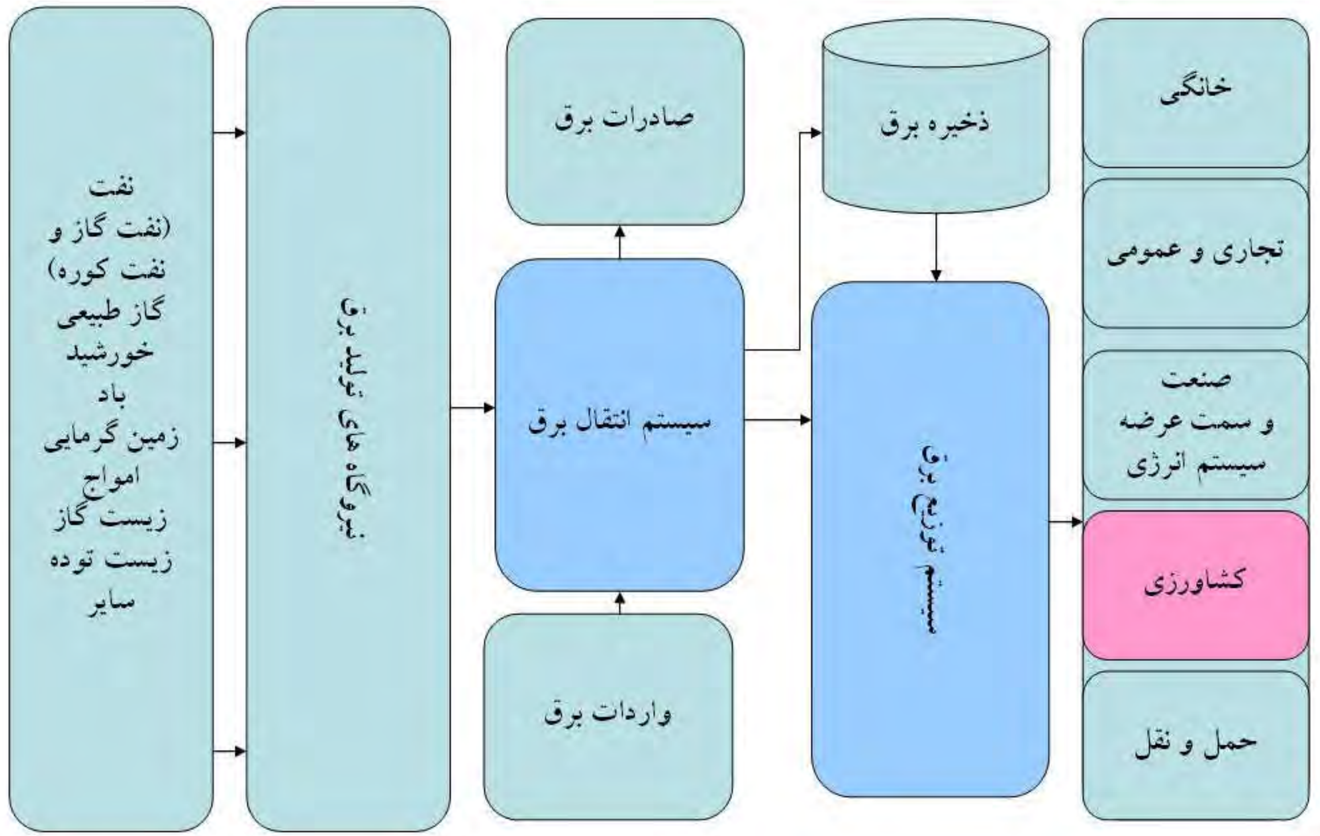
Reference Electricity Current System



نفت
(نفت گاز و
نفت کوره)
گاز طبیعی
خورشید
باد
زمین گرمایی
امواج
زیست گاز
زیست توده
سایر

نیروگاه های تولید برق

صادرات برق

سیستم انتقال برق

واردات برق

ذخیره برق

سیستم توزیع برق

خانگی

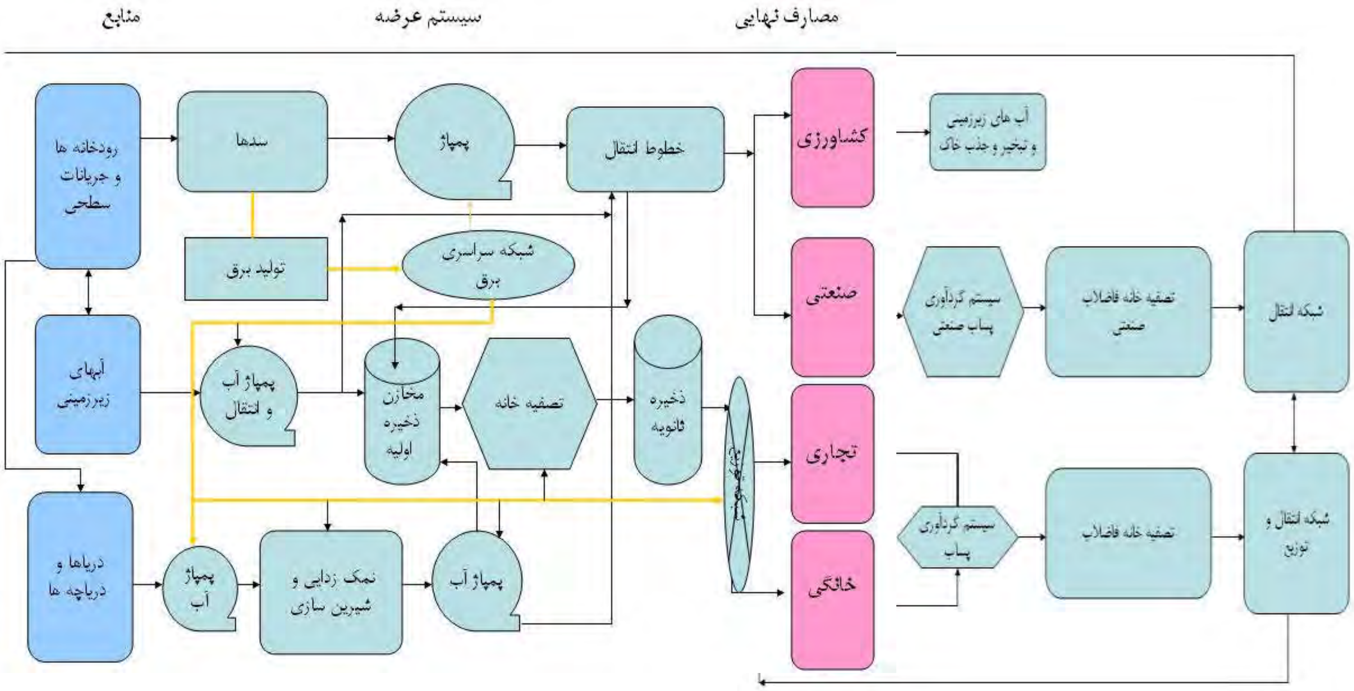
تجاری و عمومی

صنعت
و سمت عرضه
سیستم انرژی

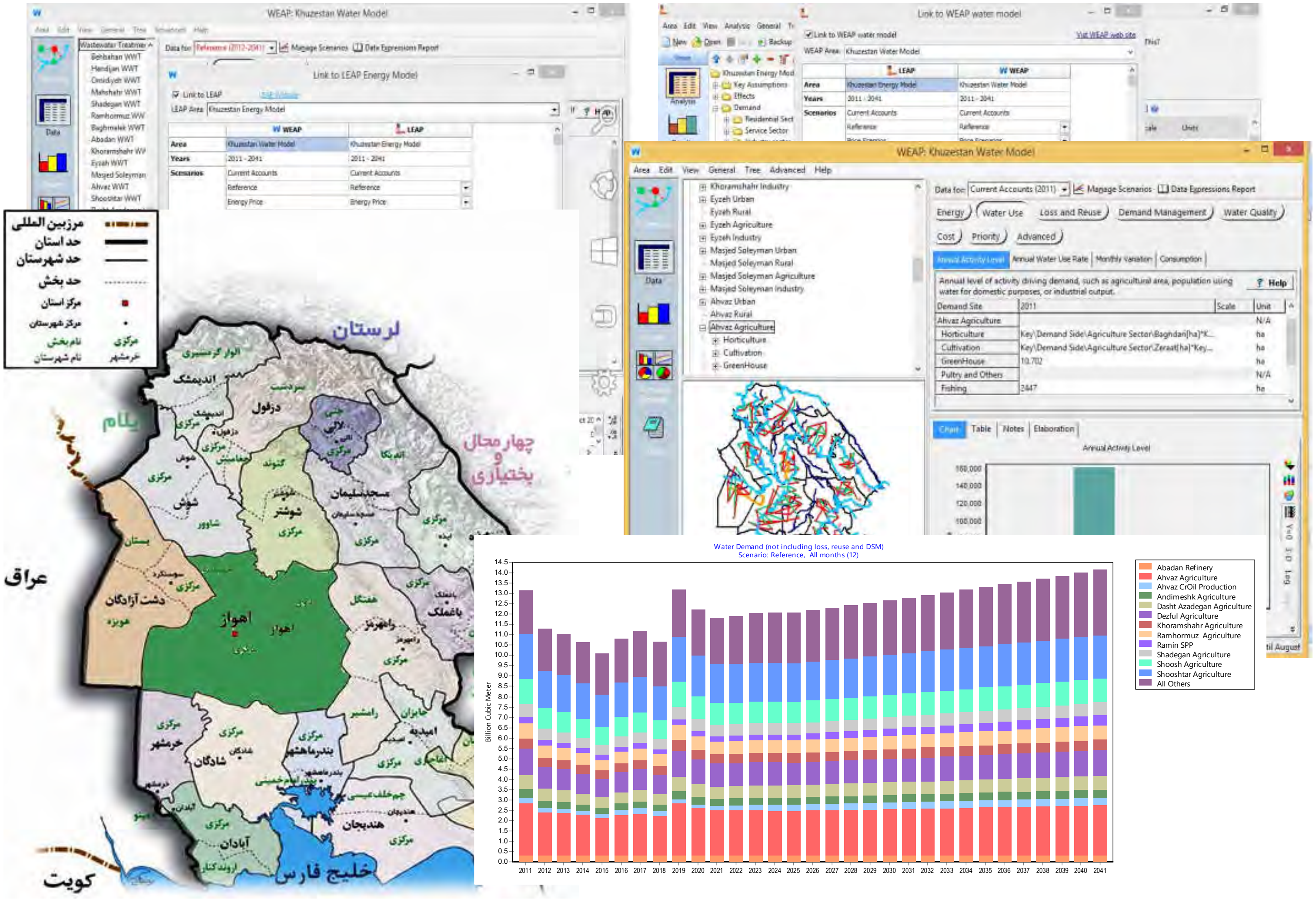
کشاورزی

حمل و نقل

Reference Water Flow System



Khuzestan WAE Nexus Model

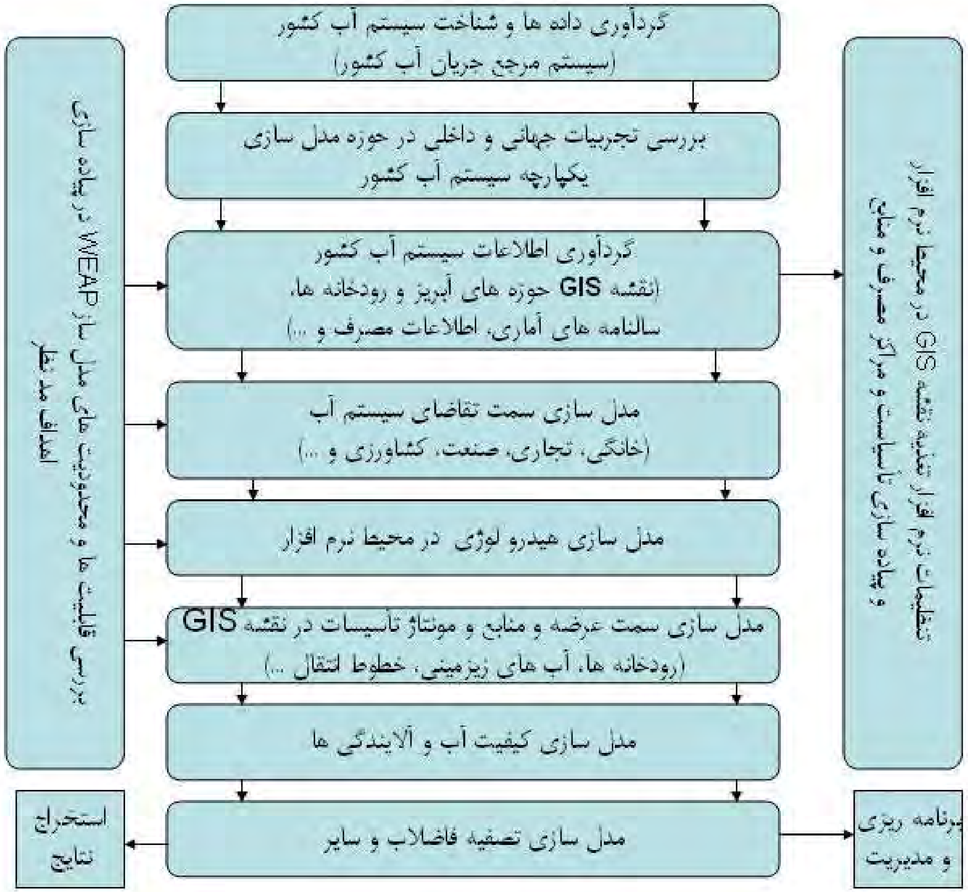


	LEAP	WEAP
Area	Khuzestan Energy Model	Khuzestan Water Model
Years	2011 - 2041	2011 - 2041
Scenarios	Current Accounts	Current Accounts
	Reference	Reference

Annual level of activity driving demand, such as agricultural area, population using water for domestic purposes, or industrial output.

Demand Site	2011	Scale	Unit
Ahvaz Agriculture			N/A
Horticulture	Key\Demand Side\Agriculture Sector\Baghdari[ha]*K...		ha
Cultivation	Key\Demand Side\Agriculture Sector\Zeraat[ha]*Key...		ha
GreenHouse	10,702		ha
Pultry and Others			N/A
Fishing	2447		ha

Different Stages in National Water System Modeling Using WEAP



گردآوری داده ها و شناخت سیستم آب کشور
(سیستم مرجع جریان آب کشور)

بررسی تجربیات جهانی و داخلی در حوزه مدل سازی
یکپارچه سیستم آب کشور

گردآوری اطلاعات سیستم آب کشور
(نقشه GIS حوزه های آبریز و رودخانه ها،
سالنامه های آماری، اطلاعات مصرف و ...)

مدل سازی سمت تقاضای سیستم آب
(خانگی، تجاری، صنعت، کشاورزی و ...)

مدل سازی هیدرو لوژی در محیط نرم افزار

مدل سازی سمت عرضه و منابع و مونتاژ تأسیسات در نقشه GIS
(رودخانه ها، آب های زیرزمینی، خطوط انتقال ...)

مدل سازی کیفیت آب و آلایندگی ها

مدل سازی تصفیه فاضلاب و سایر

بررسی قابلیت ها و محدودیت های مدل ساز WEAP در پیاده سازی
اهداف مد نظر

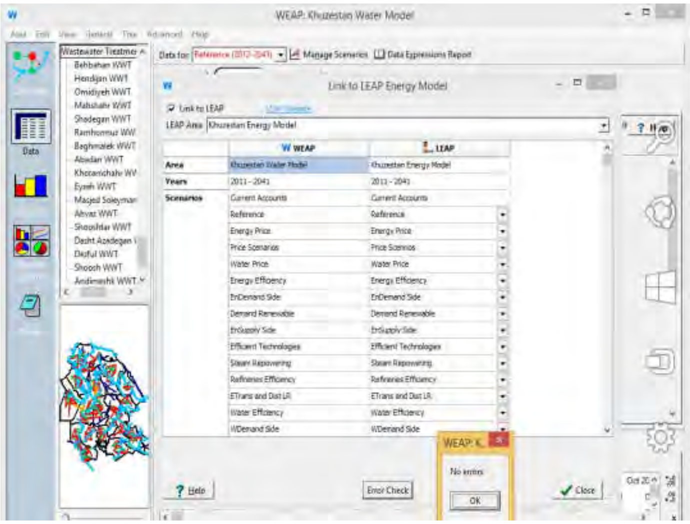
تنظیمات نرم افزار تغذیه نقشه GIS در محیط نرم افزار
و پیاده سازی تأسیسات و مراکز مصرف و منابع

استخراج
نتایج

برنامه ریزی
و مدیریت

Adjusting and Linking Water-Environment-Energy Models

Water System Model (WEAP)



WEAP: Khuzestan Water Model

Link to LEAP Energy Model

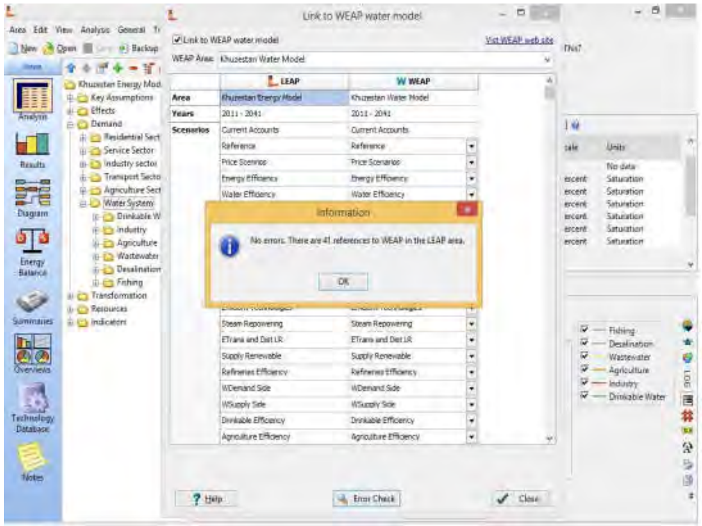
☑ Link to LEAP

LEAP Area: Khuzestan Energy Model

	WEAP	LEAP
Area	Khuzestan Water Model	Khuzestan Energy Model
Years	2011 - 2041	2011 - 2041
Scenarios	Current Accounts	Current Accounts
	Reference	Reference
	Energy Price	Energy Price
	Price Scenarios	Price Scenrios
	Water Price	Water Price
	Energy Efficiency	Energy Efficiency
	EnDemand Side	EnDemand Side
	Demand Renewable	Demand Renewable
	EnSupply Side	EnSupply Side
	Efficient Technologies	Efficient Technologies
	Steam Repowering	Steam Repowering
	Refineries Efficiency	Refineries Efficiency
	ETrans and Dist LR	ETrans and Dist LR
	Water Efficiency	Water Efficiency
	WDemand Side	WDemand Side

No errors

Energy System Model (LEAP)



Link to WEAP water model

☑ Link to WEAP water model

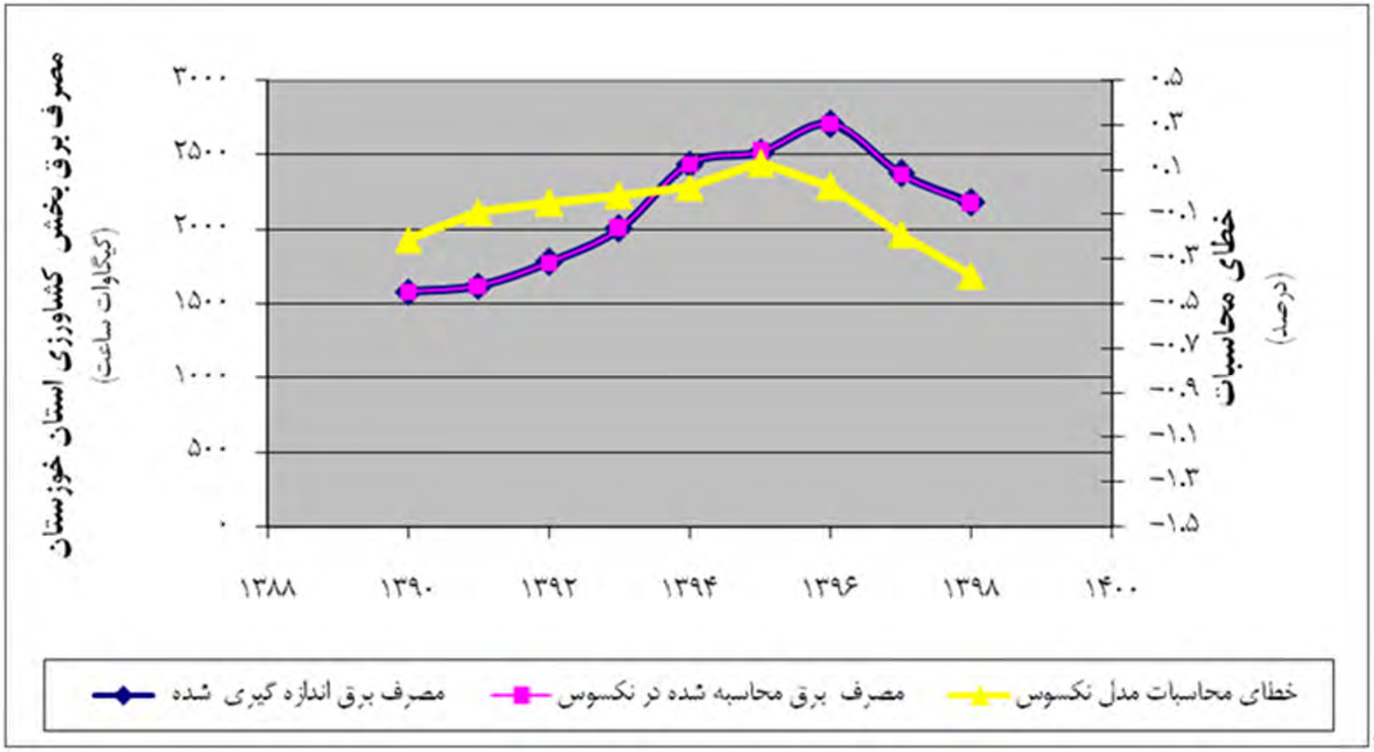
WEAP Area: Khuzestan Water Model

	LEAP	WEAP
Area	Khuzestan Energy Model	Khuzestan Water Model
Years	2011 - 2041	2011 - 2041
Scenarios	Current Accounts	Current Accounts
	Reference	Reference
	Price Scenarios	Price Scenarios
	Energy Efficiency	Energy Efficiency
	Water Efficiency	Water Efficiency
	Steam Repowering	Steam Repowering
	ETrans and Dist LR	ETrans and Dist LR
	Supply Renewable	Supply Renewable
	Refineries Efficiency	Refineries Efficiency
	WDemand Side	WDemand Side
	WSupply Side	WSupply Side
	Drinkable Efficiency	Drinkable Efficiency
	Agriculture Efficiency	Agriculture Efficiency

Information

No errors. There are 41 references to WEAP in the LEAP area.

