Life Cycle Assessment (LCA) on economic sectors of Jordan based on I/O analysis with an adapted version of the ecological scarcity method

by Dr. Fredy Dinkel, Carbotech AG, Switzerland
Marc Bachmann, Carbotech AG, Switzerland
f.dinkel@carbotech.ch

Life Cycle Assessment on economic sectors of Jordan based on I / O analysis

Master's Thesis of Marc Bachmann

MAS Environmental Technology and –Management

University of Applied Sciences Northwestern Switzerland (FHNW), Fredy Dinkel

in collaboration with

Royal Scientific Society (RSS) in Amman, Bassam Hayek

- ***Which economic sectors are seen most eco-efficient for Jordan and should be developed?***

- *How much water is needed to earn 1'000 JD in the different economic sectors?*
- *What are the environmental impacts of the economic sectors in relation to its value added?*

Method

Jordan I-O Matrix

- An input-output matrix of Jordan's economic sectors has been developed showing the economic interrelations between the different sectors.

- Linking the input-output matrix with environmental data from Life Cycle Assessment (LCA) enables to express the environmental impacts per unit of turnover and / or value added of an economic sector.

Collection of data

- From the Jordanian Department of Statistics (DOS) the following data of the year 2006 has been available for every sector:
  - intermediate consumption of goods and services
  - imports
  - gross output and
  - gross domestic product
- To generate the matrix it was necessary to distribute the intermediate consumption to the different sectors. This has been done by estimations based on expert judgements.
- This process of data acquisition was difficult. Although a lot of information was available it was not always possible to get the figures needed in a qualitatively sufficient manner.

➢ **A detailed matrix for about 50 sectors has been generated.**

Adaptation to the Jordanian situation

The use of LCA for decision making is quite new in the MENA region but of increasing interest.

- **Most LCA valuation methodologies** and **databases** were developed in and for **Europe** and **North America:**
  - Some **environmental problems** as well as **human activities** are **specific** to countries or regions.
  - Thus, valuation methodologies and databases must be **adapted to the Jordanian situation.**
- **There is the need of adaptation:**
  - Important **data sets** like electricity mix or fuel production (refinery) and transport have been generated based on the ecoinvent database.
  - The **valuation method ecological scarcity** was adapted to Jordan taking into account the environmental goals and situation of Jordan.

Adaptation of valuation methodology by Grégoire Meylan, Fredy Dinkel & RSS LCA Team

- Ecological scarcity 2006 valuates environmental impacts according to Swiss environmental policy goals and actual flows:
  - If a human activity generates an environmental impact in a field which is highly sensitive for Switzerland, it will be highly valuated.

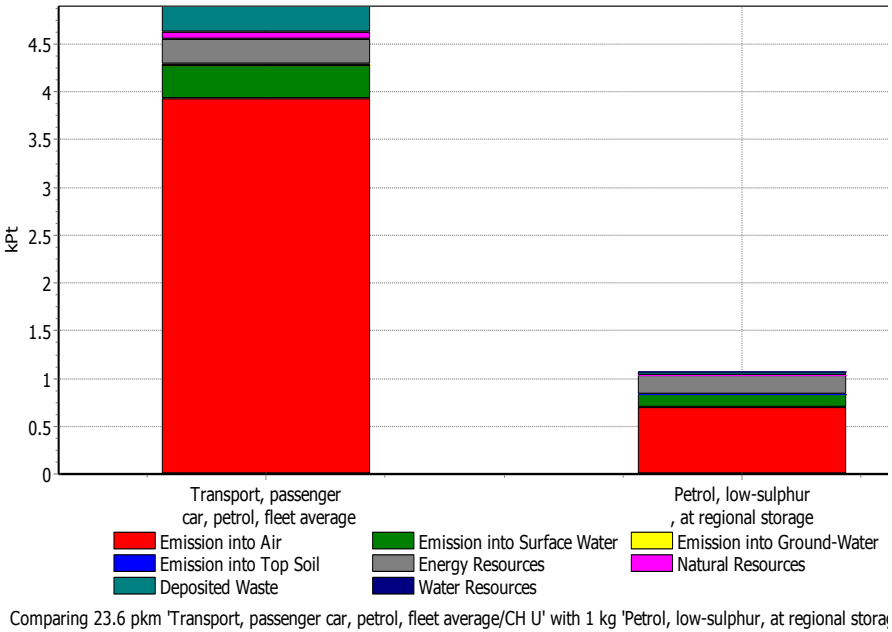
    → E.g. ecological scarcity 2006 does not highly valuate the use of water as there is no water scarcity in Switzerland.

- Ecological scarcity 2006 was adapted to Jordan taking into account the actual flows, the legal situation, the environmental goals and the scarcity of resources like water:
  - The whole set of factors have been adopted to the Jordanian situation.
  - If no data was available Swiss data has been used taking into account the population and the technical situation of Jordan.