Verifying the Nexus Model, through error Calculations between Measured and Estimated Values (Great Results: Errors -0.5% to +0.3%)



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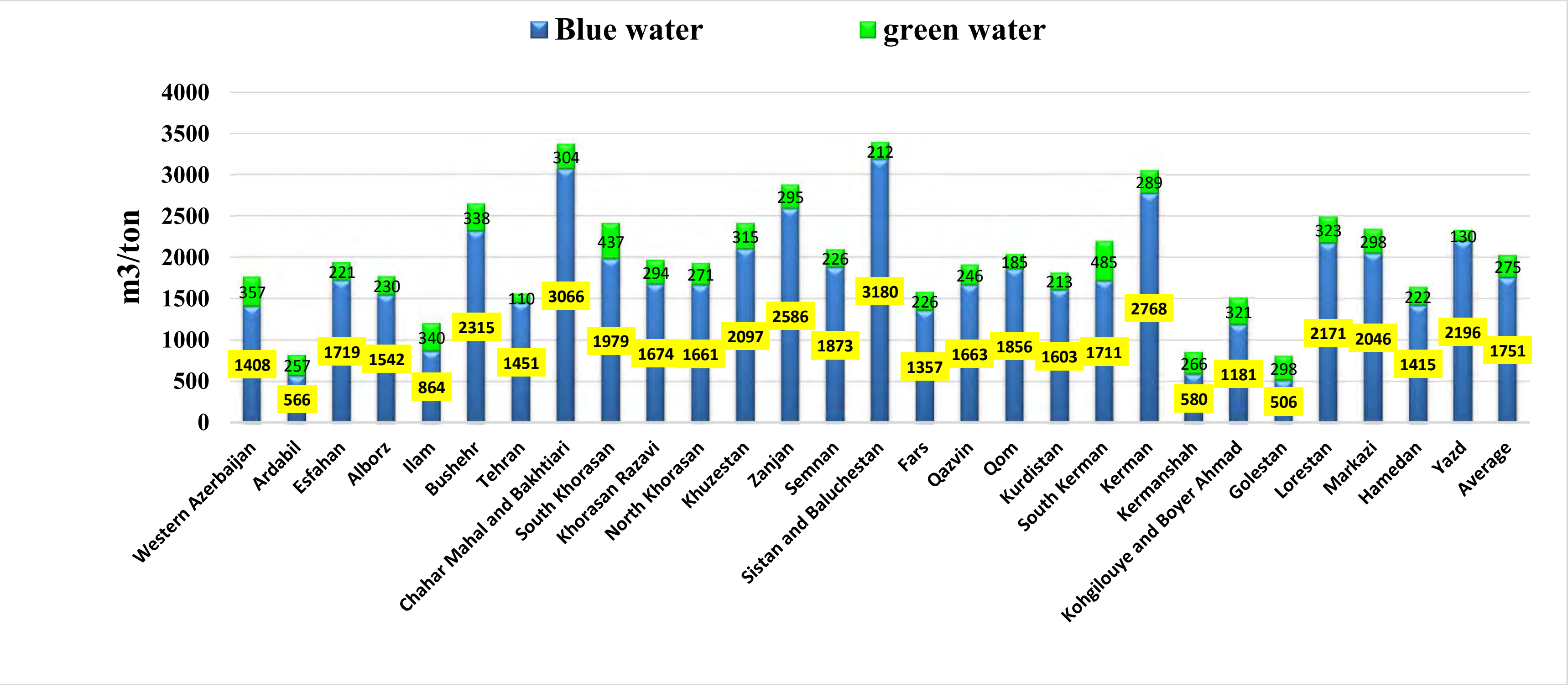
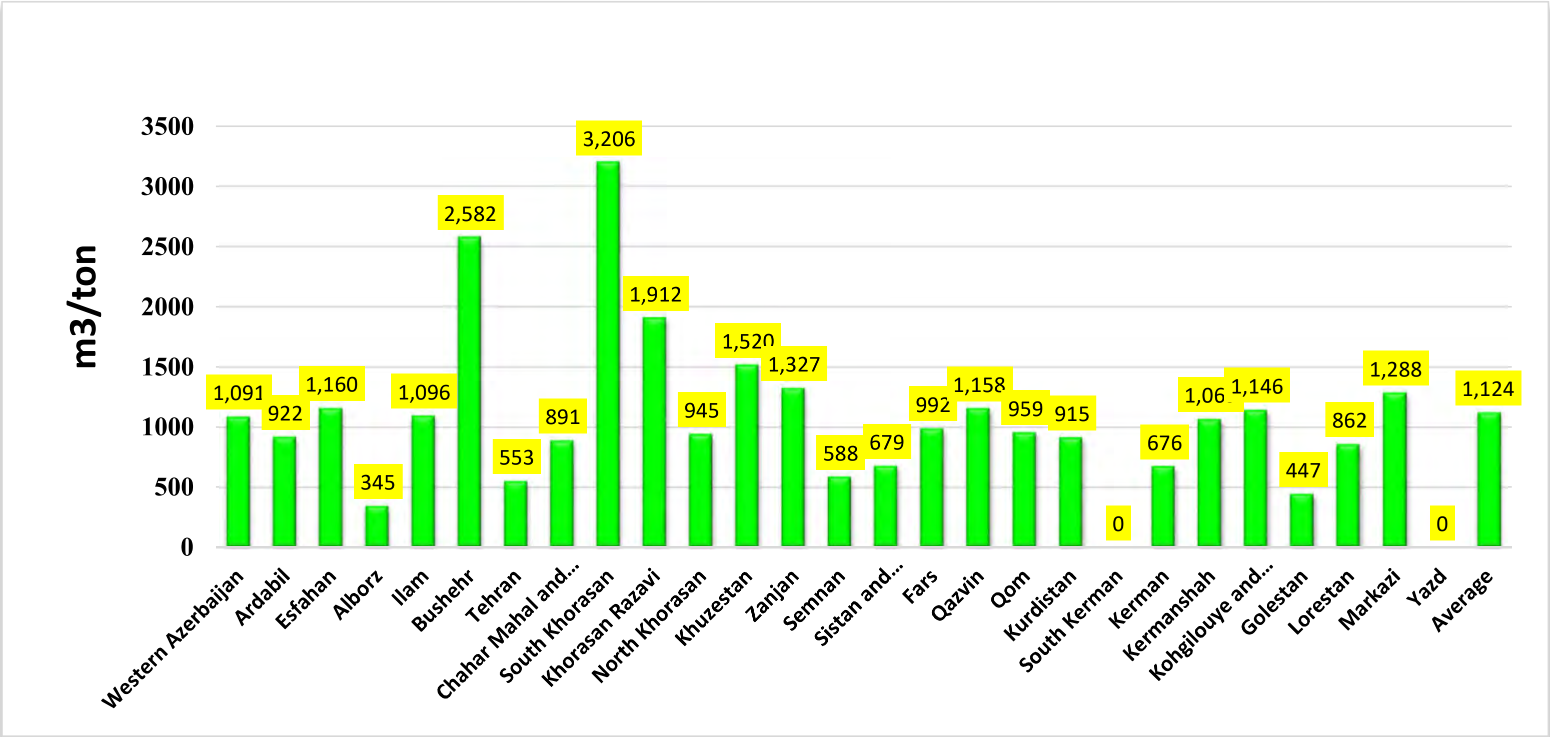
Blue Water, Green Water, Grey Water Energy, Land use, Crop Productivity and Virtual Water Trade Optimization

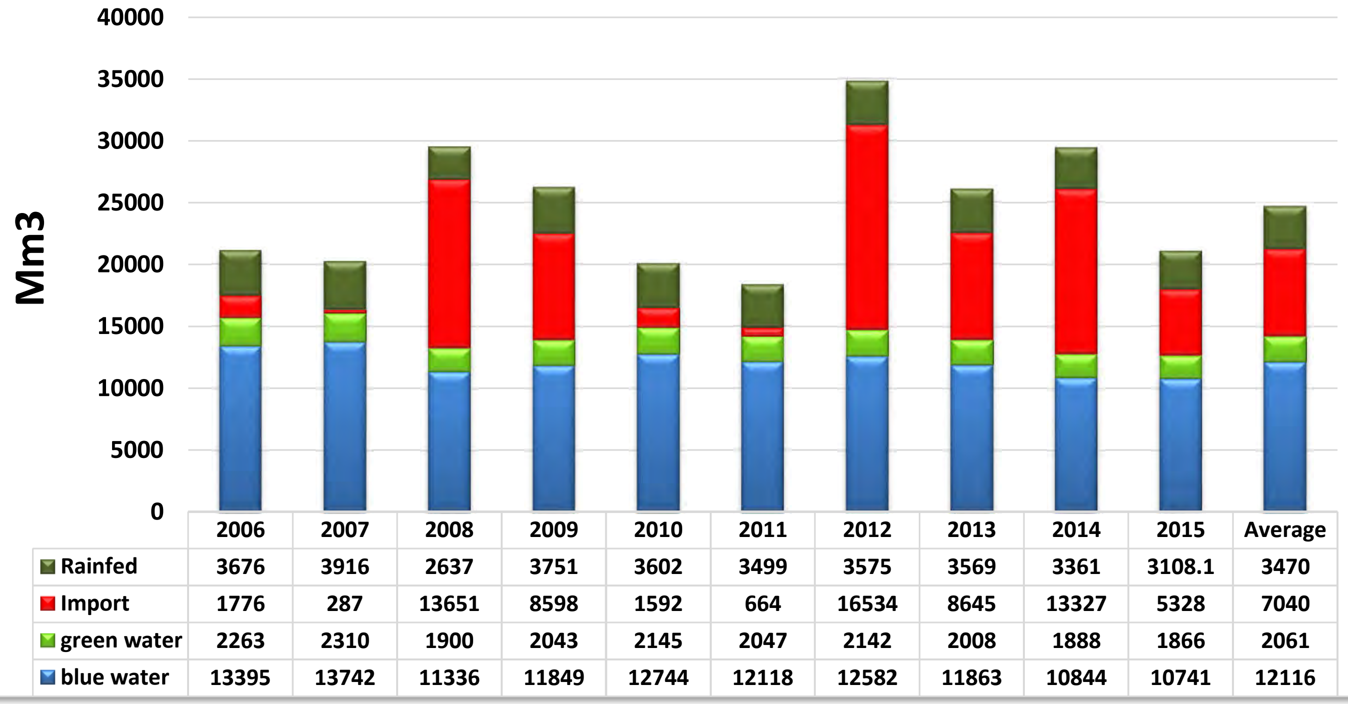
Wheat Virtual Water based on the applied water



Rainfed wheat Virtual Water



Wheat Virtual-Water “Flows” for 2006-2015



	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Average
▨ Rainfed	3676	3916	2637	3751	3602	3499	3575	3569	3361	3108.1	3470
🟥 Import	1776	287	13651	8598	1592	664	16534	8645	13327	5328	7040
🟩 green water	2263	2310	1900	2043	2145	2047	2142	2008	1888	1866	2061
🟦 blue water	13395	13742	11336	11849	12744	12118	12582	11863	10844	10741	12116

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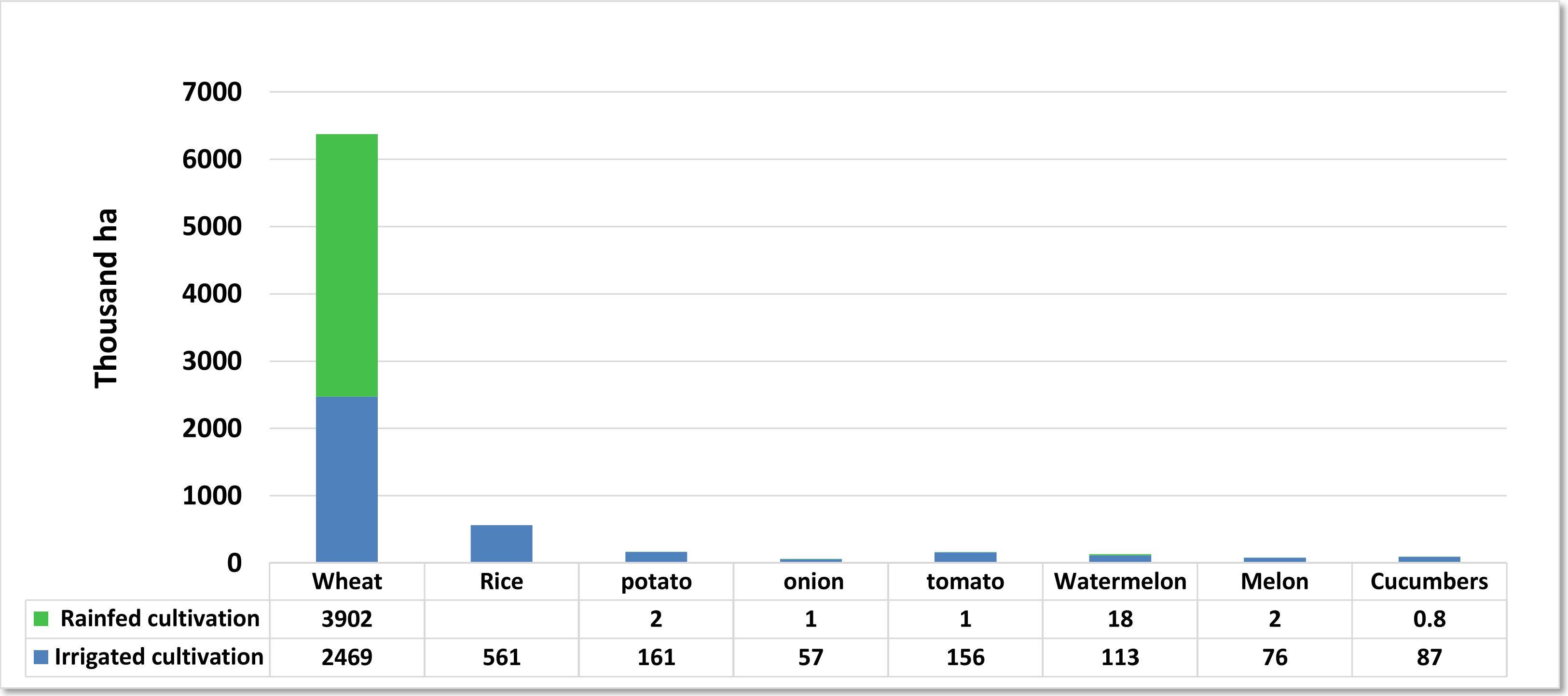
The average level of crops cultivation for 2006-2015



	Wheat	Rice	potato	onion	tomato	Watermelon	Melon	Cucumbers
🟩 Rainfed cultivation	3902		2	1	1	18	2	0.8
🟦 Irrigated cultivation	2469	561	161	57	156	113	76	87

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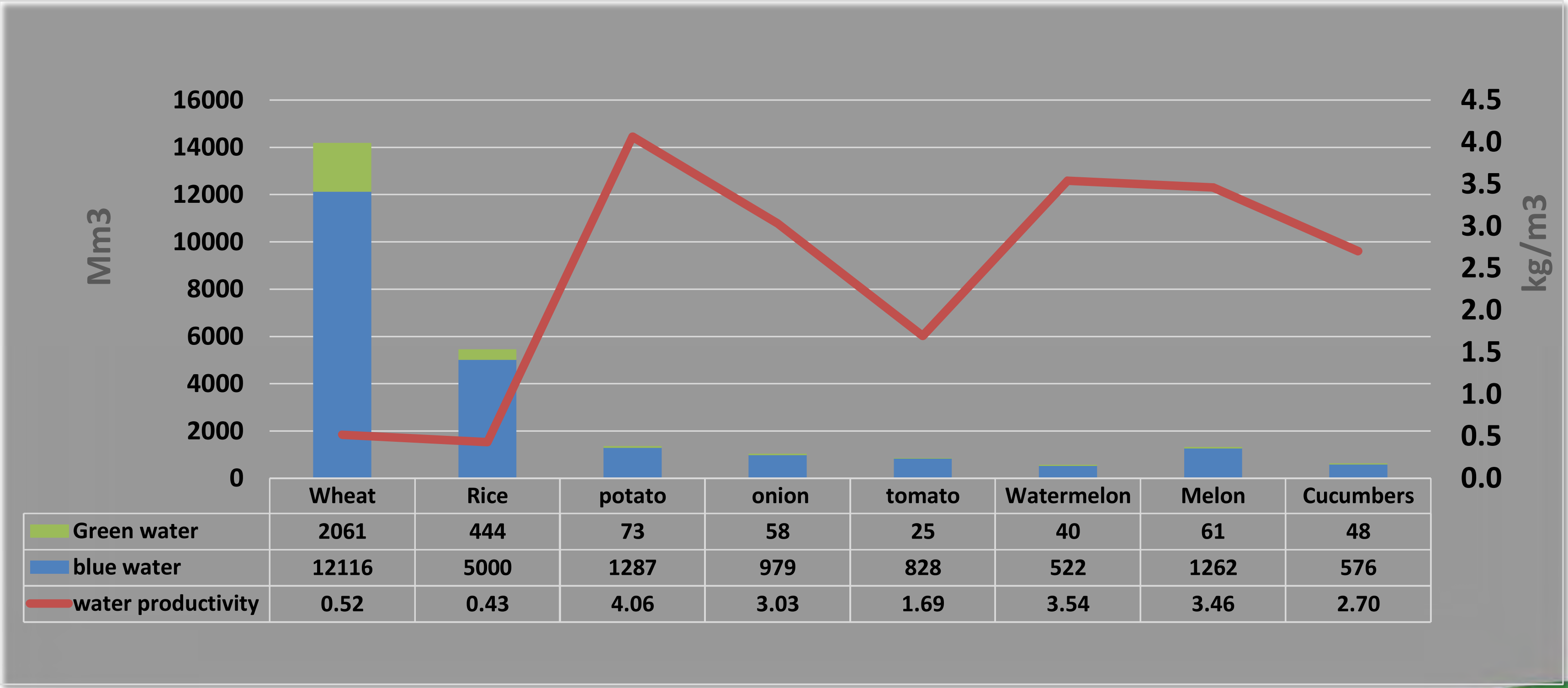
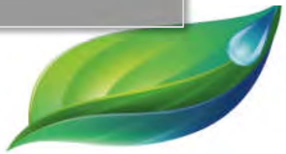
Crops water use and water productivity



	Wheat	Rice	potato	onion	tomato	Watermelon	Melon	Cucumbers
🟩 Green water	2061	444	73	58	25	40	61	48
🟦 blue water	12116	5000	1287	979	828	522	1262	576
— water productivity	0.52	0.43	4.06	3.03	1.69	3.54	3.46	2.70



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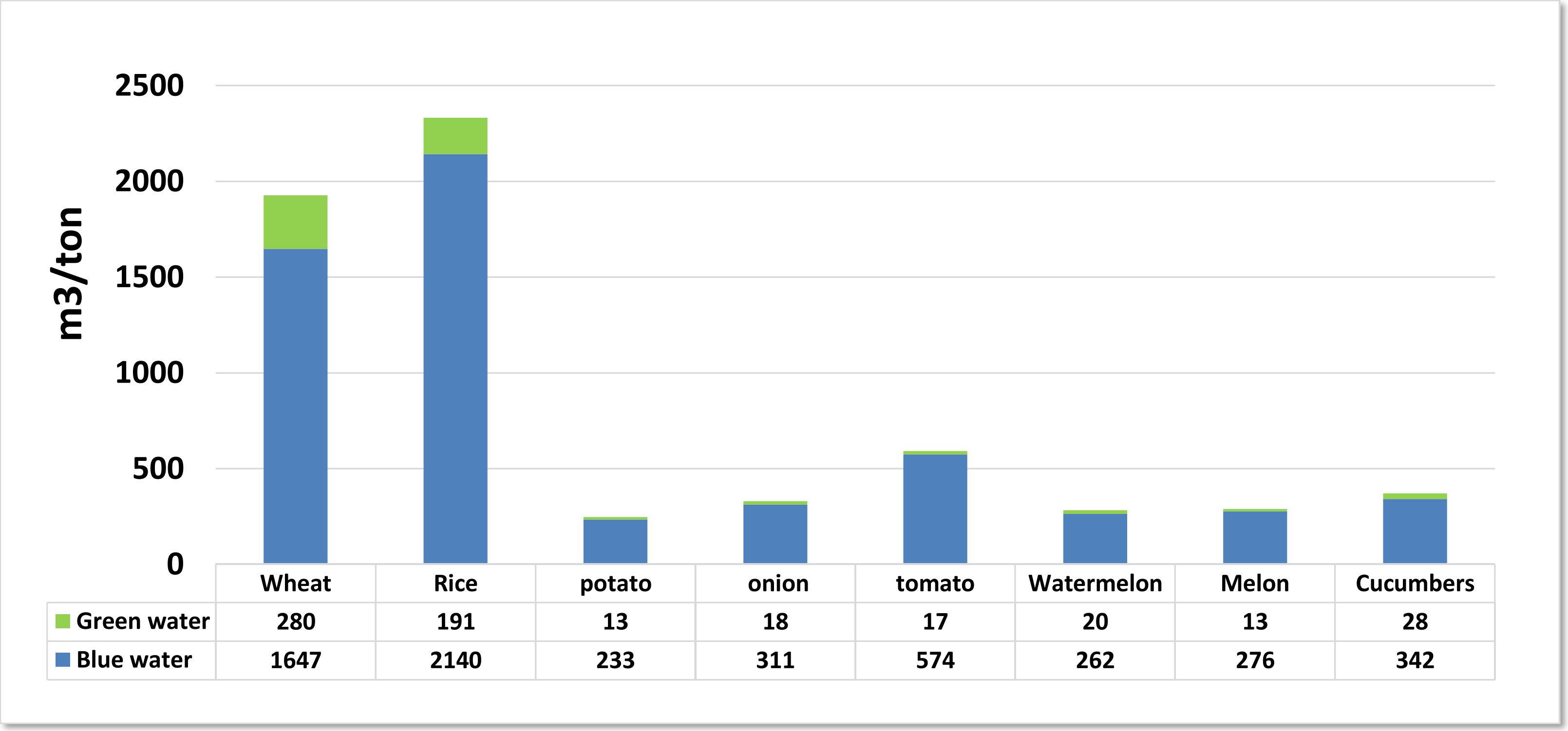
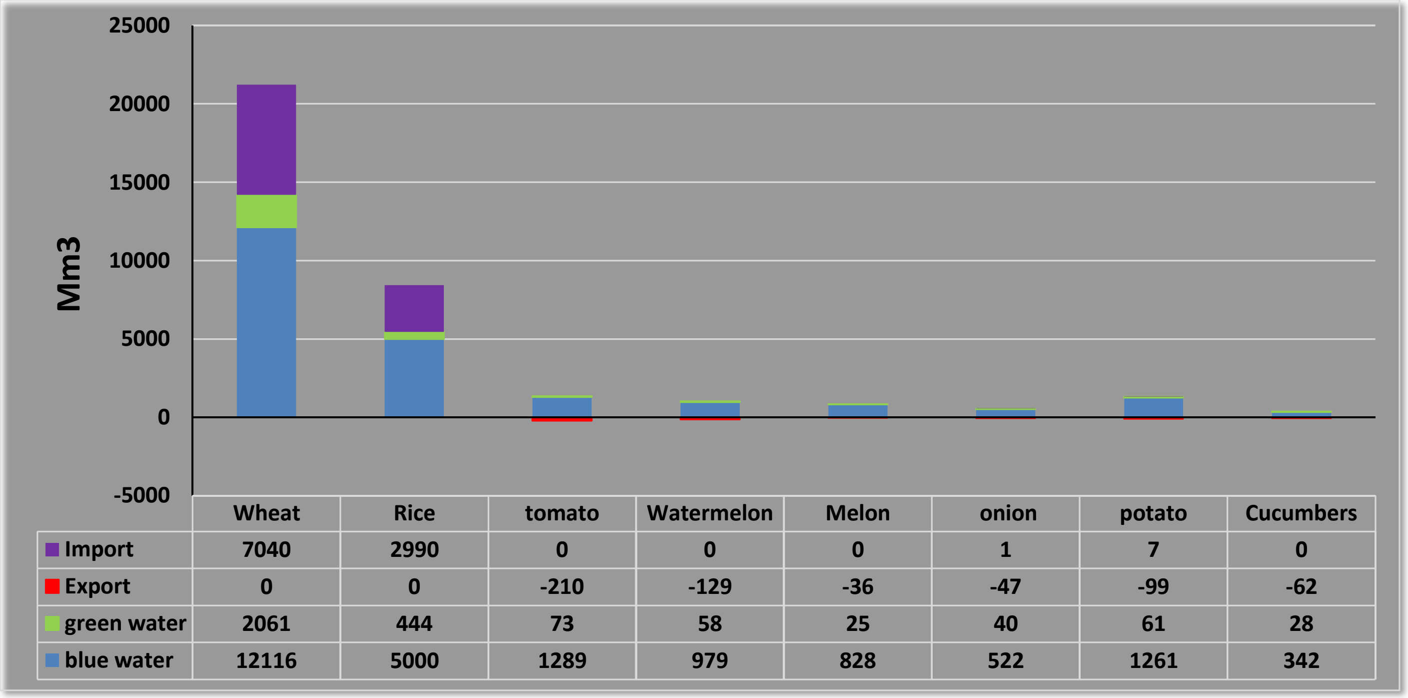
Crops virtual water



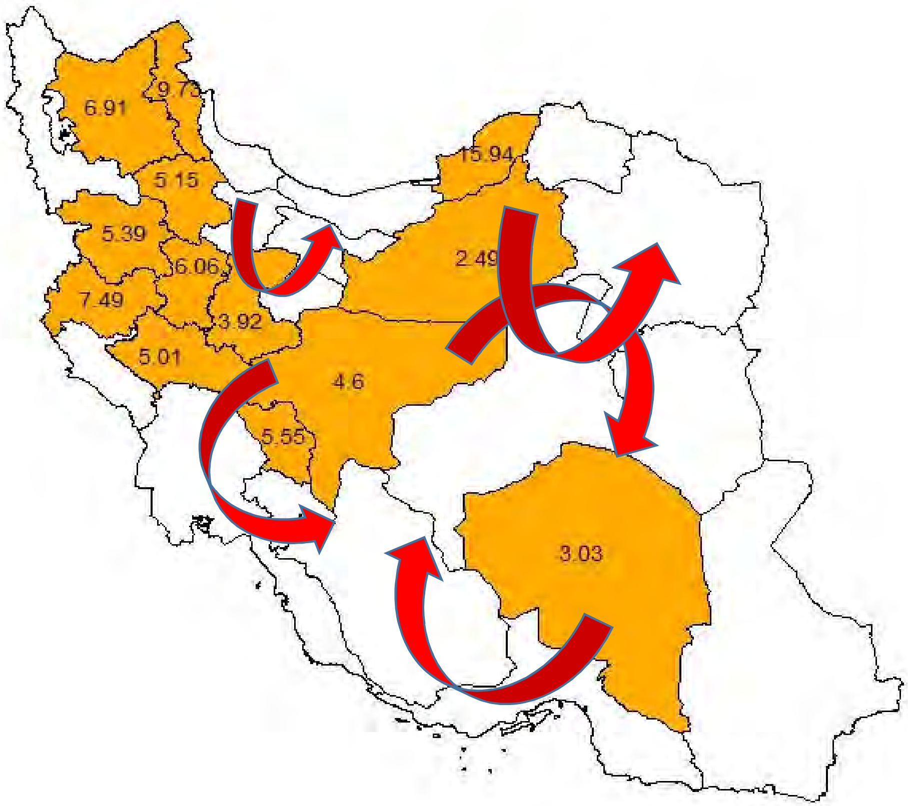
	Wheat	Rice	potato	onion	tomato	Watermelon	Melon	Cucumbers
🟩 Green water	280	191	13	18	17	20	13	28
🟦 Blue water	1647	2140	233	311	574	262	276	342

Crops Virtual-Water "Flows" for 2006-2015



	Wheat	Rice	tomato	Watermelon	Melon	onion	potato	Cucumbers
🟪 Import	7040	2990	0	0	0	1	7	0
🟥 Export	0	0	-210	-129	-36	-47	-99	-62
🟩 green water	2061	444	73	58	25	40	61	28
🟦 blue water	12116	5000	1289	979	828	522	1261	342

Potato Virtual-Water “Trade” within the country



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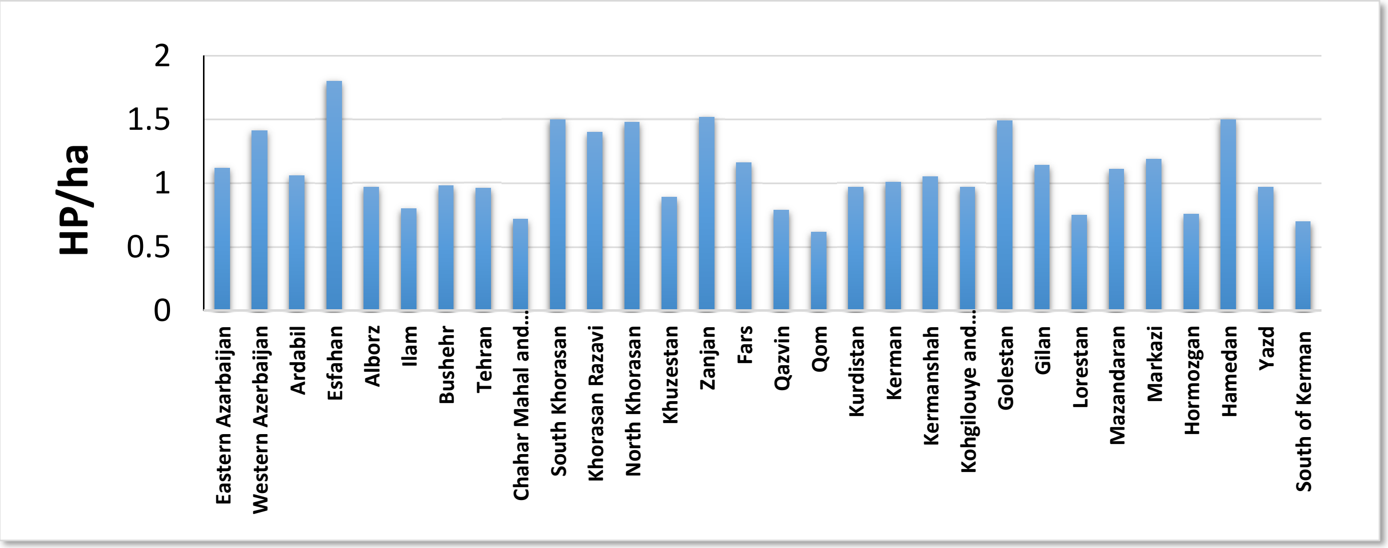
Energy Use, Technology Application



NEXUS
NEXUS & HSE CENTER

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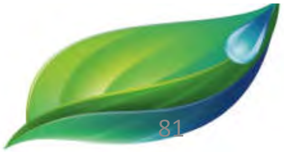
Sustainable Soil Management Practices

In Soil & Water Conservation Center, University of Tehran

Manouchehr Gorji, Prof. of Soil Science

President, Soil Science Society of Iran(SSSI)



Conventional tillage (Moldboard plow)

(High disturbance and horizontal displacement of soil)

Conventional dry land farming

(Runoff and Soil Erosion)

Conservation Agriculture Systems

Three principles and some complementary aspects:

1. Minimizing the soil disturbance (No-till, Min. till, …..),

- Reducing the operation time and costs, improvement of soil quality.

2. Management of Crop residue,

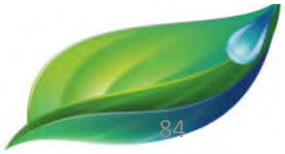
- Increasing SOC, Improving plant nutrition, Enhancing soil microbial activities, thermal adjustment.

3. Applying of appropriate crop rotation,

- Soil quality improvement and pests & weeds control,

Other practices,

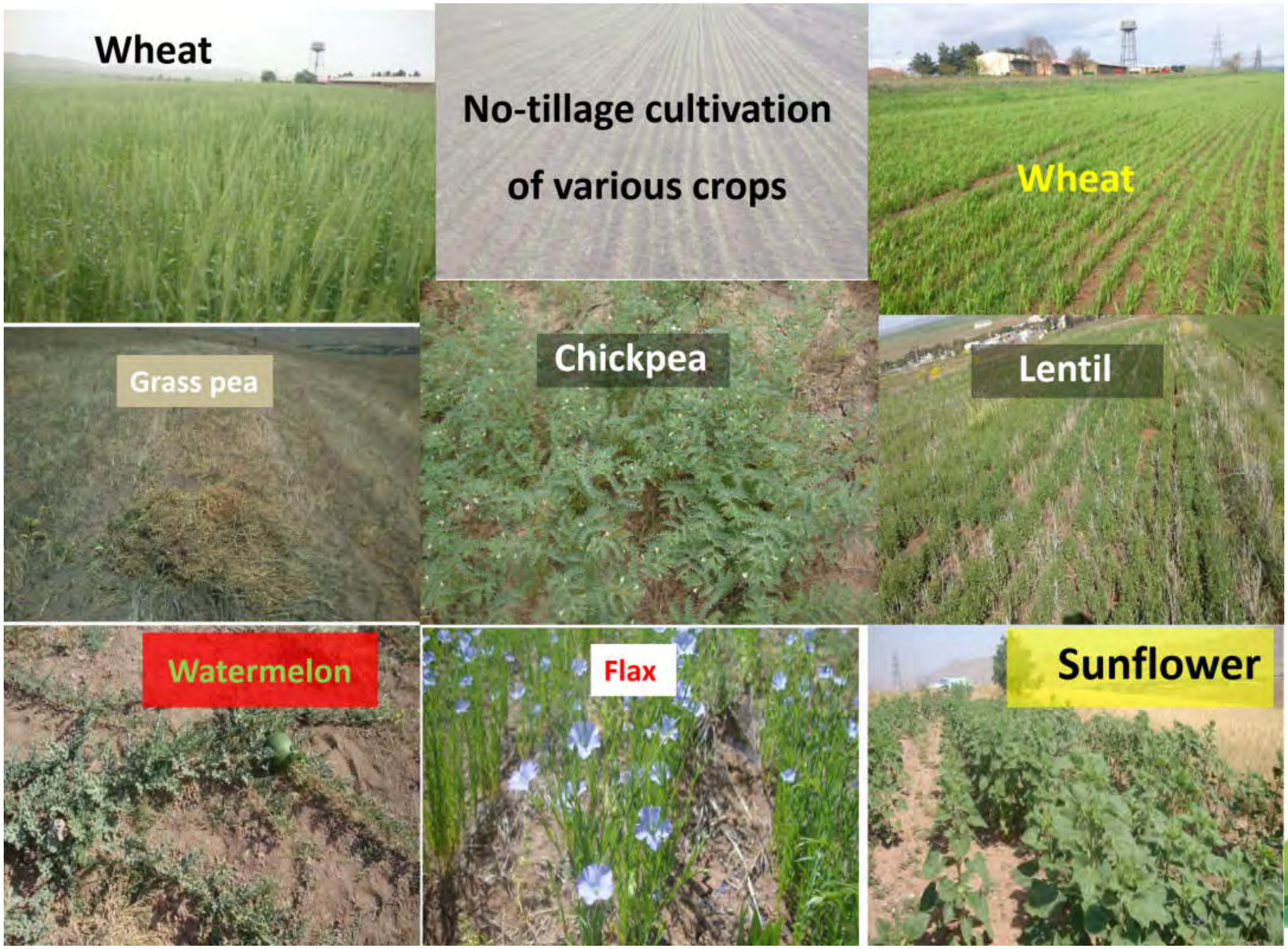
- Mixed cropping, improved seeds, Manure & fertilizers, and other useful crop management measures.



Conservation tillage

Retention of at least 30% crop residue on soil surface

No Tillage planter



No-tillage cultivation of various crops

Effects of pilot project on Soil Quality Improvement

- **Increasing the SOC content:**

(Improved soil quality, Carbon sequestration, and reduction of Greenhouse gases).

- **Improvement of soil phosphorus and potassium,**

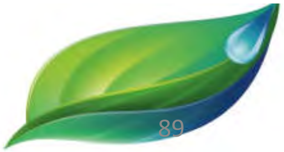
(Enhanced soil fertility, and reduced fertilizer use).

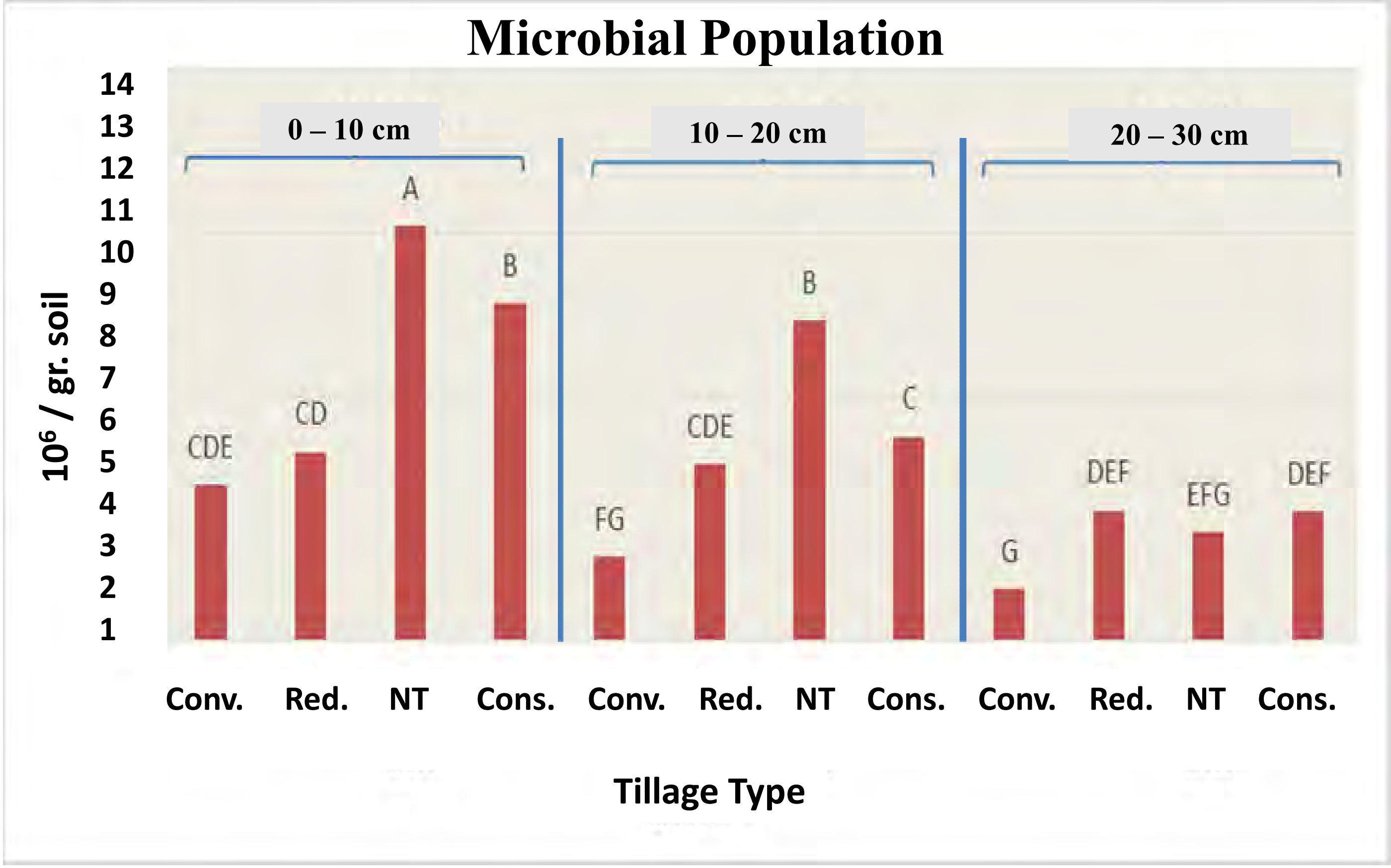
- **Modification of soil physical properties**

(Hardpans removal, reducing of soil surface cracks, increased soil aggregate stability and infiltration rate, improving the soil porosity status and water holding capacity).

Effects of pilot project on Soil Quality Improvement (Continued)

- Reduction of runoff and elimination of soil erosion,
- Prevention of soil moisture loss, and increasing the rain water productivity.
- Adjustment of soil temperature in summer and winter, and providing suitable conditions for seed germination and plant growth.
- Enhancing the biological activities, and increasing nitrogen fixation by 100 percent.