Example: Transport, passenger car

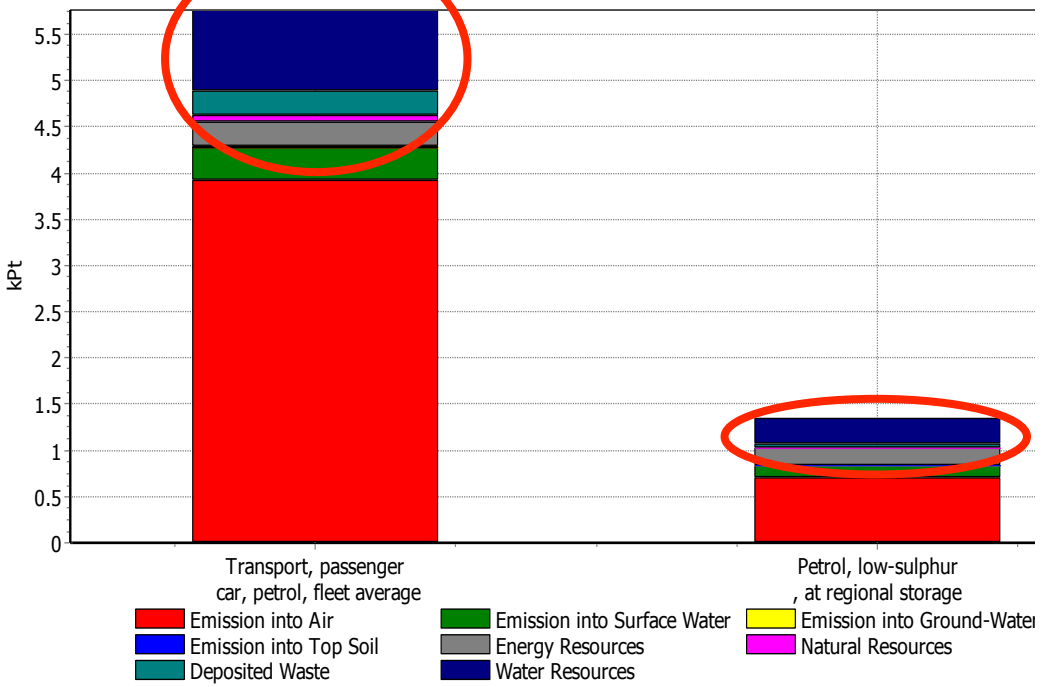
Adaptation of valuation methodology & data

Europe



Comparing 23.6 pkm 'Transport, passenger car, petrol, fleet average/CH U' with 1 kg 'Petrol, low-sulphur, at regional stora

Jordan



Comparing 23.6 pkm 'Transport, passenger car, petrol, fleet average/CH U' with 1 kg 'Petrol, low-sulphur, at regional stor

E.g. the scarcity of water is very high in Jordan. In consequence the water consumption will be valuated very high.

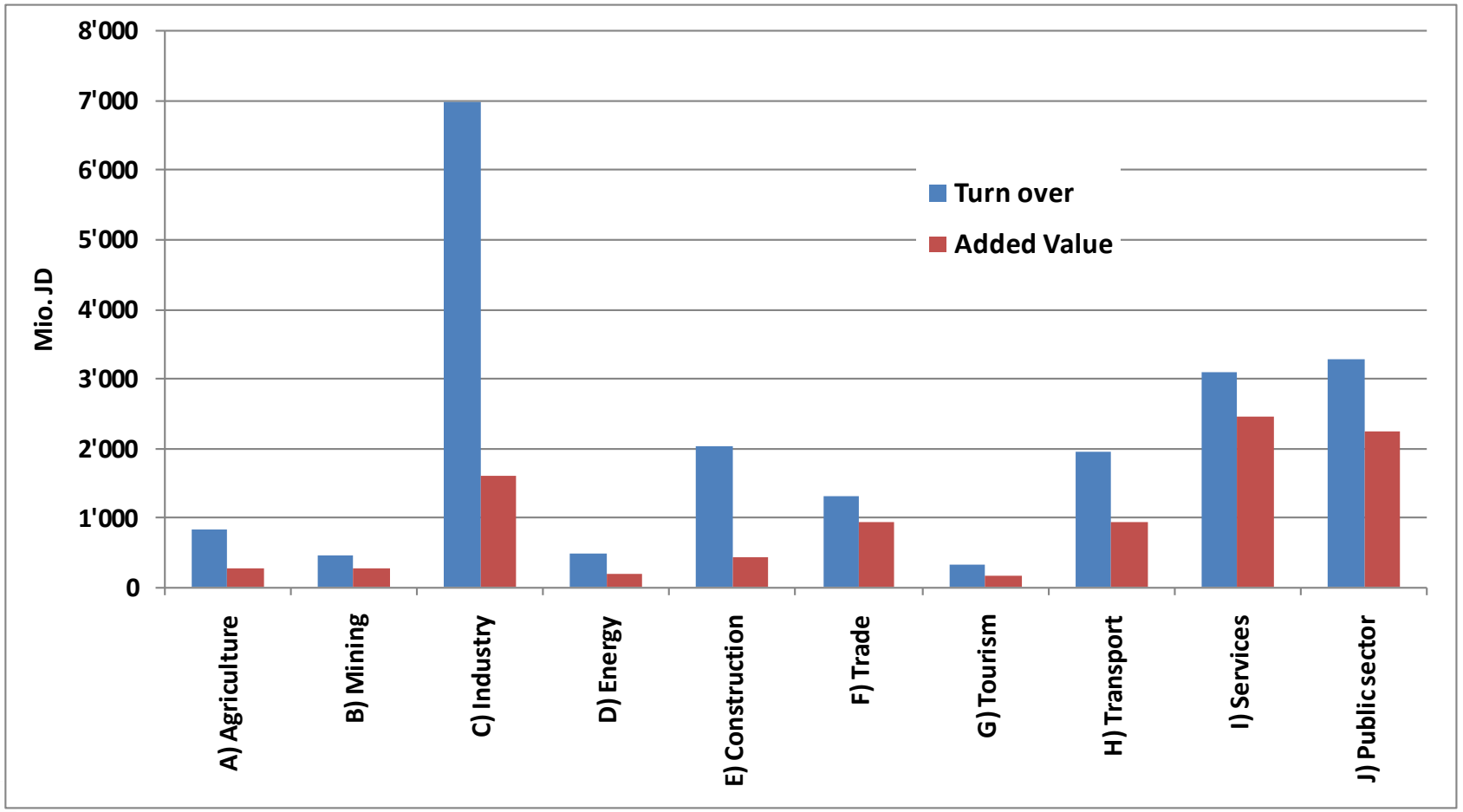
Life Cycle Assessment (LCA)
on economic sectors of Jordan