Microbial Population
0 – 10 cm
10 – 20 cm
20 – 30 cm
10^6 / gr. soil
14
13
12
11
10
9
8
7
6
5
4
3
2
1
CDE
CD
A
B
FG
CDE
B
C
G
DEF
EFG
DEF
Conv.
Red.
NT
Cons.
Conv.
Red.
NT
Cons.
Conv.
Red.
NT
Cons.
Tillage Type

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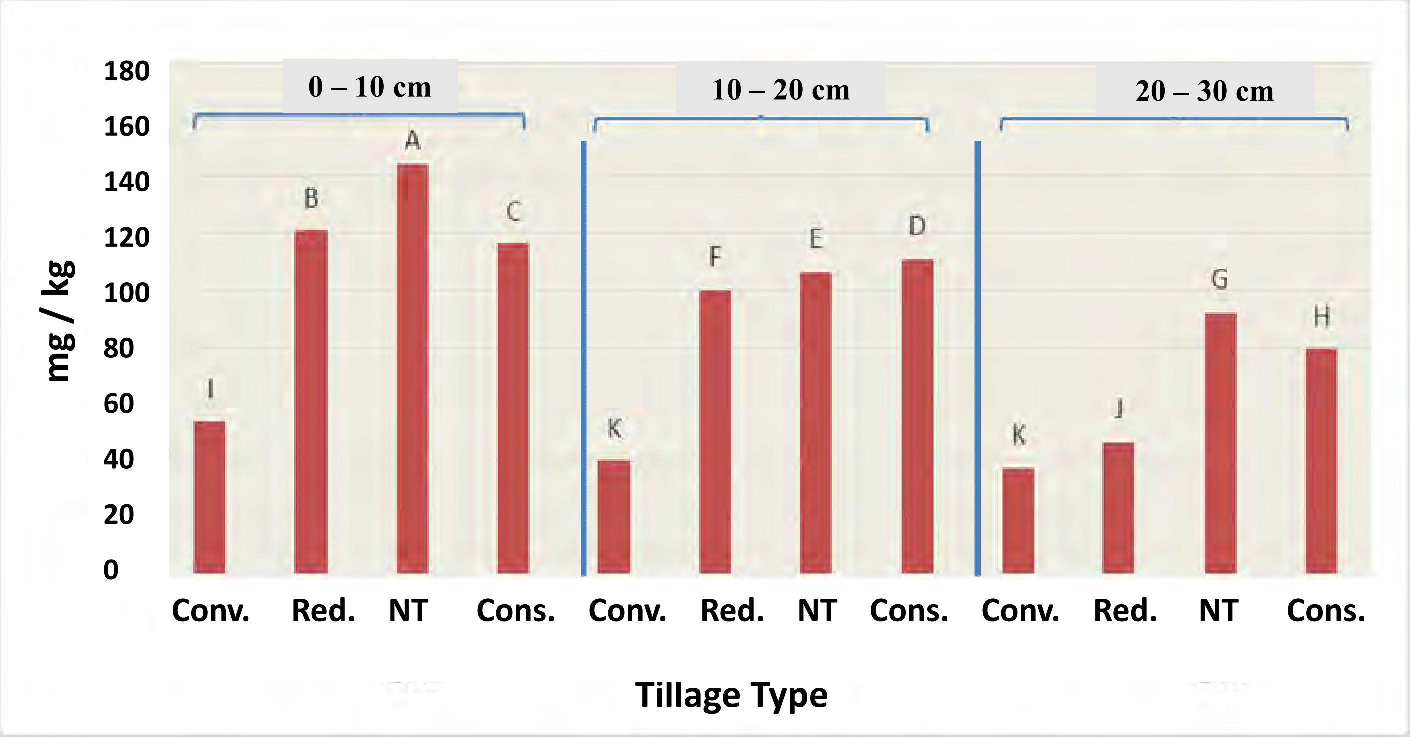
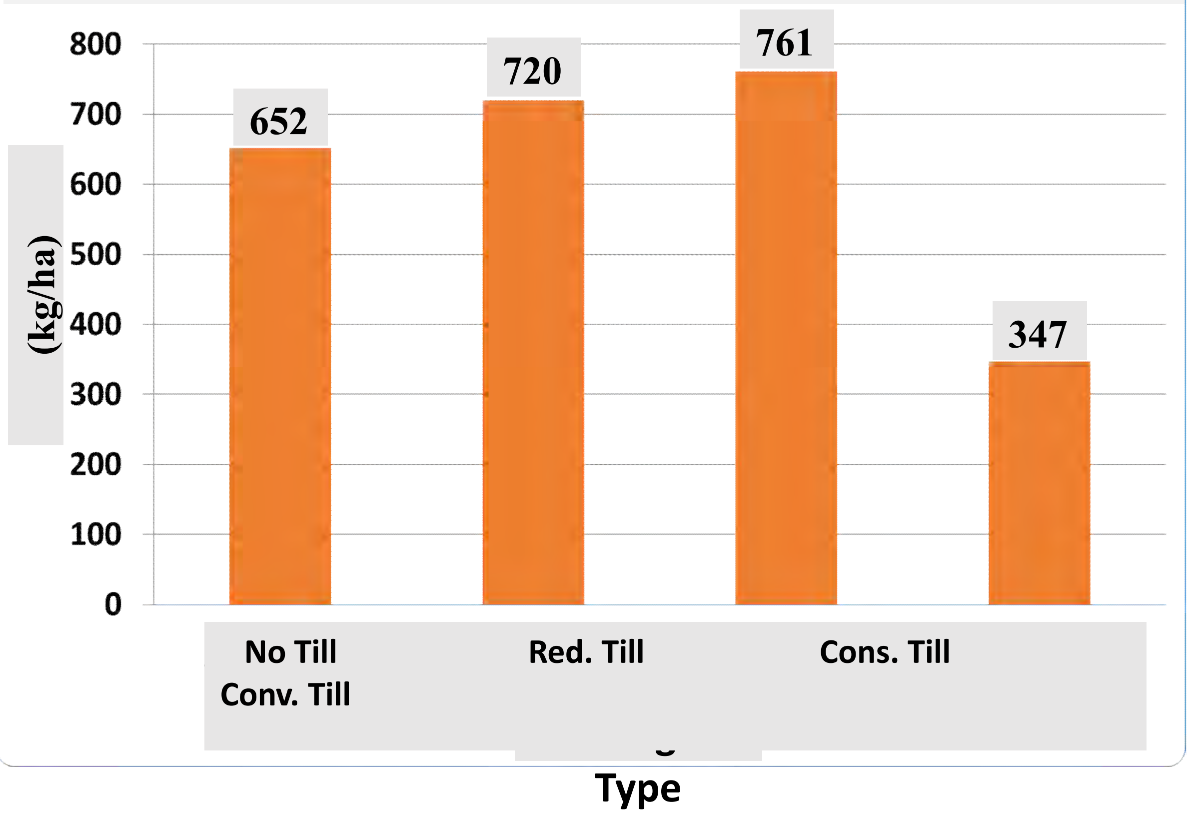
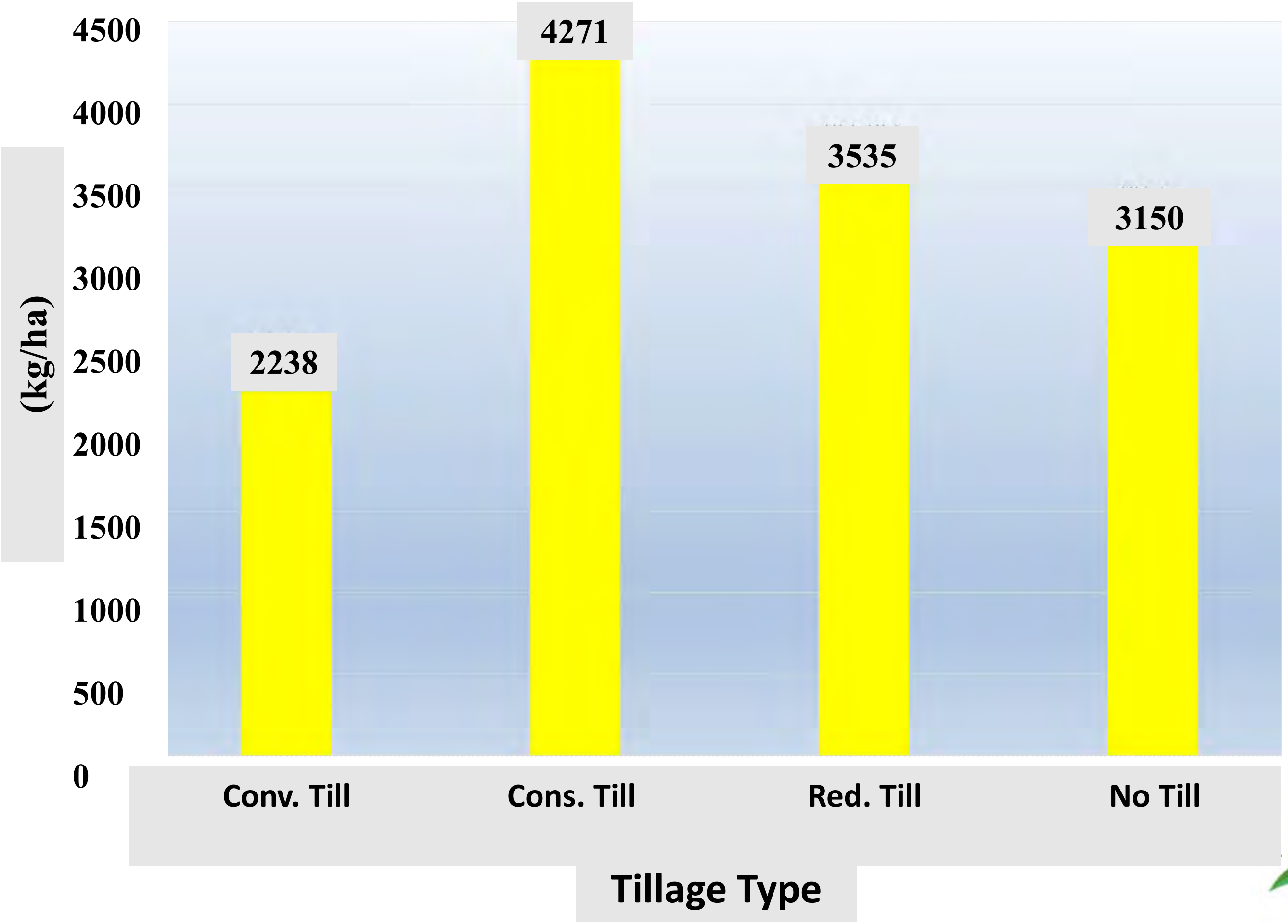
Microbial Biomass Carbon



Comparison of wheat yield in different tillage systems



Total Dry Matter of Wheat (TDM)



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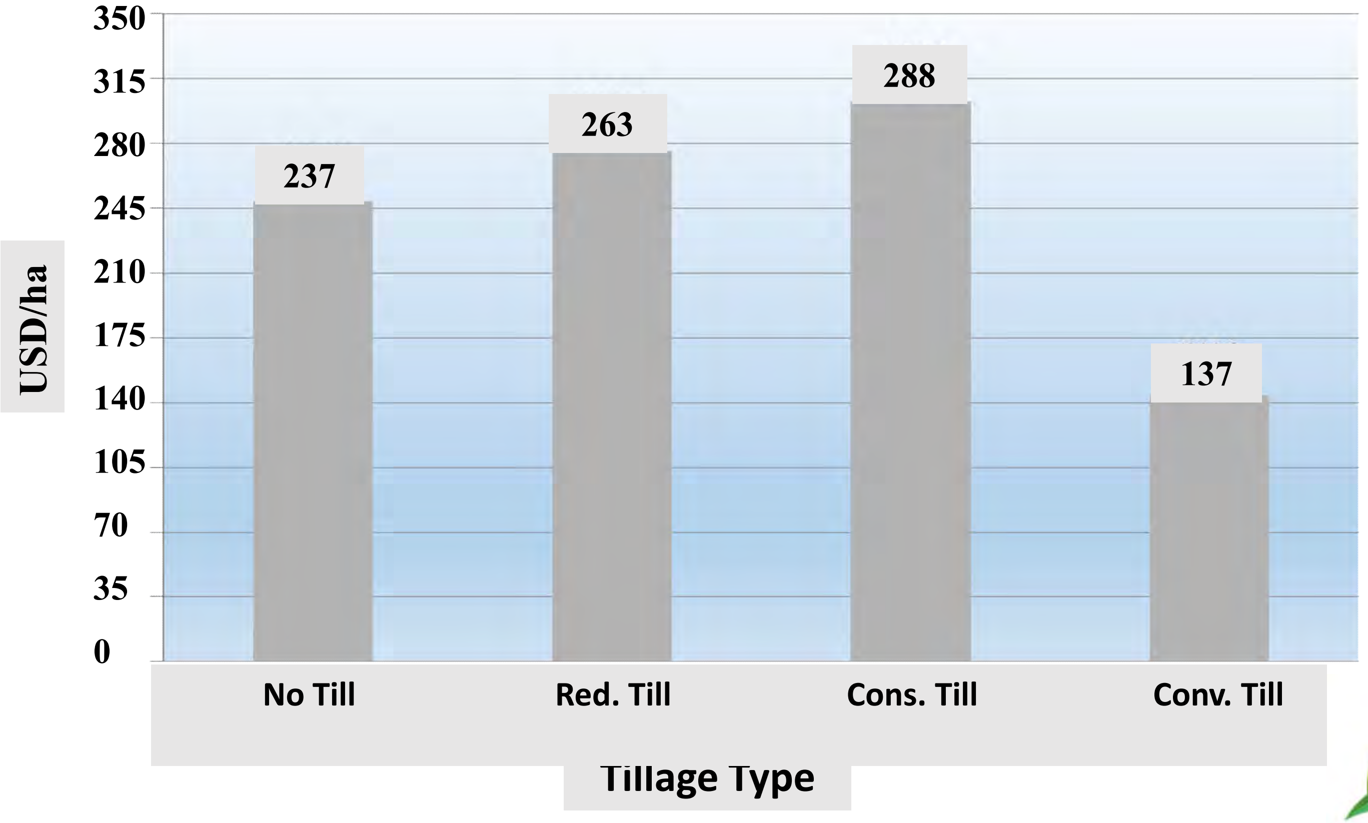
Gross income of wheat production



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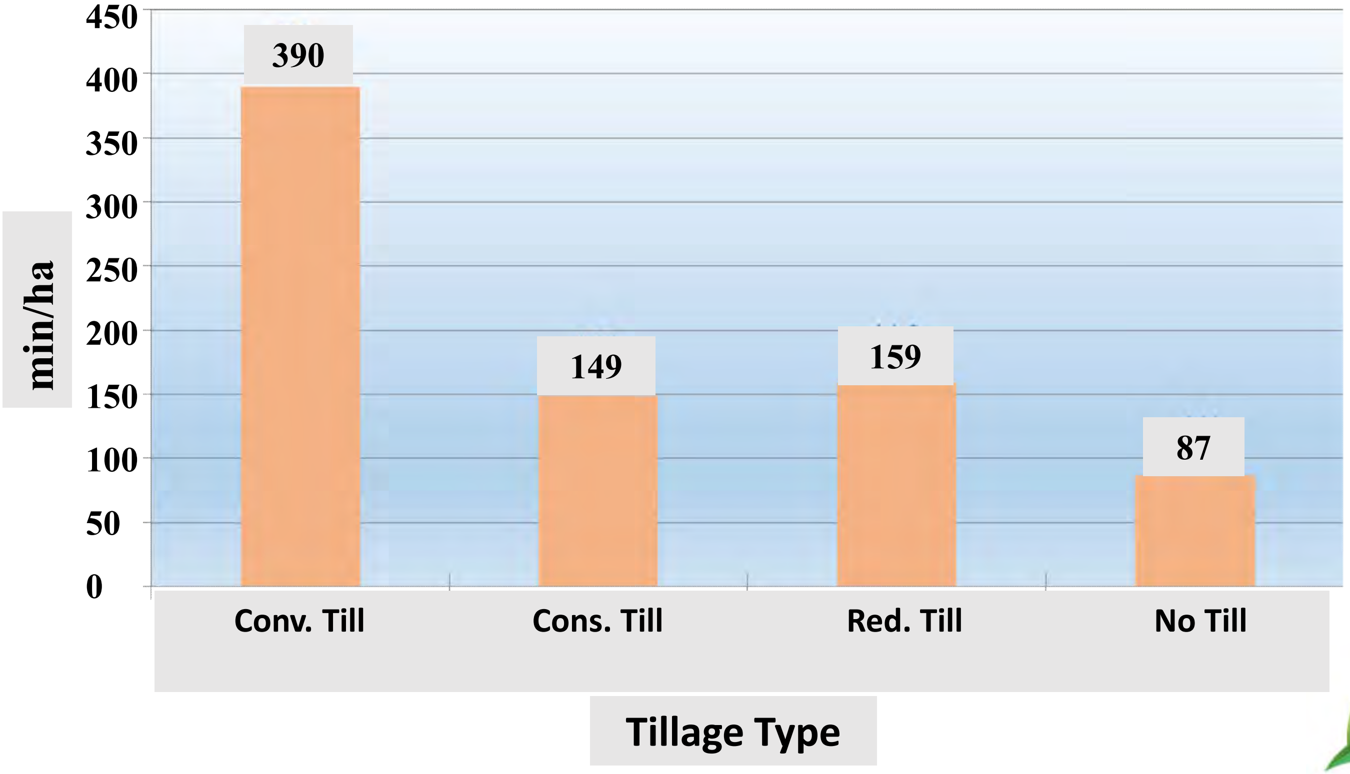
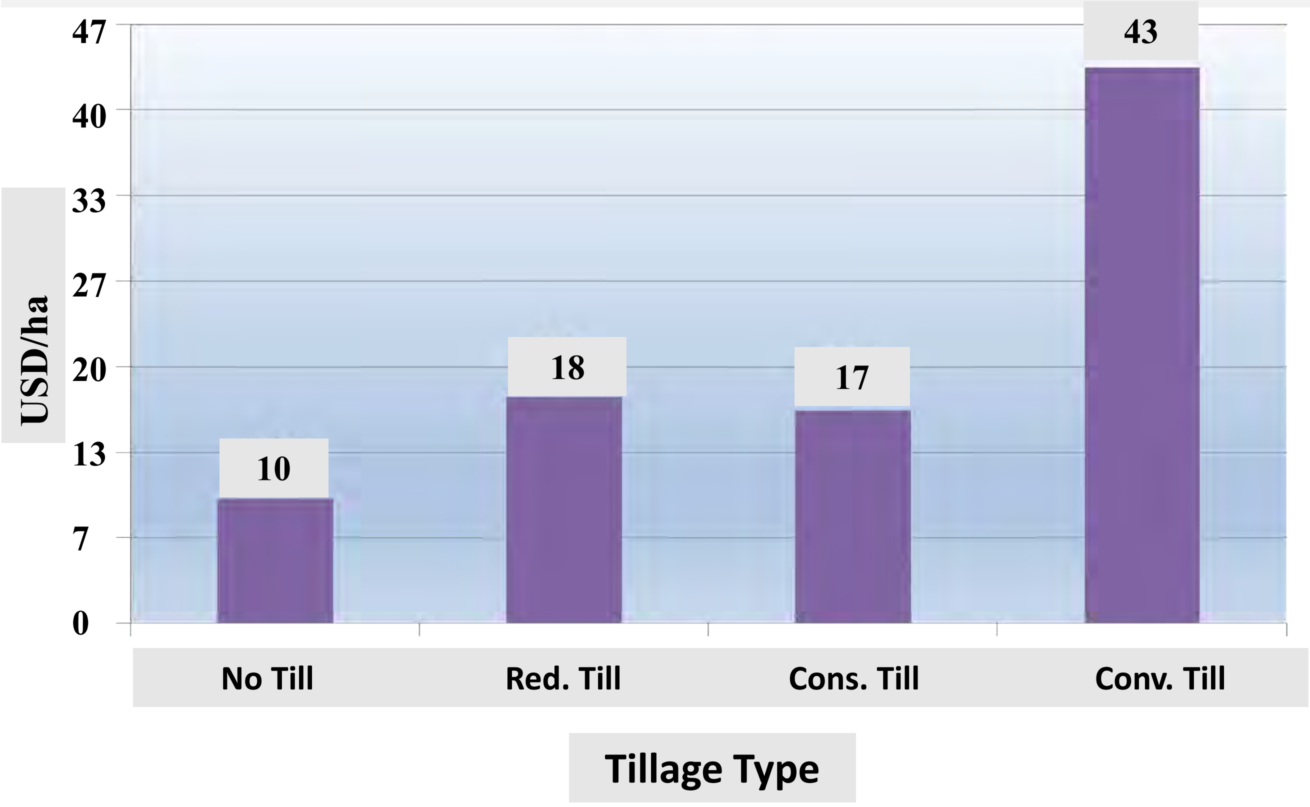
Machinery operation time (min/ha)



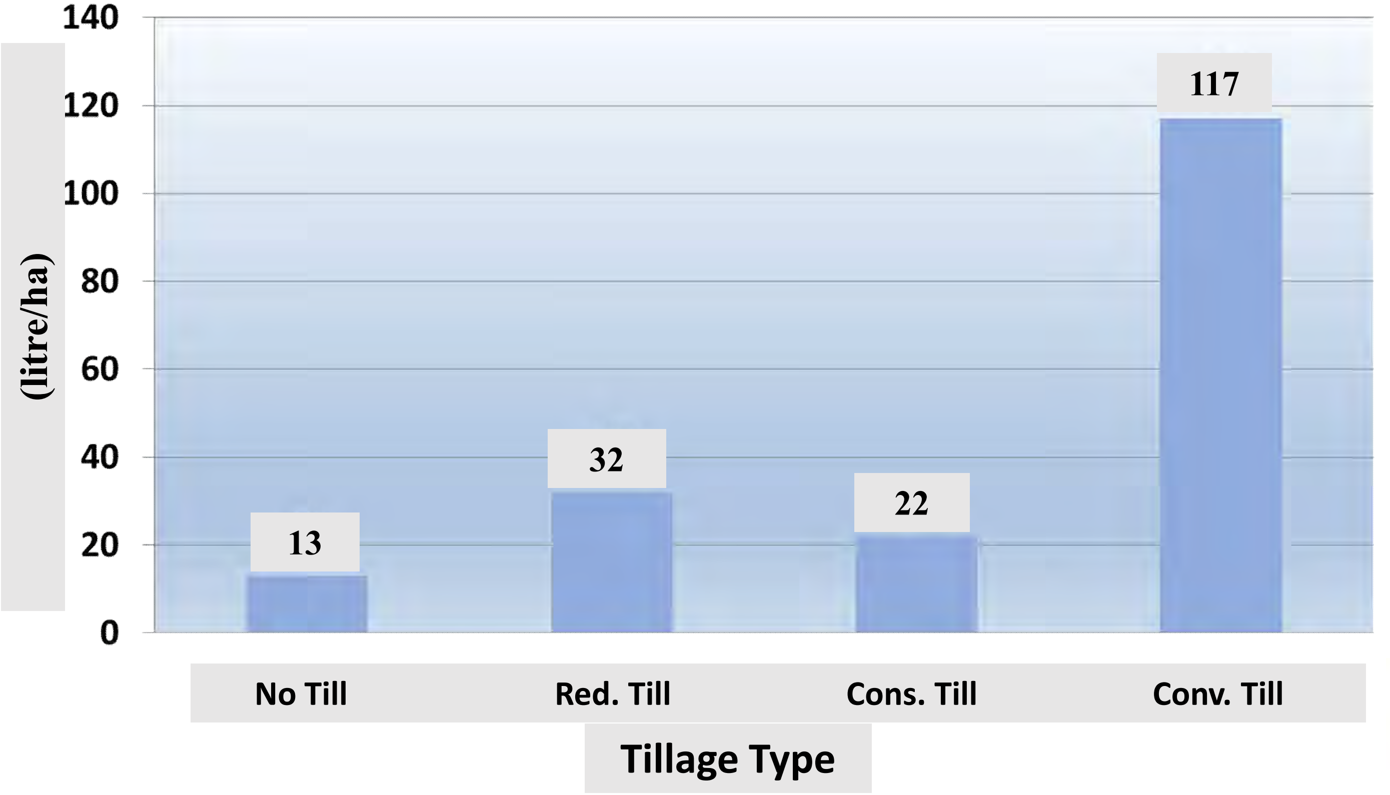
Tillage cost

مقایسه هزینه مکانیزاسیون در هکتار در سامانه‌های مختلف خاک‌ورزی

(هزار ریال)



Fuel consumption (liter/ha)



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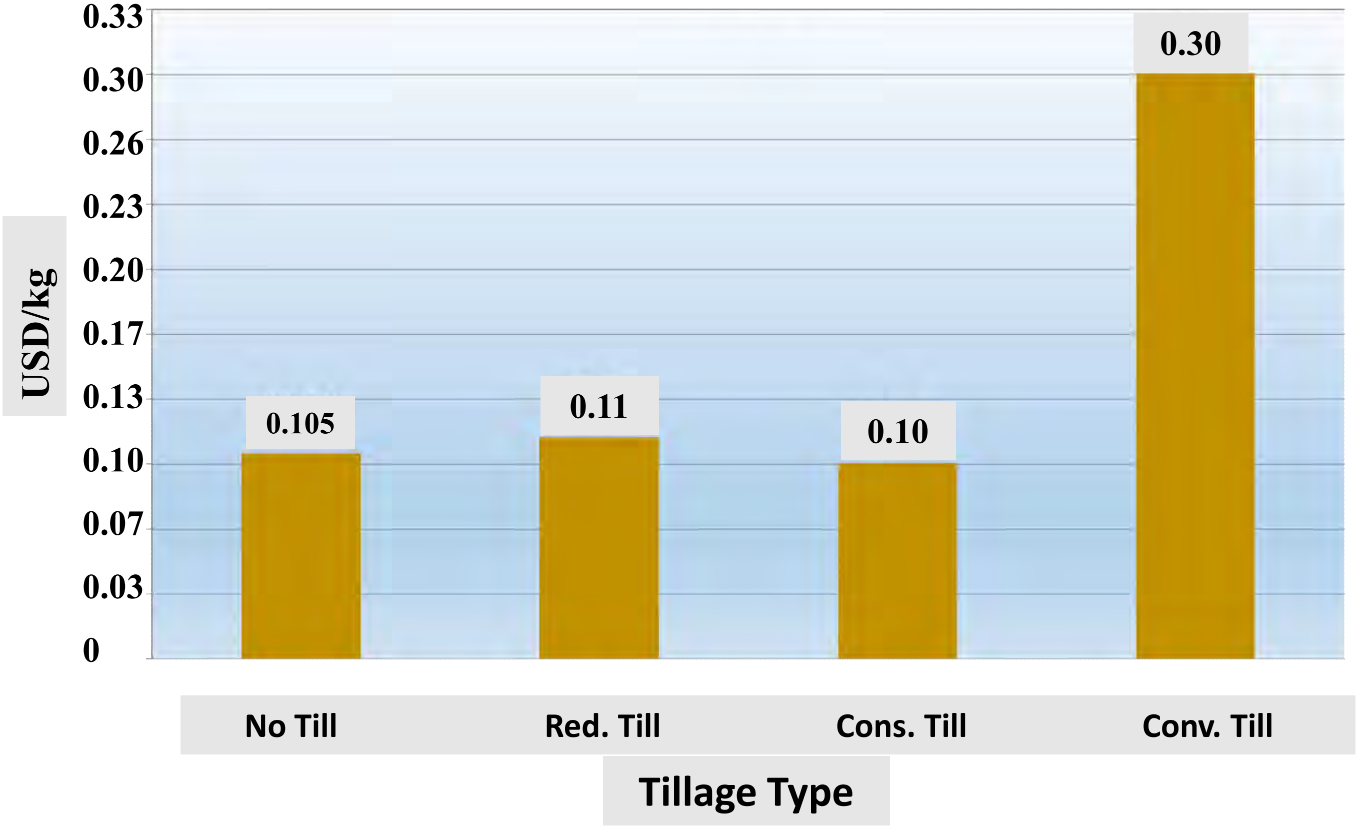
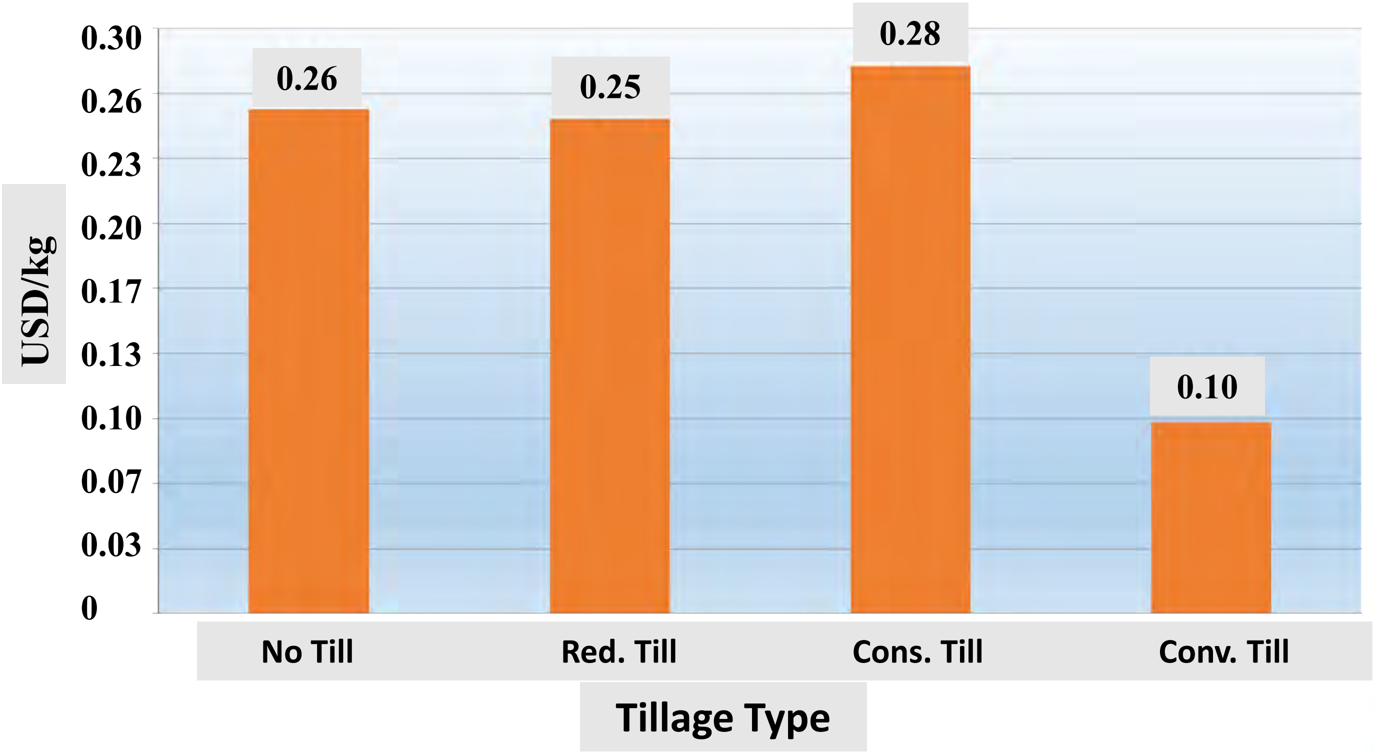
Wheat production cost

هزینه تولید هرکیلوگرم گندم در سامانه های مختلف خاک‌ورزی

(ریال)



Net income of wheat production



The economic achievement of project (cost-benefit)

- ✓ **Reduction of production costs (by 35 %)**
- ✓ **Increasing of crop production (by 100 %)**
- ✓ **Reducing the time of machinery operation (by 65%)**
- ✓ **Reduction of energy consumption (by 80%)**
- ✓ **Increasing net income of farmers (By 500 %)**

2- SiahBisheh Pump & Storage Dam, a Water-Battery
(Mr. Naghavi, et al, IWPRD Co.)
Partners of Nexus Center

Iran Water & Power Development Co.

Siah Bisheh Technical, Educational and Recreation Project

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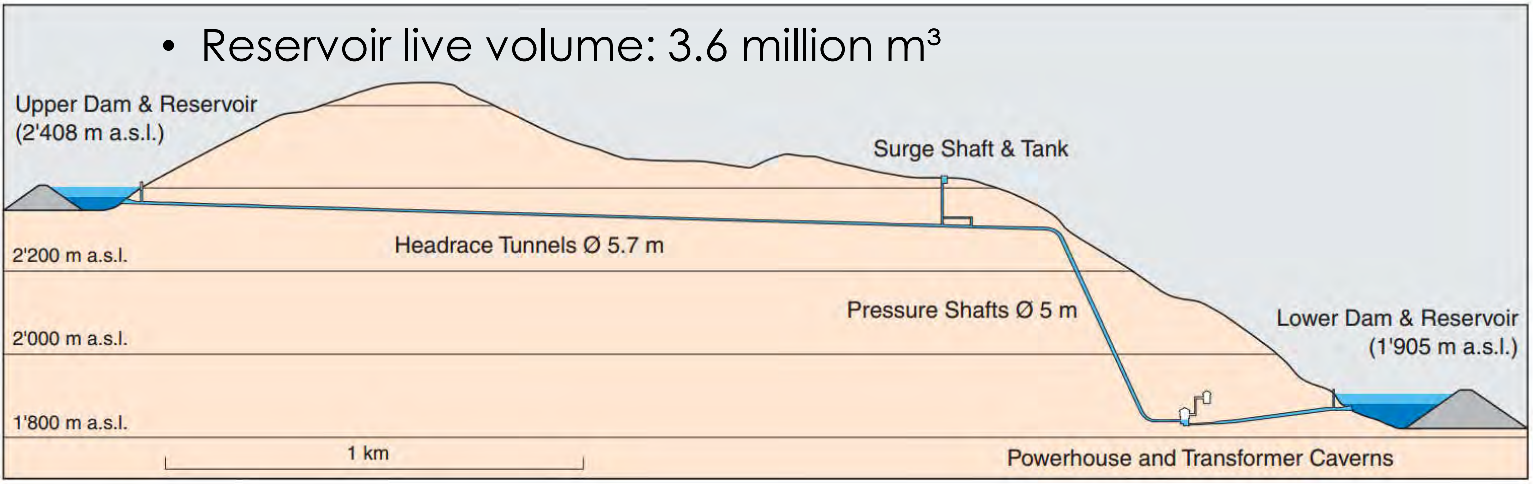
- The Siah Bishe Pumped Storage Plant is designed to produce a rated capacity of 4 x 260 = 1040 MW peak energy, estimated cost: 389 million USD
- Gross Head: Max. 520.8 m, Min. 470.8 m
- Dam Volume 4.93 million m³
- Reservoir live volume: 3.6 million m³



Layout of the Siah Bishe Pumped Storage Project

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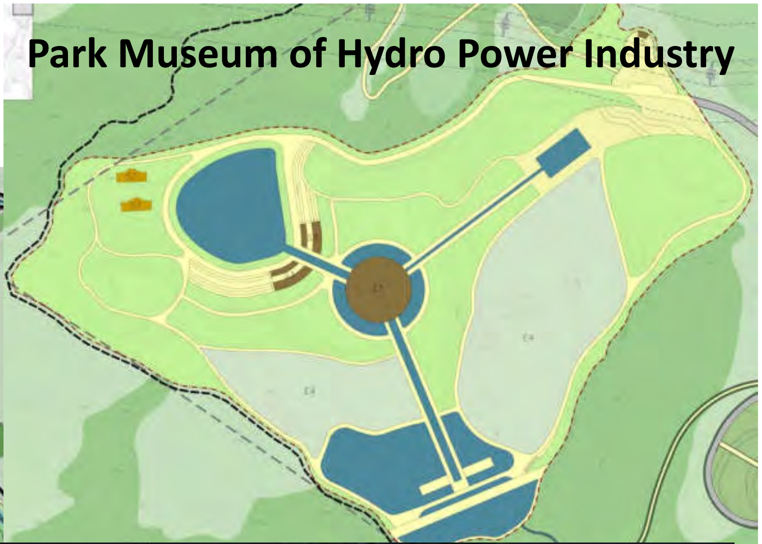

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South Entrance

Dream Village

Health Village

Mountain Village

3- South Tehran Wastewater Company
(Dr. Barati, Ms. Ekhtiarzadeh)
Nexus Center Partners in Nexus & Circular Economy

Anaerobic Digestion
Provision of gas

Closing the Carbon Cycle

Nexus Center has proposed a Demonstration Nexus Greenhouse

Global Cooling vs Global Warming

Renewable Biogas

Power in MW	Location	
4.8	South WW Plant	Modules 1-4
2.4	South WW Plant	Modules 5 & 6
6	West WW Plant	Modules 1-4

Reduction of Carbon Footprint for Water
And
Income generation

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4- Carbon Capture from Energy & Petrochemical Industry (Mr. Salimi, Ms. Karimi)

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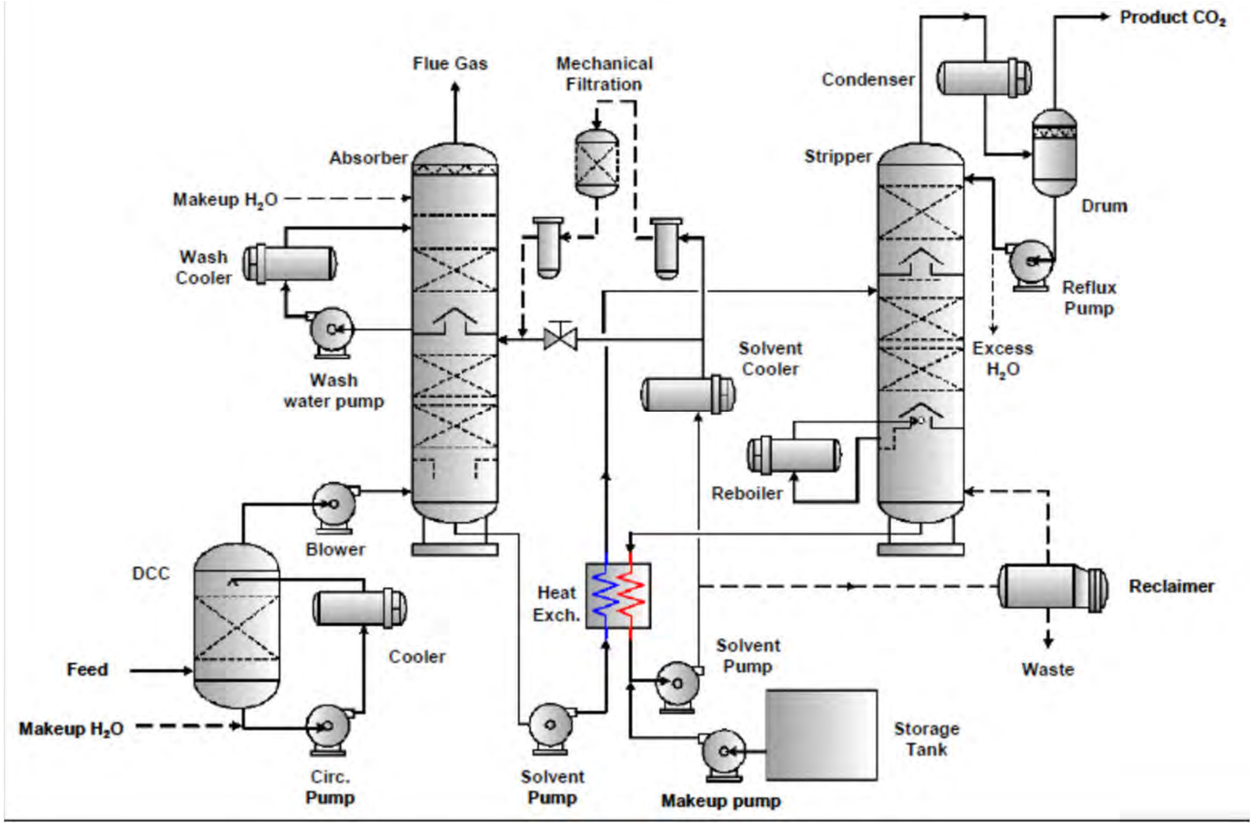
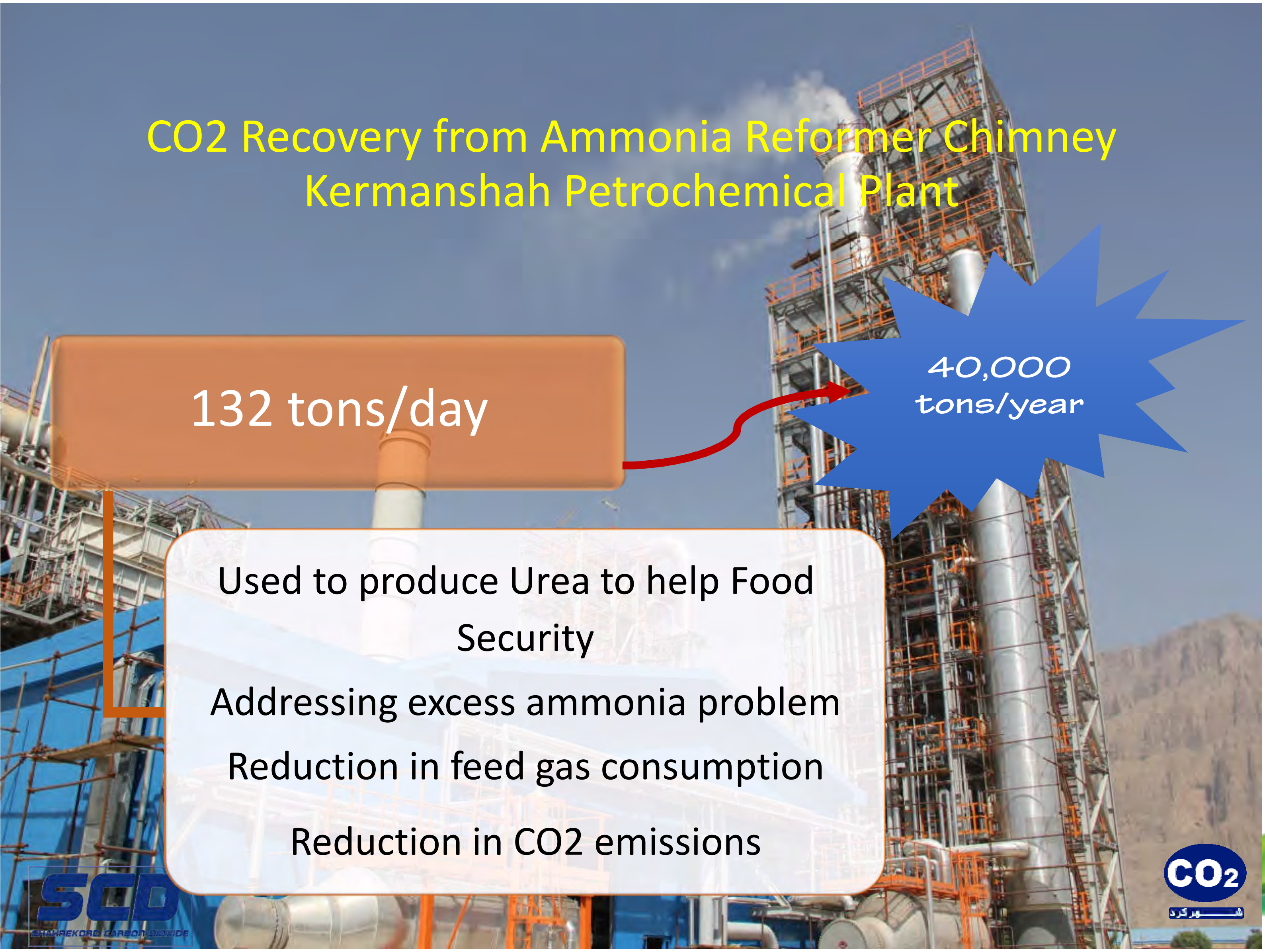
Carbon Capture Plant PFD (MEA)