University of Applied Sciences
Northwestern Switzerland

carbotech
ENVIRONMENTAL PROJECTS/
CONSULTING/ANALYSIS

Economic analysis of the main sectors of Jordan

Results



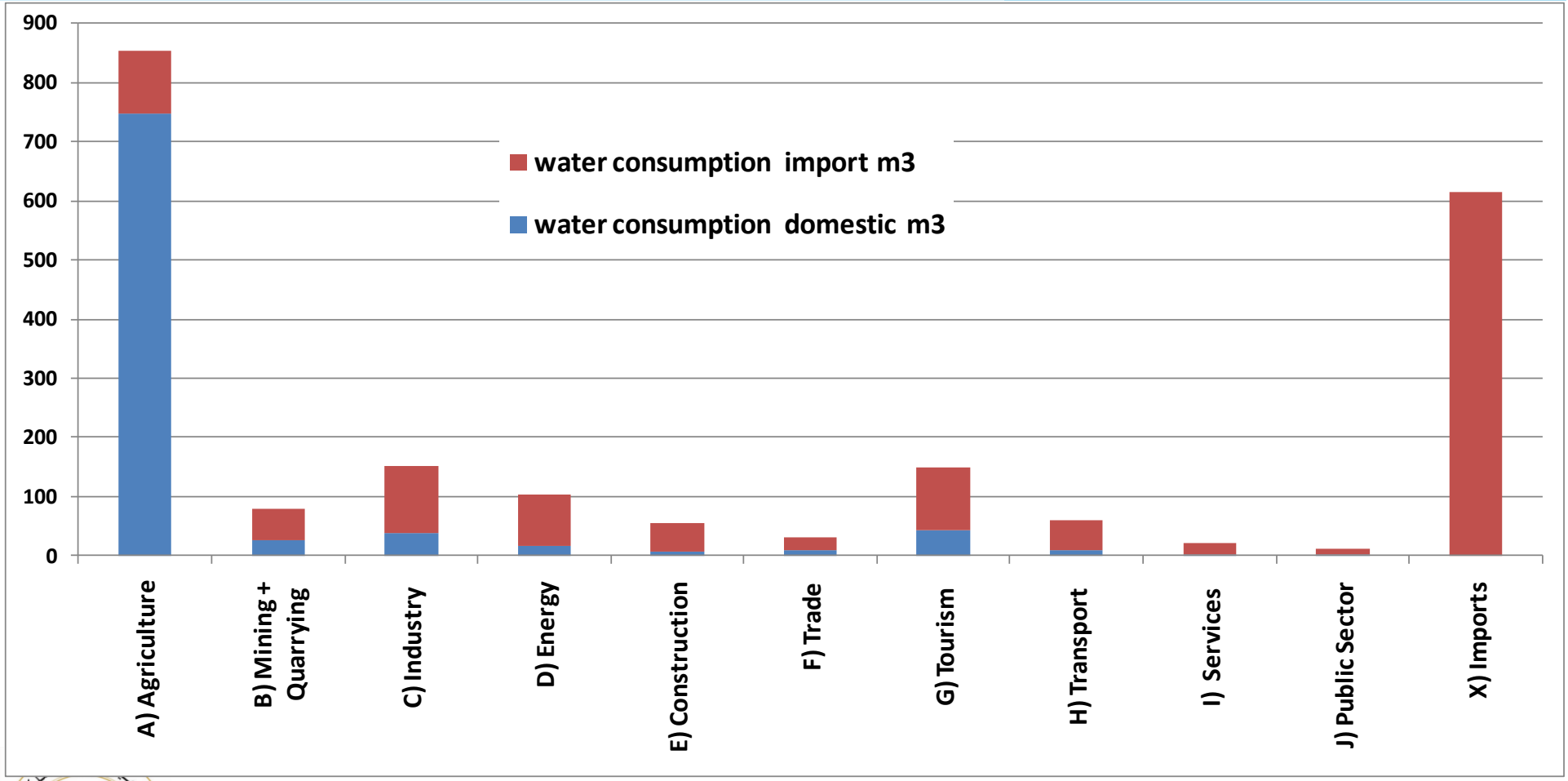
Life Cycle Assessment (LCA)
on economic sectors of Jordan