CO2 Recovery from Tehran Be'sat Powerplant

50 tons/day

Use: Dry Ice, Carbonated Drinks



CO2 Recovery from Ammonia Reformer Chimney Kermanshah Petrochemical Plant

132 tons/day

40,000 tons/year

Used to produce Urea to help Food Security

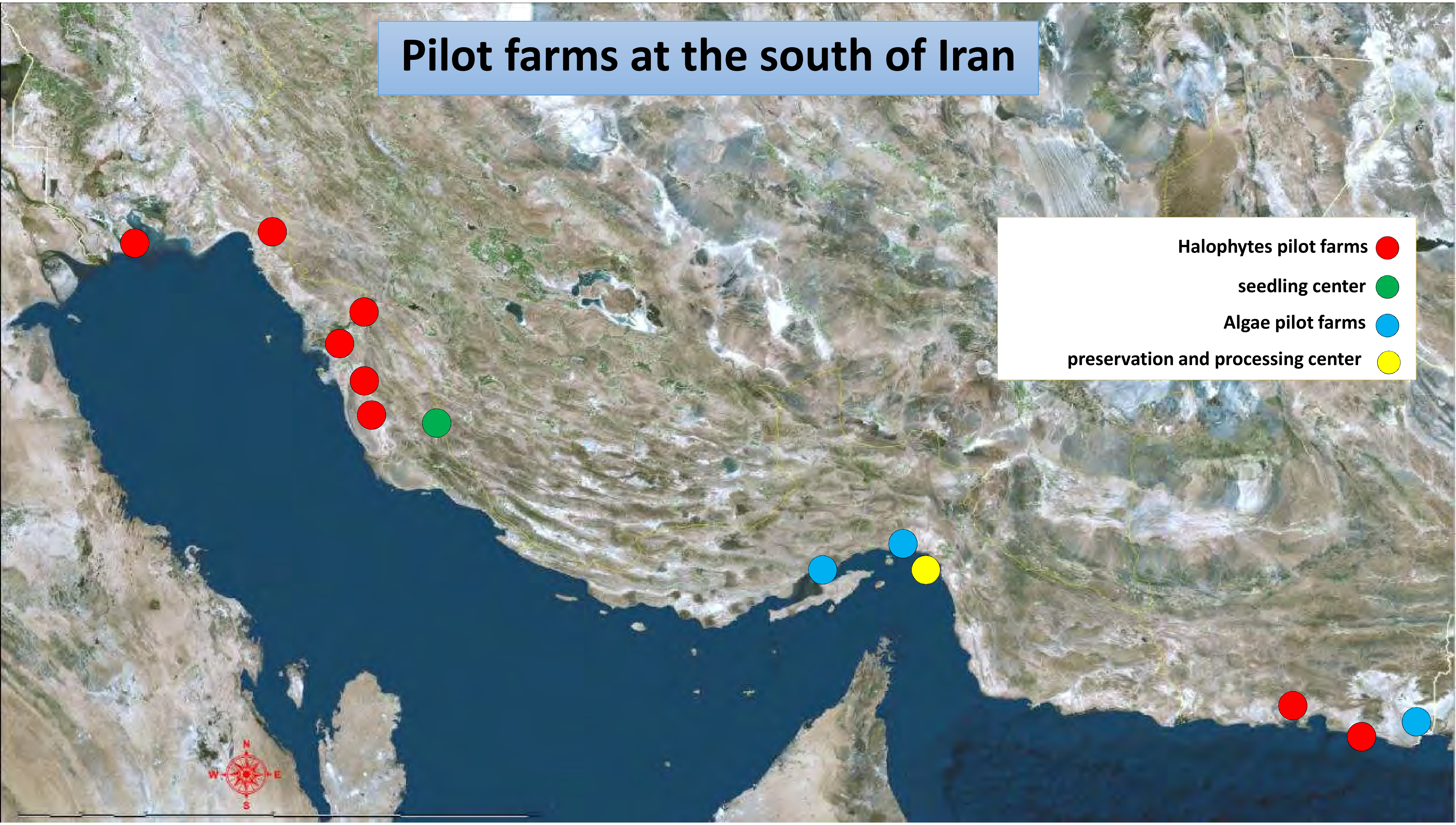
Addressing excess ammonia problem

Reduction in feed gas consumption

Reduction in CO2 emissions

5-Development of Iran’s South Coastal Area Nexus Center Partners and one of the Winners of Dutch Saline Agriculture Competition

Pilot farms at the south of Iran



Halophytes pilot farms 🔴

seedling center 🟢

Algae pilot farms 🔵

preservation and processing center 🟡

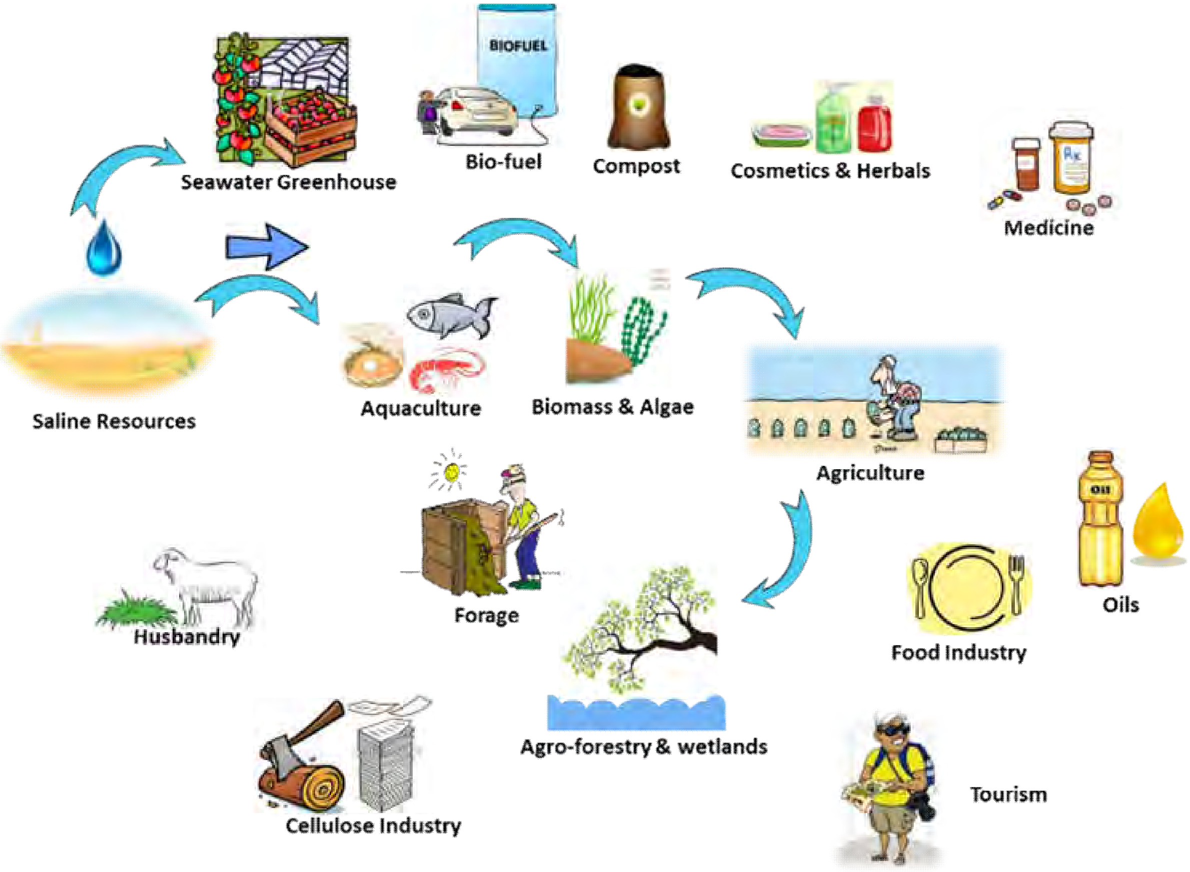
Vision/Mission/ Goals

Vision: Promoting Sustainable Development in the area

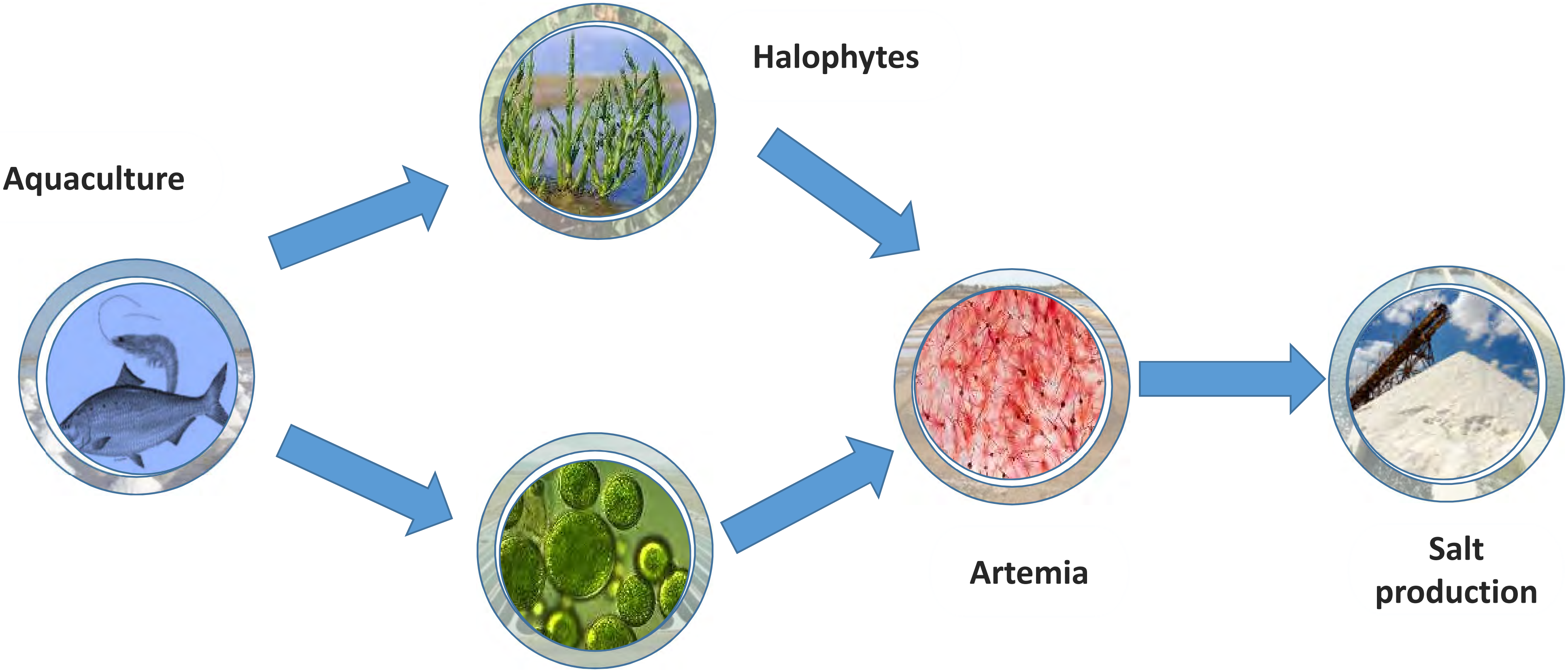
Mission: Introduction of Sustainable Development Patterns Based on the Use of Saline Soil and Water (non-conventional sources)

Goals: Environmental/Social/Economical Improvement (job creation, food production, education, people participation,...)

Seawater Cultivation Potentials



Integrated Seawater Farms



Aquaculture

Halophytes

Algae

Artemia

Salt production

Macro Algae farm

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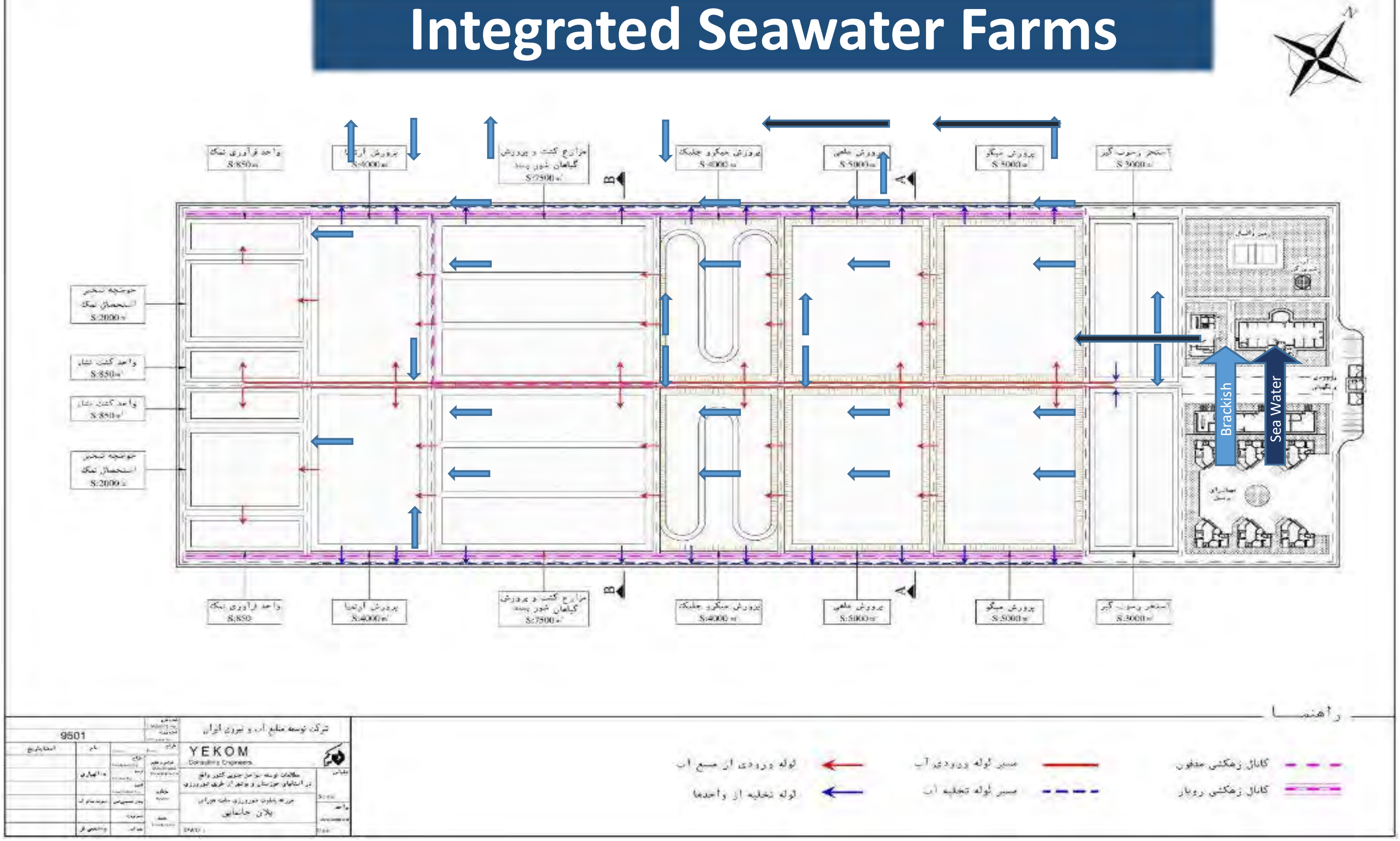
Integrated Seawater Farms



Site Selection

Site Selection

Competitive advantages

Job creation at lower prices

Water and land are cheaper

Environmental friendly

Such farms uses **wastes** from shrimp farms

Food production at lower costs

Water, land and labor costs are cheaper

Saving Fresh Water

By producing alternative crops from non-conventional sources, fresh water is saved for **more valuable purposes** at rural communities.

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Prospective Hands-on Nexus Tools, Nexus Mind maps
A Few Exercises to Work on

Bahram Taheri

13:45-14:05

Some Suggestions

- Starting a Nexus Network and Community in the NENA region and expand it beyond the region.
- We have planned such a networking facility in AKUF Nexus Center and would be more than happy to use it as a starting point under SIDA project.
- Working on a few problems together by developing mind maps and sharing those with each other for getting a more complete understanding of problem definitions and suggested solutions.

As Rumi said:

If each had a candle and they went in together
the differences would disappear

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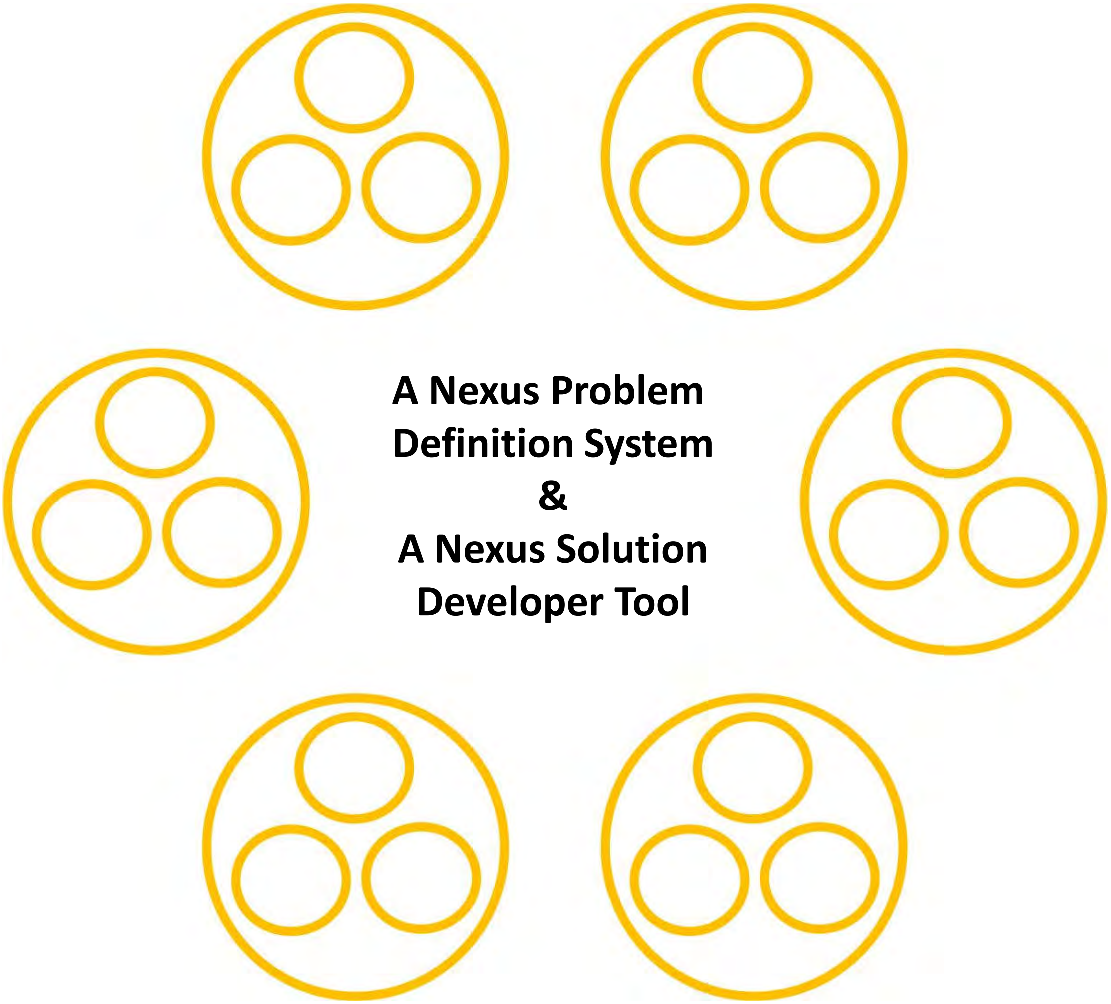
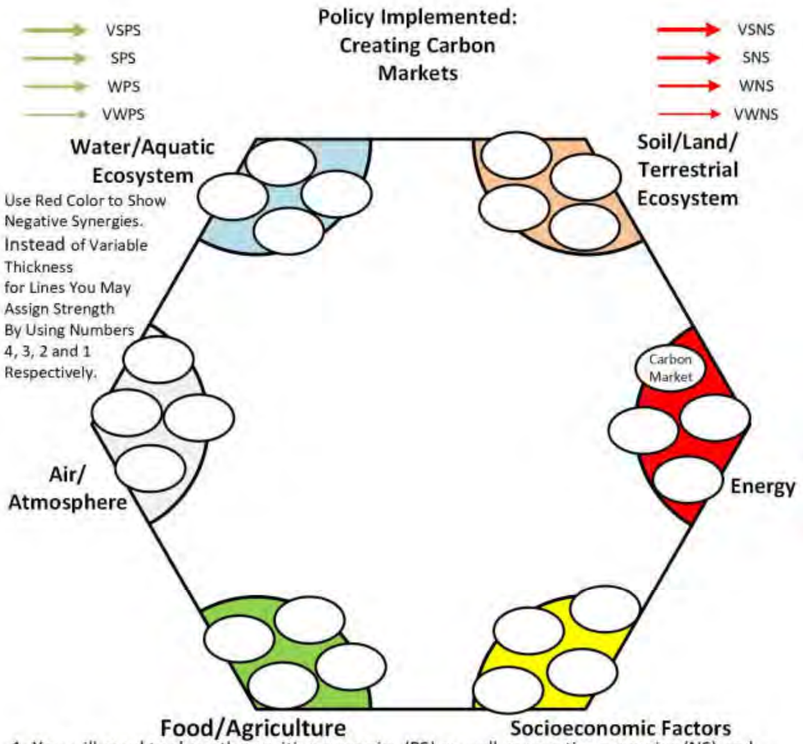


A Nexus Problem Definition System & A Nexus Solution Developer Tool



Policy Implemented: Creating Carbon Markets

Use Red Color to Show Negative Synergies. Instead of Variable Thickness for Lines You May Assign Strength By Using Numbers 4, 3, 2 and 1 Respectively.