University of Applied Sciences
Northwestern Switzerland

carbotech
ENVIRONMENTAL PROJECTS/
CONSULTING/ANALYSIS

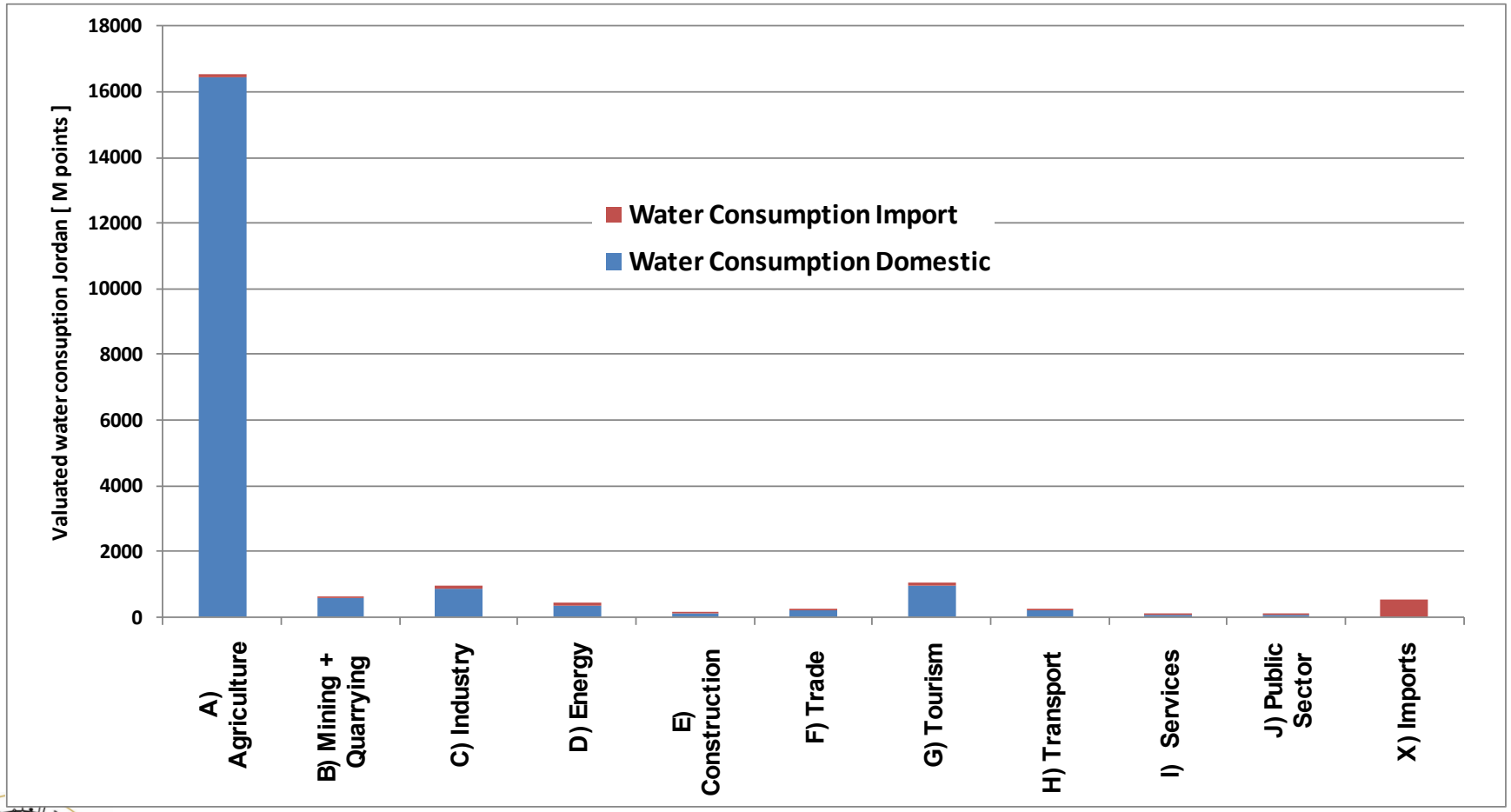
Water consumption per 1'000 JD value added in the different economic sectors

Results



Valuated water consumption per 1'000 JD value added in the different economic sectors

Results



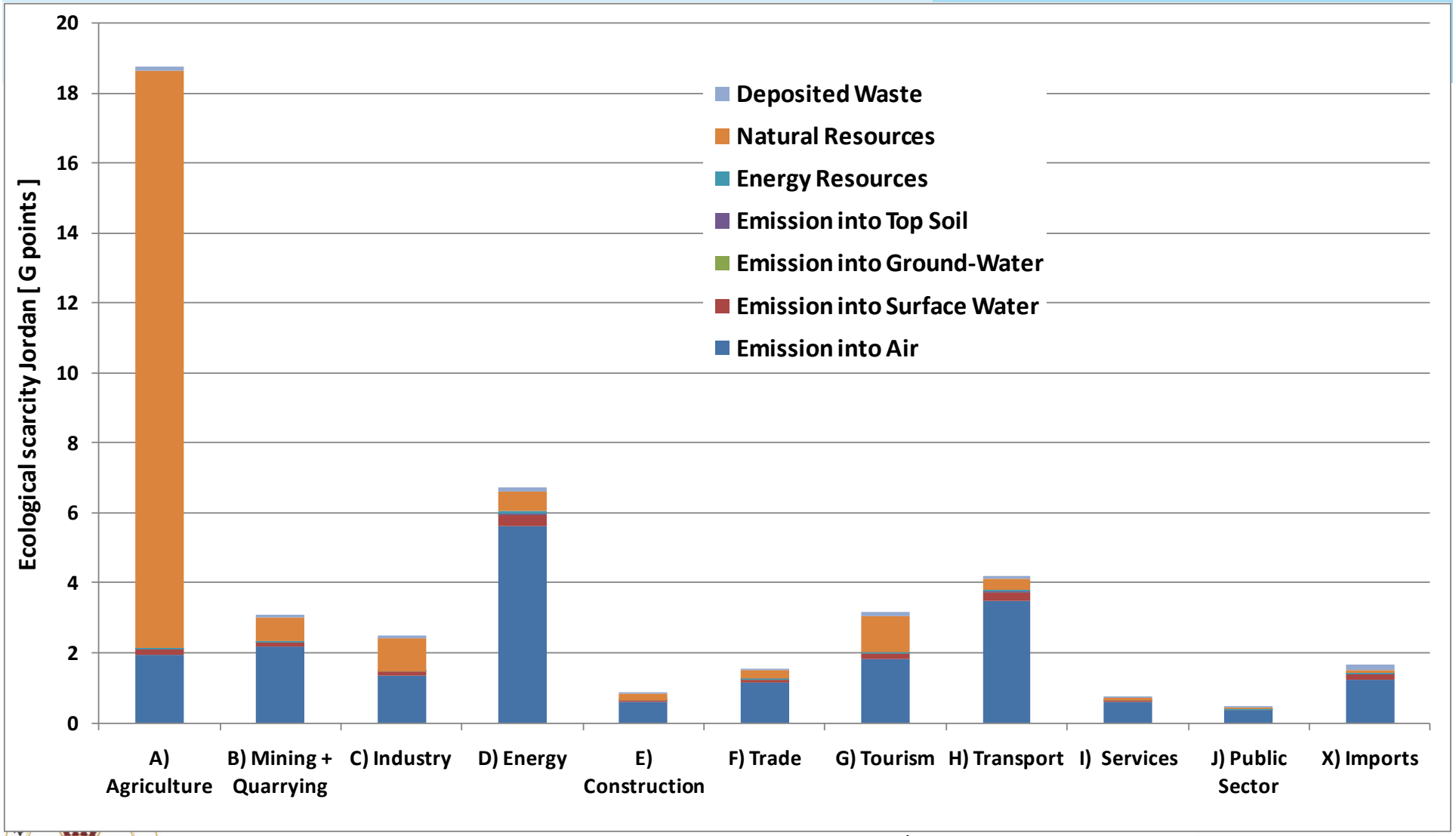
Life Cycle Assessment (LCA)
on economic sectors of Jordan