1- You will need to show the positive synergies (PS) as well as negative synergies (NS) and trade offs related to the specified policy or action.

2- You may choose a maximum of four highest priorities in each of the affected nexus elements.

3- You may demonstrate existence of a more complex nexus relation by showing an element being positively or negatively impacted due to the implemented policy or action first and then causing secondary or tertiary impact on other elements of the nexus either positively or negatively.

4- Can you identify a negative or positive secondary or tertiary impact coming back from other impacted nexus elements to the original element where the nexus interactions have been triggered?

5- Can you suggest a business model or technological innovation with multiple nexus benefit opportunities demonstrated in your analysis above.

6- Suggest an article of policy or regulation or a technology innovation to minimize the impact of a priority negative nexus identified in your analysis above.

NEXUS
NEXUS & HSE CENTER

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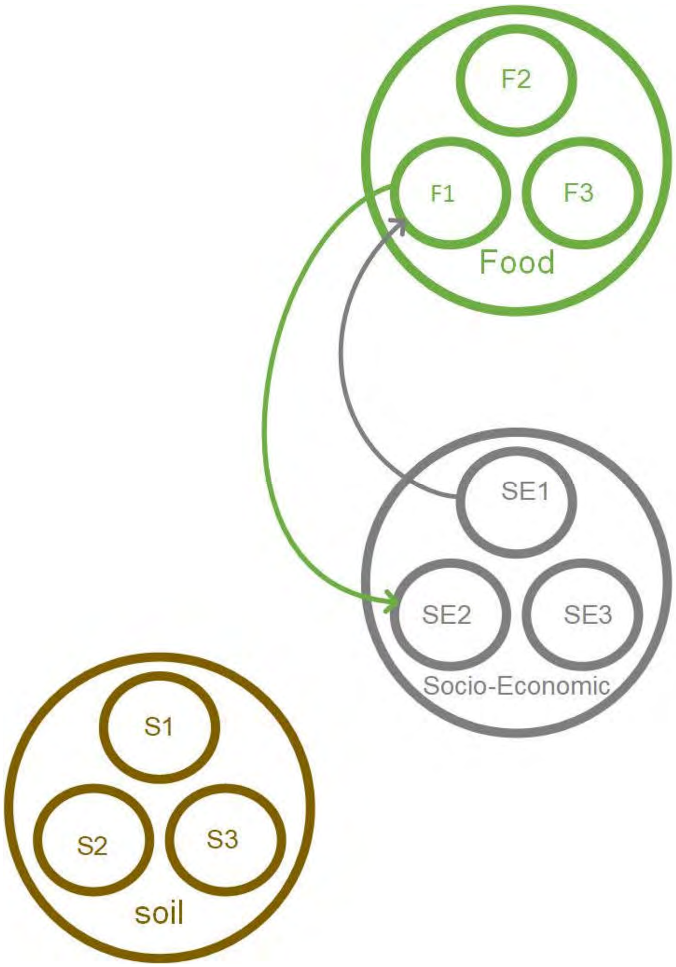

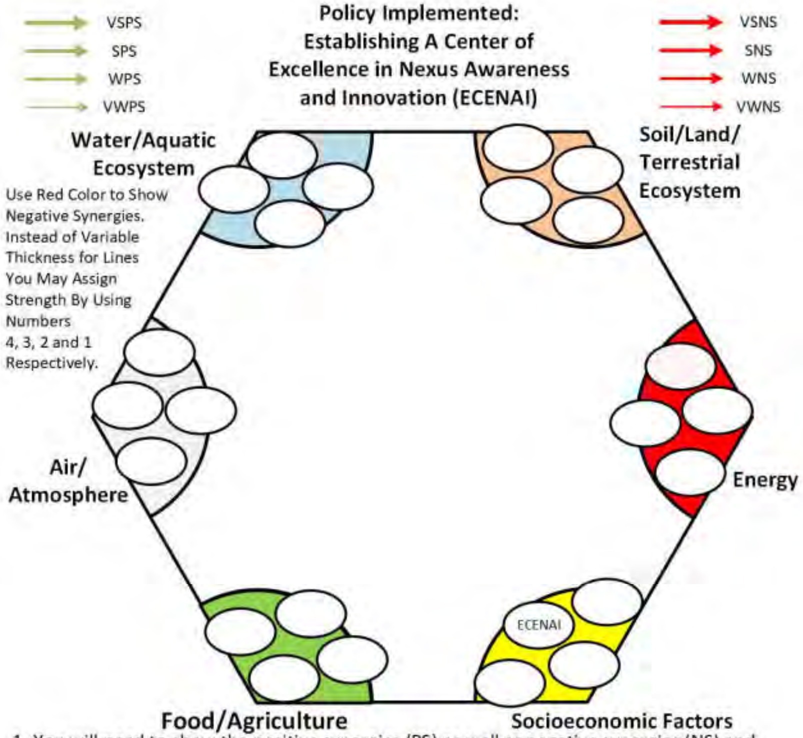

**Policy Implemented:
Establishing A Center of
Excellence in Nexus Awareness
and Innovation (ECENAI)**

Use Red Color to Show Negative Synergies. Instead of Variable Thickness for Lines You May Assign Strength By Using Numbers 4, 3, 2 and 1 Respectively.

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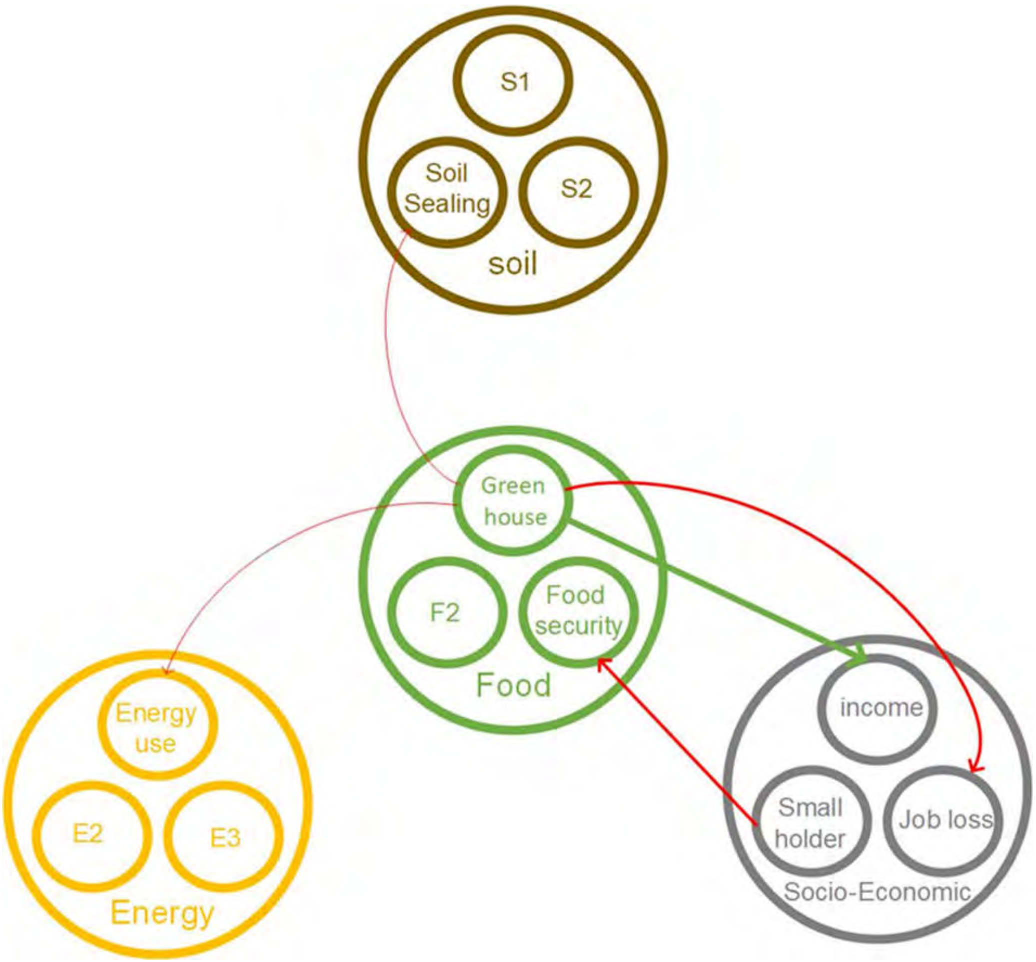

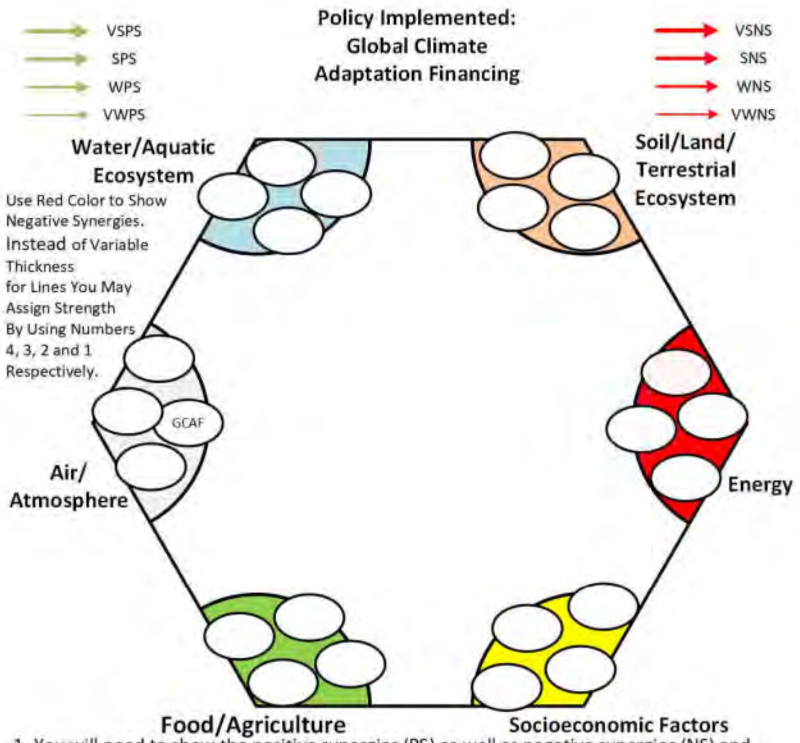
Policy Implemented:
Global Climate
Adaptation Financing

Use Red Color to Show Negative Synergies. Instead of Variable Thickness for Lines You May Assign Strength By Using Numbers 4, 3, 2 and 1 Respectively.

1- You will need to show the positive synergies (PS) as well as negative synergies (NS) and trade offs related to the specified policy or action.

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NEXUS

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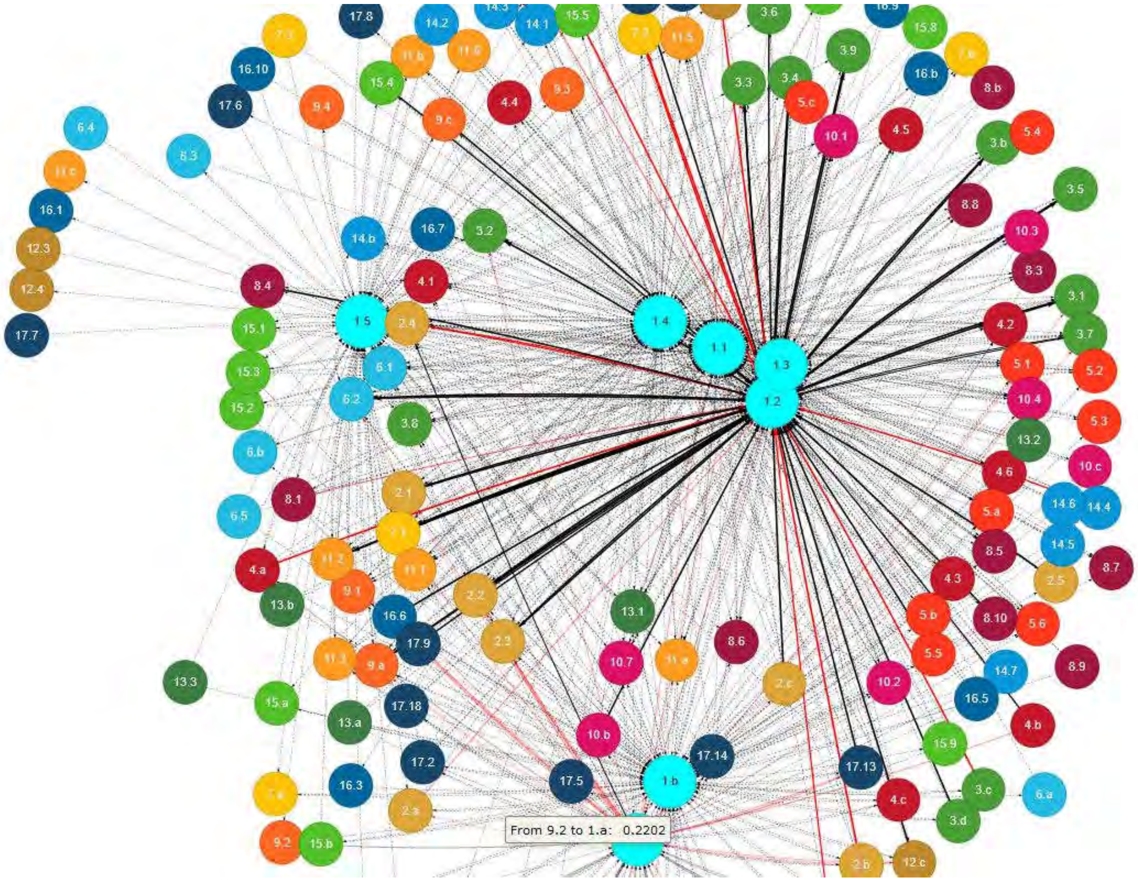
Need for an SDG Nexus Tool
Links Among SDG Indicators
Does it Look Complex and Difficult to Manage?



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Links Between Mitigation Actions and Other SDGs

Legend:

Only negative links	More negative links	Both positive and negative links	More positive links	Only positive links	No links
🟥	🩷	🟨	🟢	🟩	

	Electricity & heat	Transport	Buildings	Waste	Industry	Agriculture	Forestry	General
1. No poverty	🩷		🟩	🟥		🟩	🟨	🩷
2. Zero hunger	🩷	🟨				🟢	🟢	🟥
3. Good health and well-being	🟢	🟢	🟢	🟩	🟢	🟩	🟩	
4. Quality education	🟩							🟩
5. Gender equality	🟩							🟩
6. Clean water and sanitation	🩷	🟢	🟢	🟩	🟢	🟩	🟩	🟥
7. Affordable and clean energy	🟢	🟢	🟩	🟩	🟩	🟩		🟥
8. Decent work & economic growth	🟢	🟢	🟩	🟩	🟢	🟩	🟩	🟢
9. Industry, innovation & infrastructure	🟢	🟩	🟩	🟩	🟩	🟩		🟨
10. Reduced inequalities	🟩	🟩		🟥		🟩	🟥	🟥
11. Sustainable cities and communities	🟢	🟢	🟢	🟩	🟢		🟩	🩷
12. Responsible consumption and production	🟢	🟢	🟢	🟩	🟢	🟩	🟩	🟩
14. Life below water	🟢	🟩	🟩	🟩	🟩	🟩	🟩	
15. Life on land	🟨	🟢	🟢		🟢	🟩	🟩	
16. Peace, justice and strong institutions	🟩						🟩	🟩

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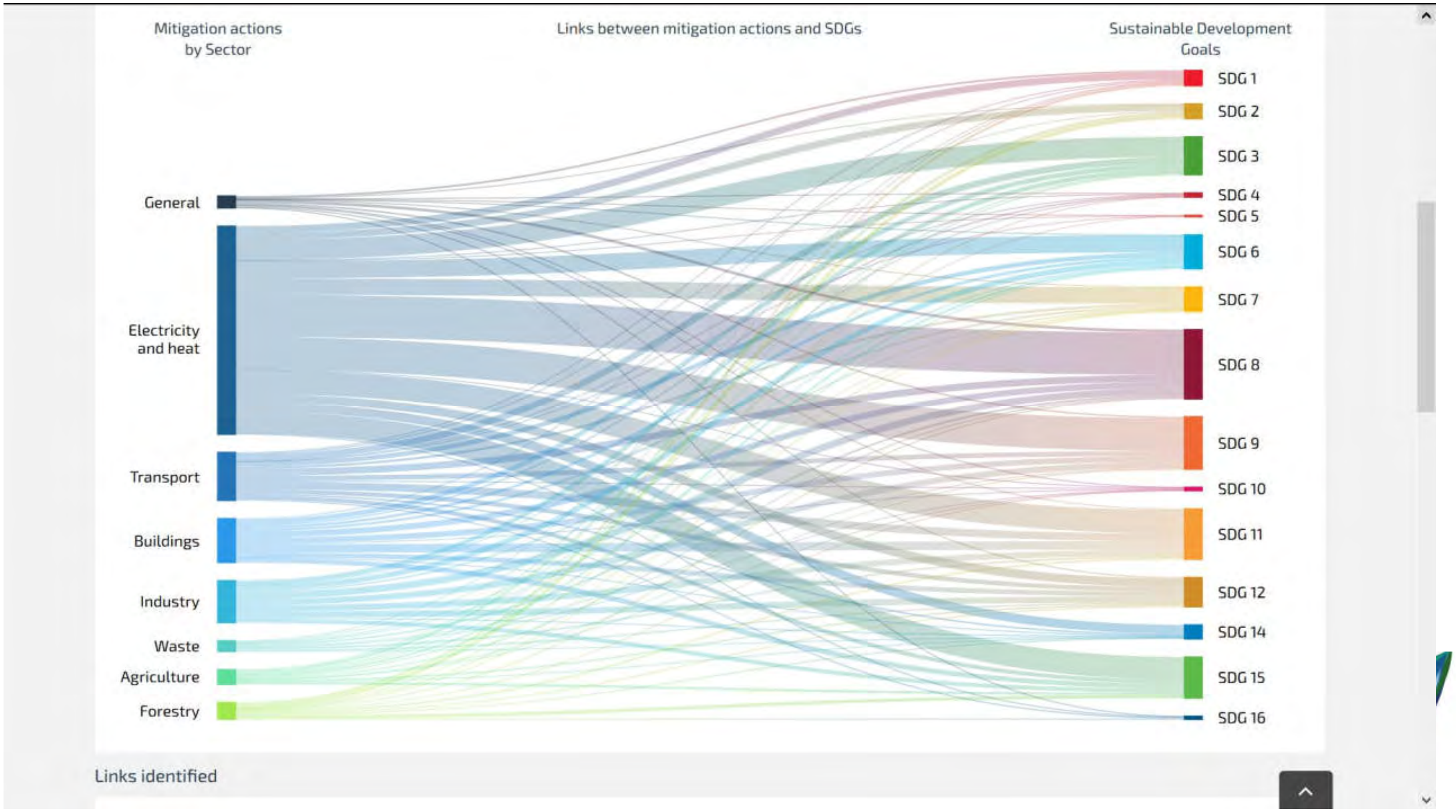
Graphic Demonstration of Climate Mitigation Actions on Other SDGs and their Sub-Targets



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Impact of Carbon Pricing on SDG1

	Category	Mitigation action	Target	
General	Pricing	Carbon and energy pricing interventions	1.1	1. No poverty