University of Applied Sciences
Northwestern Switzerland

carbotech
ENVIRONMENTAL PROJECTS/
CONSULTING/ANALYSIS

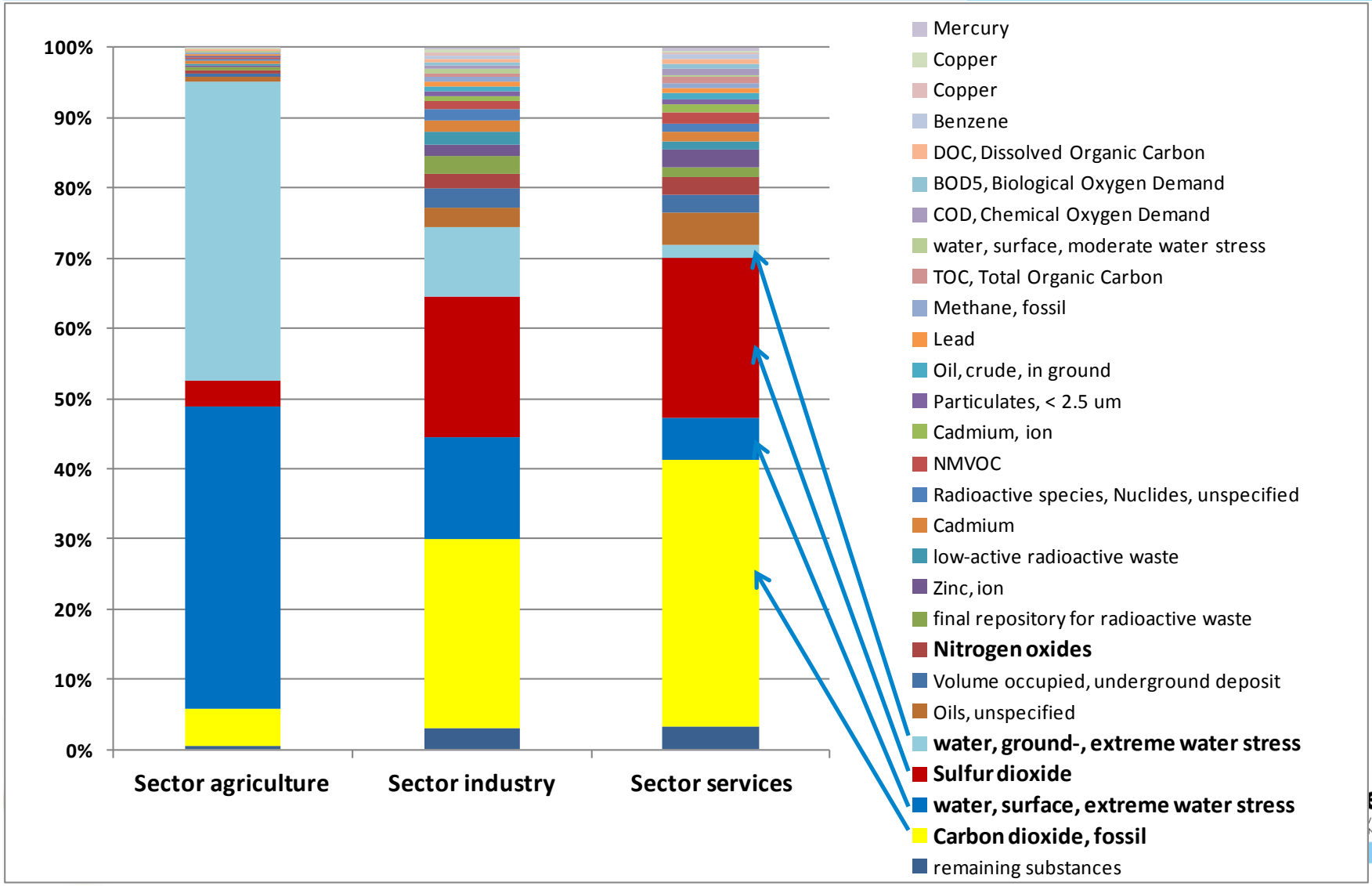
Environmental impacts per 1'000 JD value added in the different economic sectors

Results



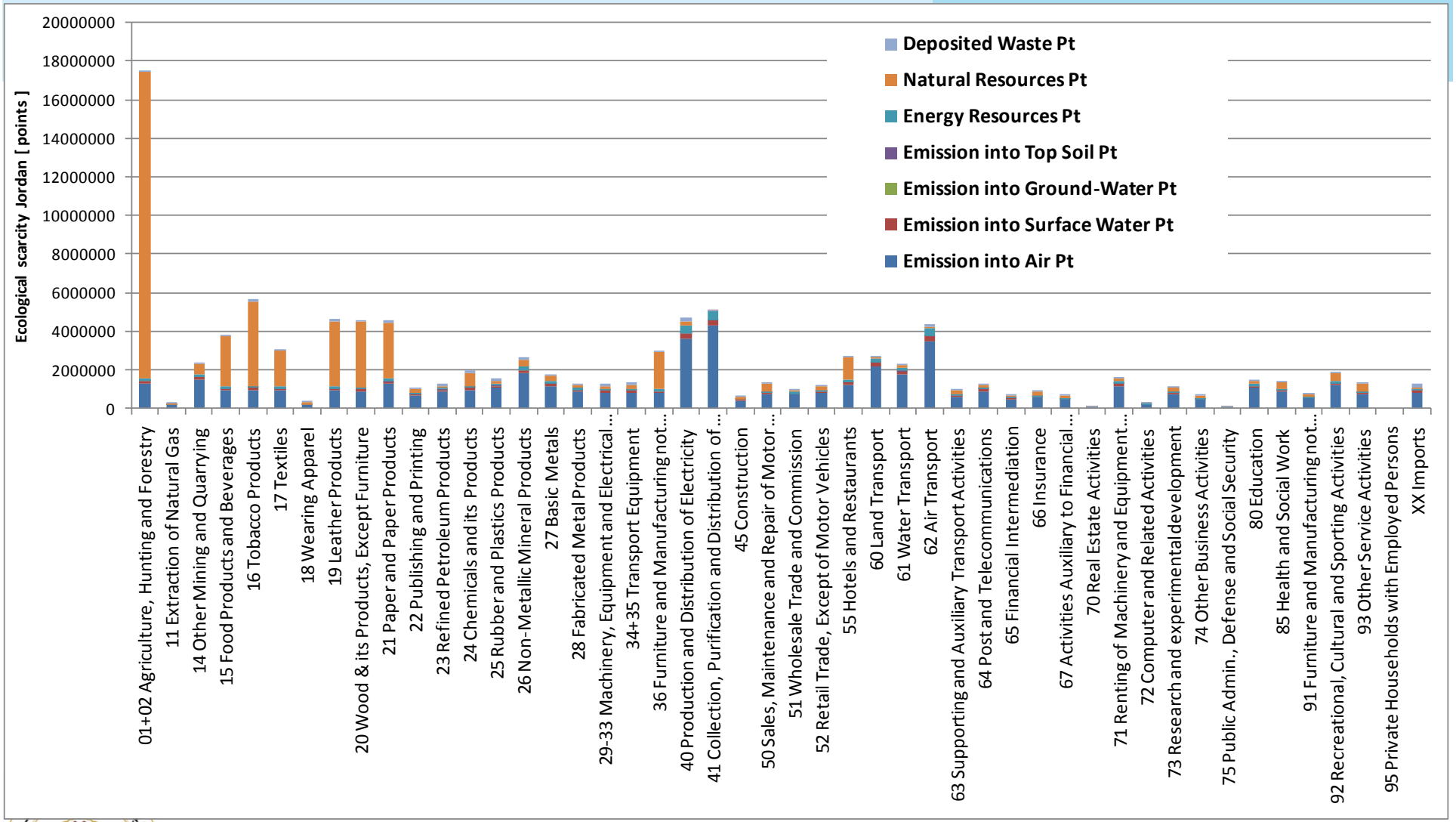
Relevant emissions and use of resources in the different sectors