Potential trade-off: Carbon pricing or reduction of fossil fuel subsidies could lead to increased consumer energy prices, which can disproportionately affect lower-income groups

Target 1.1:
By 2030, eradicate extreme poverty for all people everywhere, currently measured as people living on less than $1.25 a day

	Category	Mitigation action	Target	
General	Pricing	Carbon and energy pricing interventions	1.2	1. No poverty

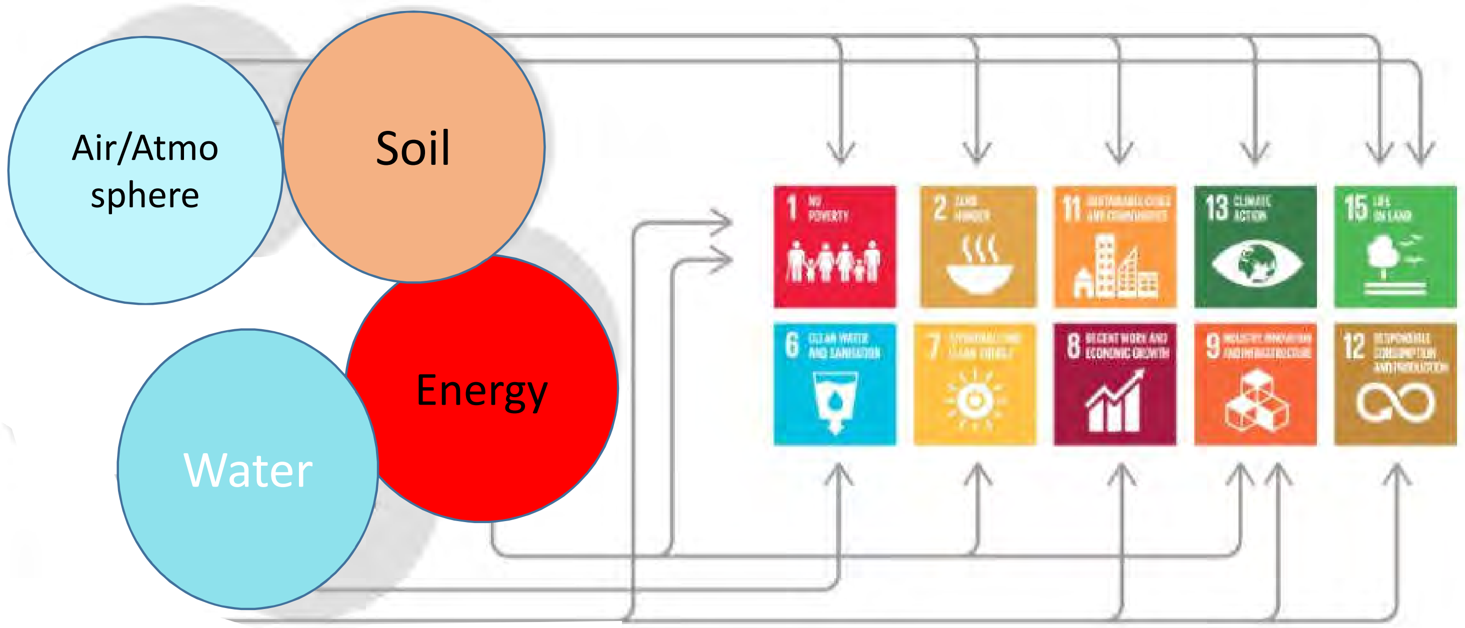
Potential trade-off: Carbon pricing or reduction of fossil fuel subsidies could lead to increased consumer energy prices, which can disproportionately affect lower-income groups

Target 1.2:
By 2030, reduce at least by half the proportion of men, women and children of all ages living in poverty in all its dimensions according to national definitions

	Category	Mitigation action	Target	
General	Pricing	Carbon and energy pricing interventions	1.4	1. No poverty

Potential trade-off: Carbon pricing or reduction of fossil fuel subsidies could lead to increased consumer energy prices, which can disproportionately affect lower-income groups

Target 1.4:
By 2030, ensure that all men and women, in particular the poor and the vulnerable, have equal rights to economic resources, as well as access to basic services, ownership and control over land and other forms of property, inheritance, natural resources, appropriate new technology and financial services, including microfinance



Air/Atmo
sphere

Soil

Energy

Water

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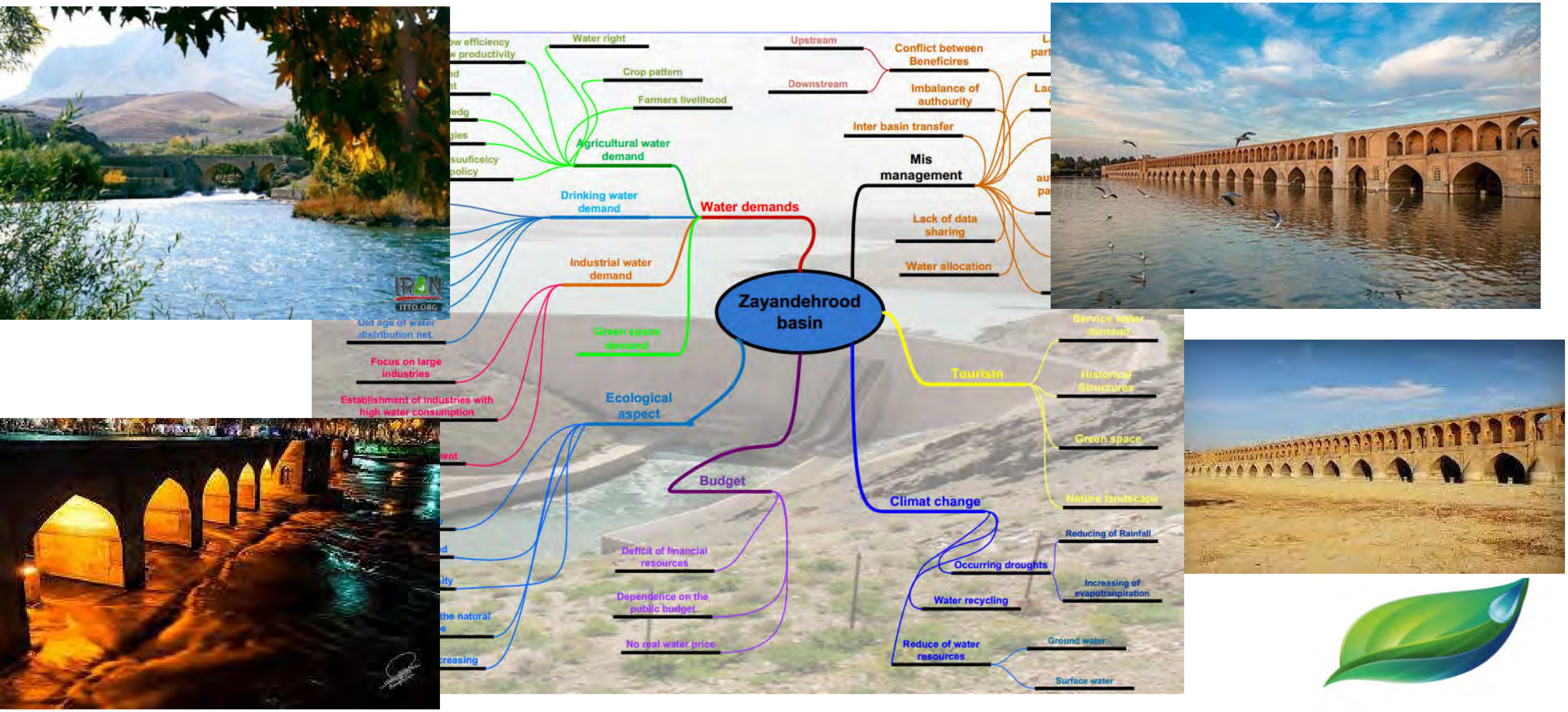
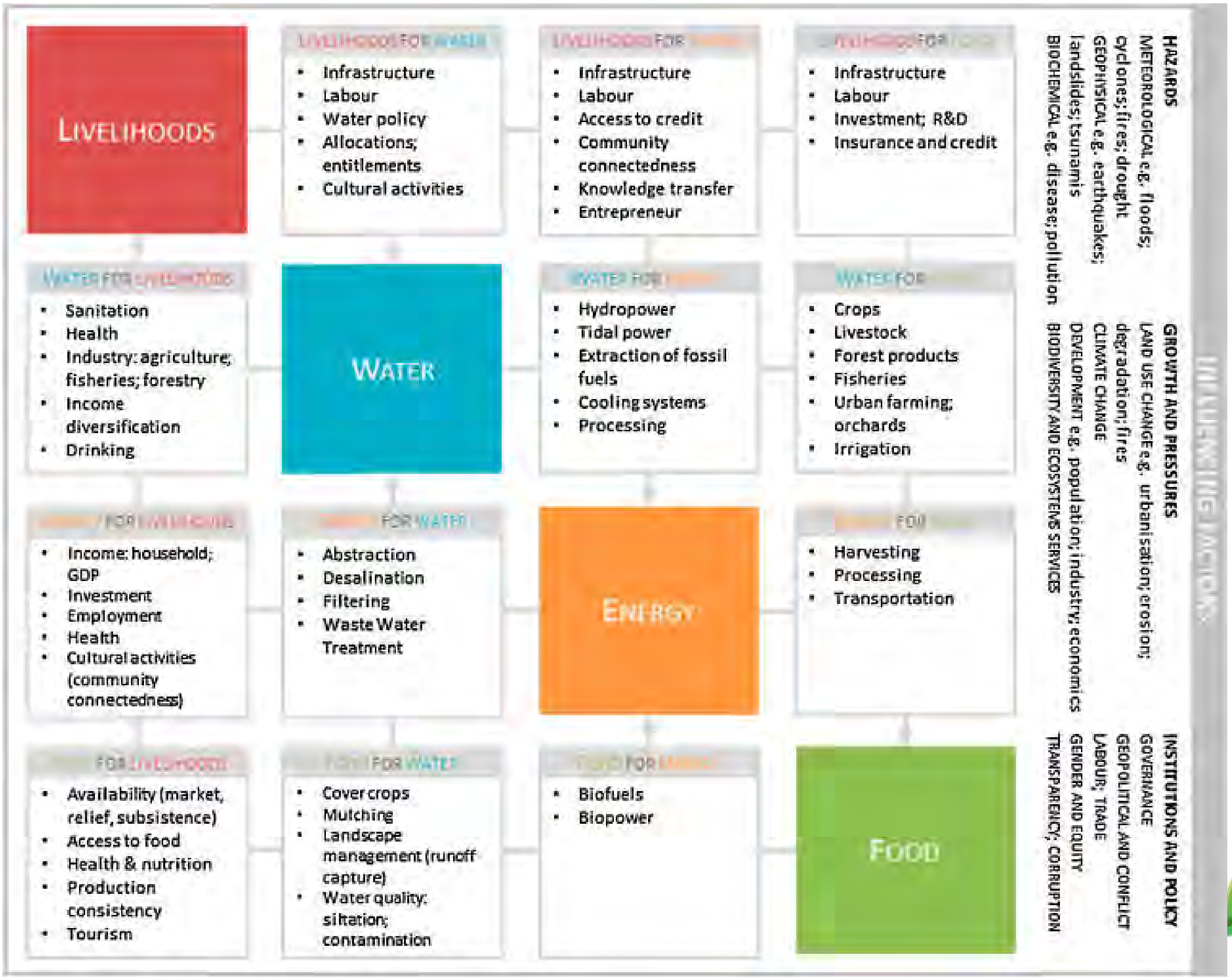
An Example of Mind map for Zayandehrood Basin in Iran



Zayandehrood basin

- **Water demands**
  - Agricultural water demand
    - ow efficiency
    - w productivity
    - Water right
    - Crop pattern
    - Farmers livelihood
    - suuficeicy
    - policy
  - Drinking water demand
    - Old age of water distribution net.
  - Industrial water demand
    - Focus on large industries
    - Establishment of industries with high water consumption
    - ent
  - Green space demand
- **Mis management**
  - Conflict between Beneficires
    - Upstream
    - Downstream
  - Imbalance of authourity
  - Inter basin transfer
  - Lack of data sharing
  - Water allocation
- **Ecological aspect**
  - ity
  - the natural
  - creasing
- **Budget**
  - Deficit of financial resources
  - Dependence on the public budget
  - No real water price
- **Tourism**
  - Service water demand
  - Historical Structures
  - Green space
  - Nature landscape
- **Climat change**
  - Occurring droughts
    - Reducing of Rainfall
    - Increasing of evapotranpiration
  - Water recycling
  - Reduce of water resources
    - Ground water
    - Surface water

Paired Nexuses in the Bidirectional 4-D Nexus Space



LIVELIHOODS	**LIVELIHOODS FOR WATER** • Infrastructure • Labour • Water policy • Allocations; entitlements • Cultural activities	**LIVELIHOODS FOR ENERGY** • Infrastructure • Labour • Access to credit • Community connectedness • Knowledge transfer • Entrepreneur	**LIVELIHOODS FOR FOOD** • Infrastructure • Labour • Investment; R&D • Insurance and credit
WATER FOR LIVELIHOODS • Sanitation • Health • Industry: agriculture; fisheries; forestry • Income diversification • Drinking	**WATER**	**WATER FOR ENERGY** • Hydropower • Tidal power • Extraction of fossil fuels • Cooling systems • Processing	**WATER FOR FOOD** • Crops • Livestock • Forest products • Fisheries • Urban farming; orchards • Irrigation
ENERGY FOR LIVELIHOODS • Income: household; GDP • Investment • Employment • Health • Cultural activities (community connectedness)	**ENERGY FOR WATER** • Abstraction • Desalination • Filtering • Waste Water Treatment	**ENERGY**	**ENERGY FOR FOOD** • Harvesting • Processing • Transportation
FOOD FOR LIVELIHOODS • Availability (market, relief, subsistence) • Access to food • Health & nutrition • Production consistency • Tourism	**FOOD FOR WATER** • Cover crops • Mulching • Landscape management (runoff capture) • Water quality: siltation; contamination	**FOOD FOR ENERGY** • Biofuels • Biopower	**FOOD**

INFLUENCING FACTORS

HAZARDS
METEOROLOGICAL e.g. floods; cyclones; fires; drought
GEOPHYSICAL e.g. earthquakes; landslides; tsunamis
BIOCHEMICAL e.g. disease; pollution

GROWTH AND PRESSURES
LAND USE CHANGE e.g. urbanisation; erosion; degradation; fires
CLIMATE CHANGE
DEVELOPMENT e.g. population; industry; economics
BIODIVERSITY AND ECOSYSTEMS SERVICES

INSTITUTIONS AND POLICY
GOVERNANCE
GEOPOLITICAL AND CONFLICT
LABOUR; TRADE
GENDER AND EQUITY
TRANSPARENCY; CORRUPTION

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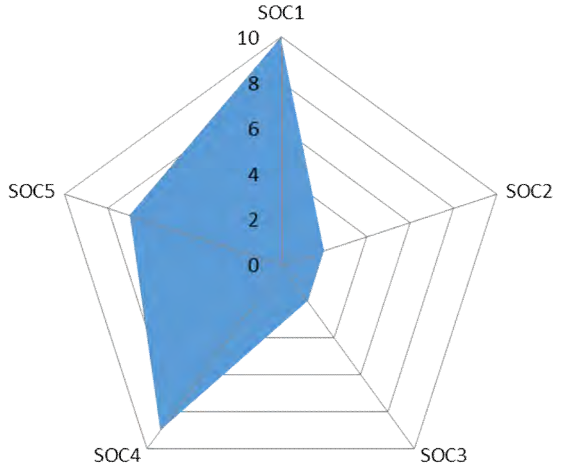
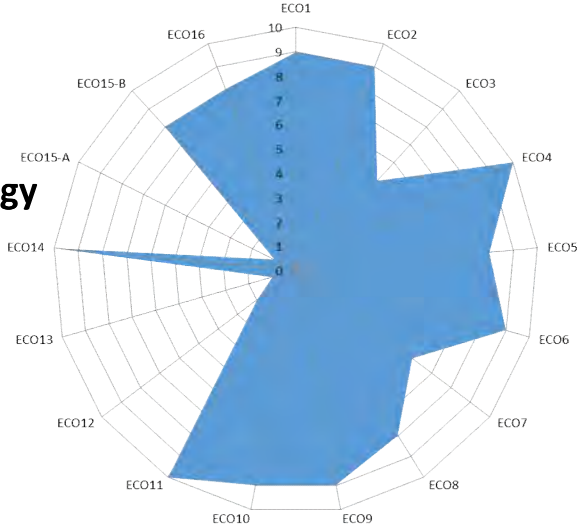
Sustainable Development and Energy Newly Nexus Center Proposed Energy & Resource Indicator System

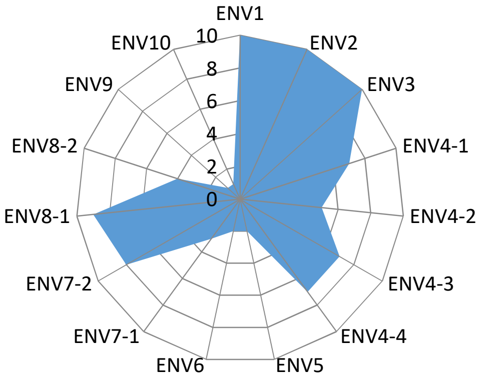
Societal Aspects/Indicators of Energy



Economic Dimensions/Indicators of Energy



Environmental Dimension/Indicators of Energy



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Discussions and Q&A
Annette Huber-Lee (SEI)
Frnacesco Fuso-Nerini (KTH)
14:05-14:25

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Closing
Domitille Vallee (FAO)
Jiro Ariyama (FAO)
14:25-14:30

The Nexus & HSE Center

Nexus & HSE Center

بنیاد دانشگاه امیرکبیر

مرکز Nexus و HSE بنیاد دانشگاه امیرکبیر

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Amirkabir University Of Technology

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Thank you!

http://neareast.fao.org

WATER
Productivity
Efficiency, and
Sustainability
in the NENA countries

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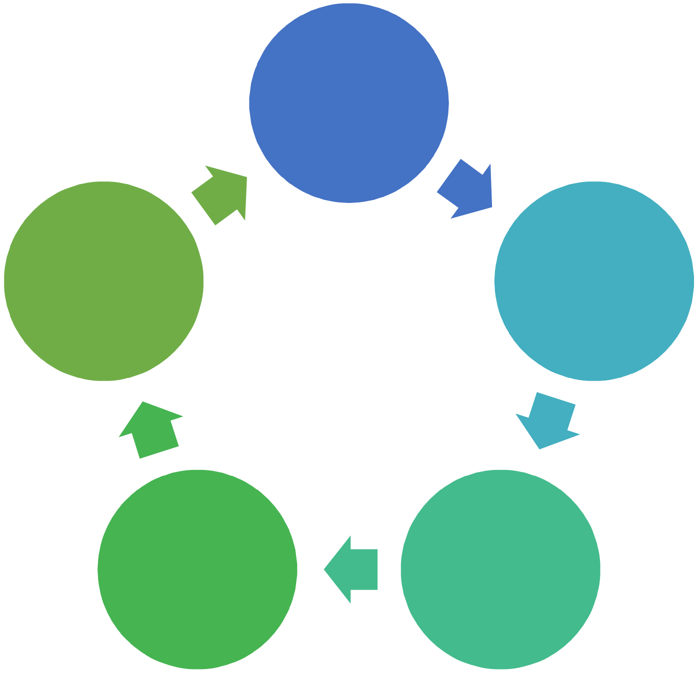
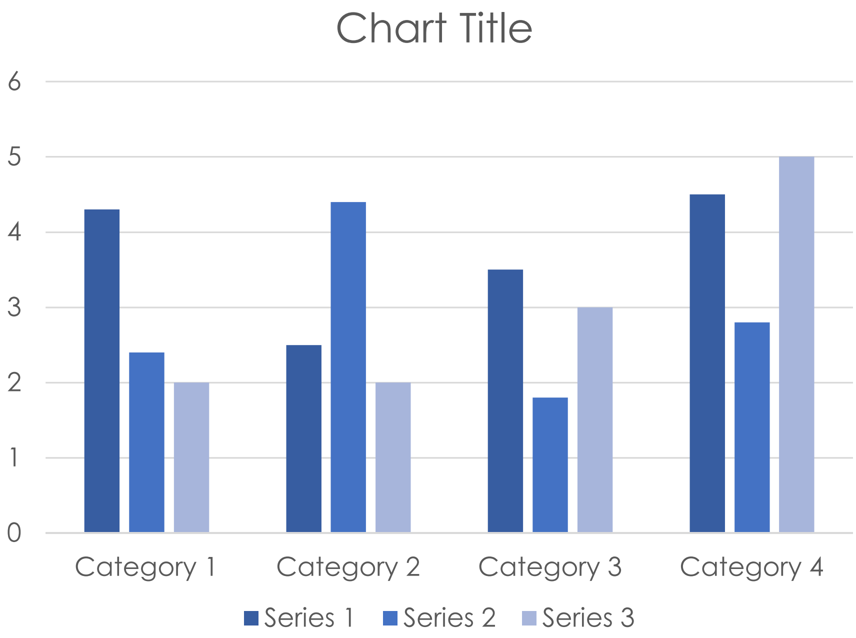
Samples of figure and table





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References