Results



Environmental impacts per 1'000 JD value added in the different economic sectors

Results



Life Cycle Assessment (LCA)
on economic sectors of Jordan

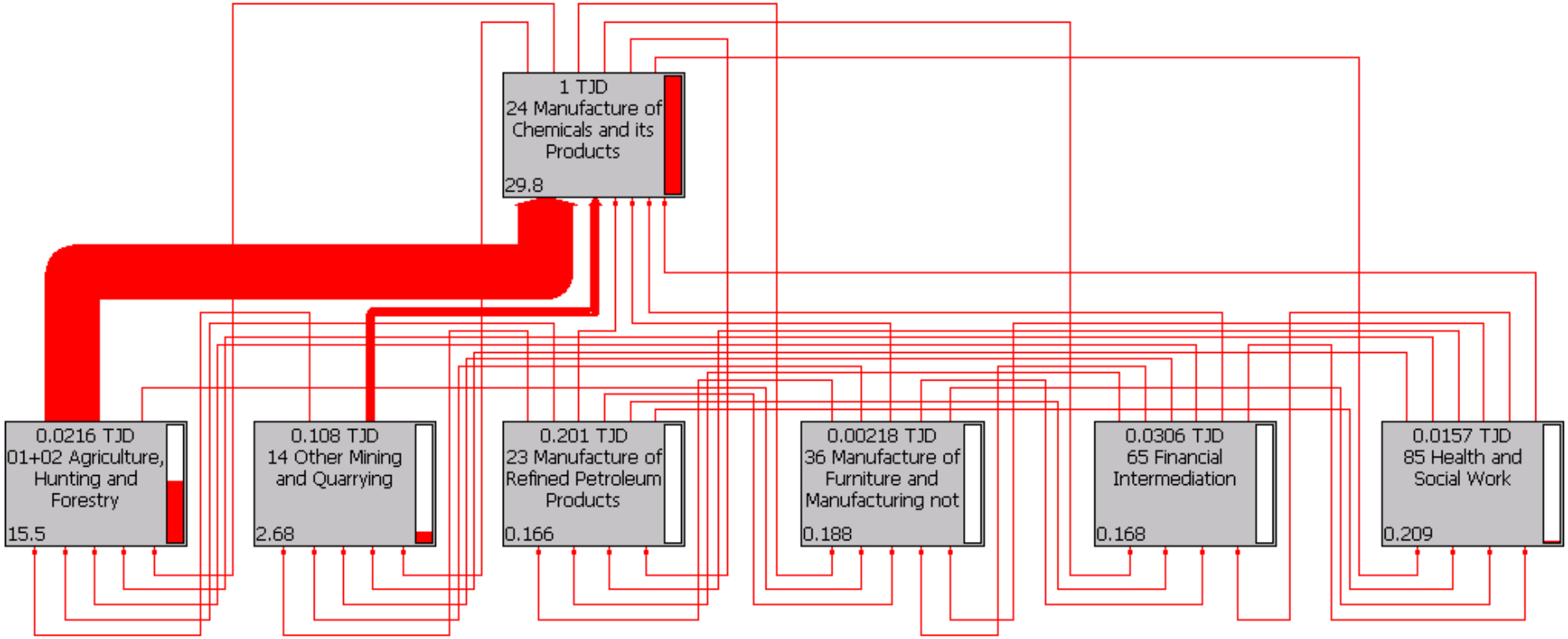
University of Applied Sciences
Northwestern Switzerland

carbotech
ENVIRONMENTAL PROJECTS/
CONSULTING/ANALYSIS

Consumption of domestic water

Example:

manufacturing of chemicals & its products



30 m^3 water is used per 1'000 JD of value added
11 m^3 direct use
19 m^3 in other sectors

Life Cycle Assessment (LCA)
on economic sectors of Jordan

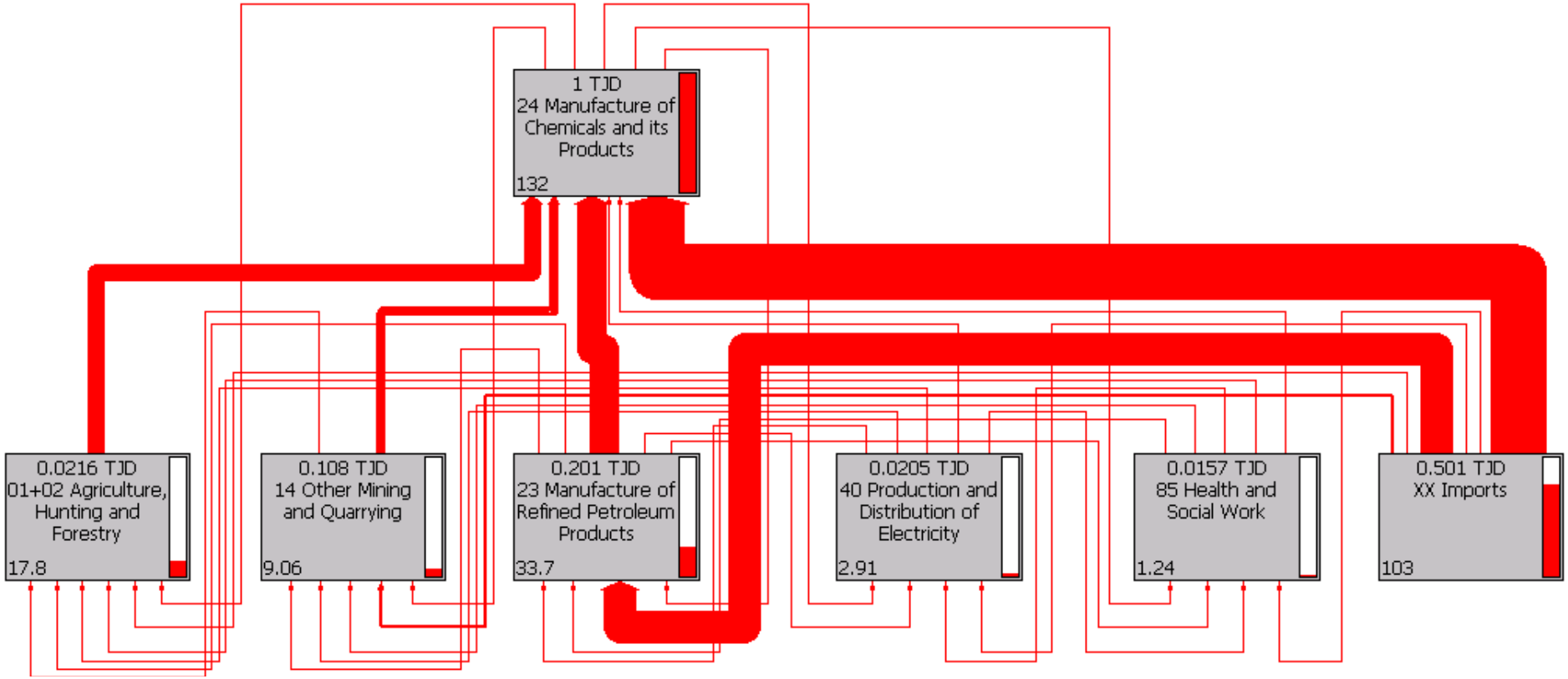
Royal Scientific Society

University of Applied Sciences Northwestern Switzerland

carbotech ENVIRONMENTAL PROJECTS/ CONSULTING/ANALYSIS

Total consumption of water

Example:
manufacturing of chemicals & its products



132 m³ water is used per 1'000 JD of value added
103 m³ water used abroad
30 m³ water used in Jordan

Life Cycle Assessment (LCA)
on economic sectors of Jordan

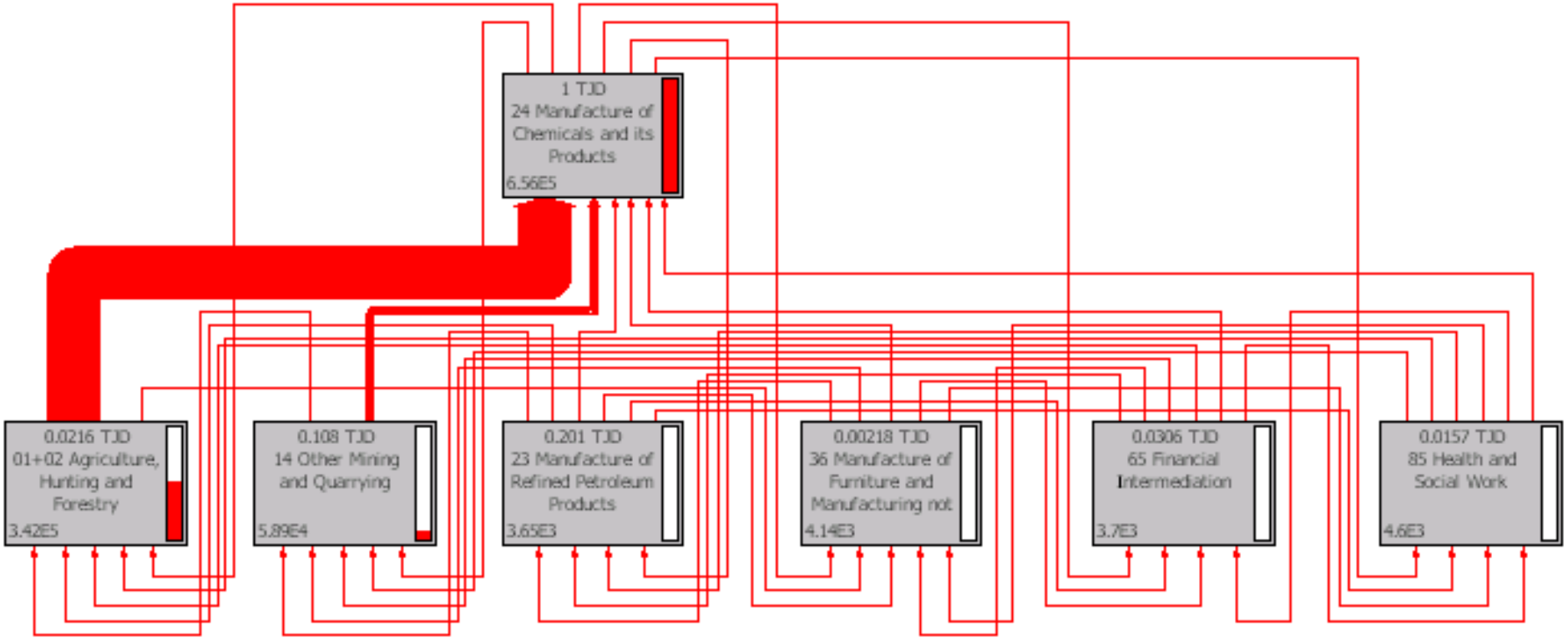
University of Applied Sciences
Northwestern Switzerland

carbotech
ENVIRONMENTAL PROJECTS/
CONSULTING/ANALYSIS

Weighted water consumption using eco-factors for fresh water

Example:

manufacturing of chemicals & its products



The use of domestic water is important regarding the Jordanian situation.

Life Cycle Assessment (LCA)
on economic sectors of Jordan

University of Applied Sciences
Northwestern Switzerland

carbotech
ENVIRONMENTAL PROJECTS/
CONSULTING/ANALYSIS

Discussion

The results clearly show the problem of domestic water use.

However it is not as simple as to conclude that there must be a shift from agriculture to other sectors. The reality is much more complex because of different reasons like:

- Social aspects like employment, education cannot be neglected when taking strategic decisions.
- The structure of the Jordanian society will not favour an economy which depends on services alone.

Detailed analyses and improvements are necessary and possible with this tool.

Conclusions

- The study is a good initial position and gives first insights into which economic sectors are more eco-efficient than others.
- The water footprint is essential for semiarid and arid areas such as Jordan but it is also important to take into account other environmental impacts.
- **Recommendation:**
  - Improvement of the input-output model
    → An official, verified input-output matrix of Jordan's economy would be very helpful.
  - Amelioration of the environmental data sets

Future actions

The tool can be used, especially after improvement, for:

- Evaluating the water footprint and the environmental impacts of sectors to evaluate e.g.:
  - where a lot of scarce domestic water is “exported” in products
  - if it could be better to “import” water intensive products from countries with less water scarcity
- Strategic decisions on which sectors have to be developed taking into account the environmental, social and economic dimension
- Analyzing the different sectors and the relations to the others for improvement
- For hybrid LCA

Workshop: How to use I/O for decision support

- Insight into practical use of I/O analysis in EMIS
- Hybrid LCA
- Two examples from practical experience:
  - Changes in the national economy represented through I/O analysis
    → economic and ecological effects
  - Calculate personal environmental footprint by using hybrid LCA

Thank you for your attention

I hope there will be questions to discuss now or later