"Regional workshop to facilitate development and use of tools and methodologies for modelling and assessing the impacts of response measures "
from 21 to 23 September 2022 in M'Bour.

Green Jobs Assessment Model (GJAM)

Input-Output Table as model framework

Green expansions – numerical application

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United Nations
Climate Change Secretariat

International Labour Office
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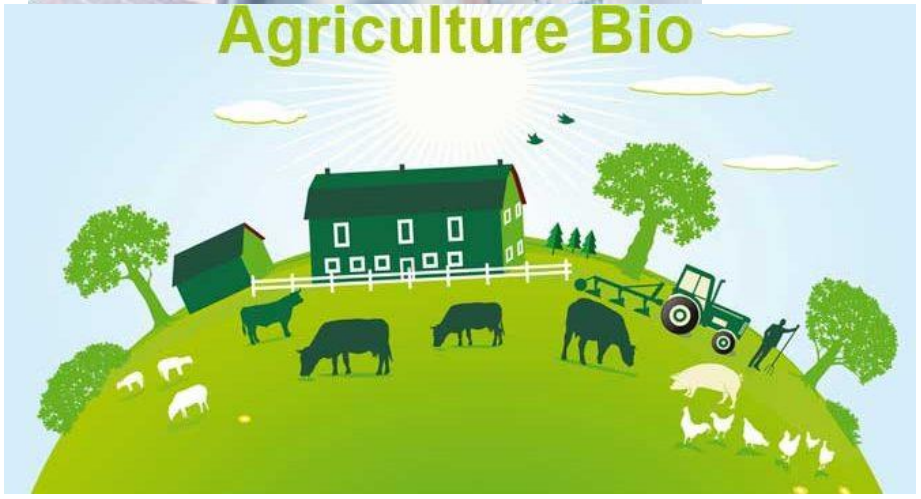
Case study : structural change

- Practice of organic/green agriculture
- Green manufacturing (renewable energy equipment)



How to obtain data on green activities and jobs?

Three options for getting green data:

- Full Survey (census)
- Estimation based on a sample survey
- Estimation based on literature and other countries

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Organic/Green Agriculture Survey

- Agriculture: Due to use of organic fertilizer, which is produced by the agricultural sector itself, organic agriculture spends 80% on intra-industry input than does conventional agriculture.
- Manufacturing input to organic agriculture is 20% of conventional agriculture's spending because of an 80% reduction of the purchasing of chemical fertilizers produced by the manufacturing sector.
- Services input to organic agriculture is 16% more because of its higher knowledge component in how to plant, combat pests, prune and harvest in organic production systems.
- Imports input to organic agriculture is none (of fertilizers);
- Taxes are at the same rate;
- Wage rates are the same. Organic agriculture is 20 per cent more labour-intensive;
- Gross operating surpluses are the same.

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Green manufacturing industry Survey (renewable energy equipment)

- ✓Intra-industry conventional energy input has the same share as the total output share of the renewable energy industry.
- ✓Intra-industry green energy input has the same share as the total output share of the renewable energy industry.
- ✓Input from the manufacturing industry is 20% higher for renewable energy than for conventional energy because, for this particular case, the equipment is produced locally (say, an industrial policy led to the creation of a wind manufacturing industry, such as happened in China in the 2010s).
- ✓Services input is 60% higher in green energy because the equipment requires more maintenance.
- ✓There are no imports in renewable energy, as no fossil fuels are required and the technology is locally produced.
- ✓Taxes shares are the same.
- ✓Wages are the same, but renewable energy is 30% more labour-intensive, and so the total wage bill is 30% higher for renewable energy.
- ✓Shares going to gross operating surplus are the same.
- ✓Green energy production is 5% of the total.

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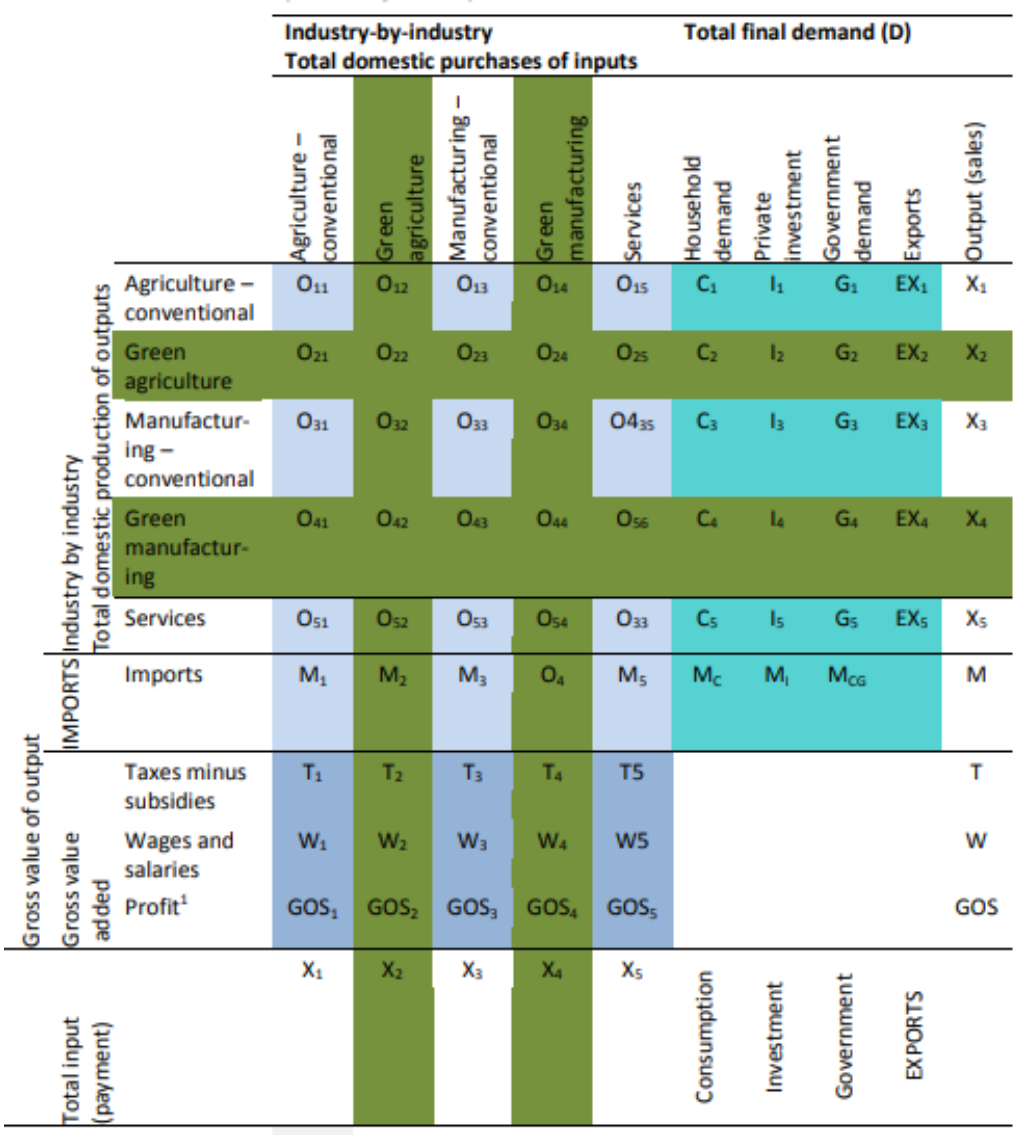
Accounting for "Green" activities



		Industry-by-industry Total domestic purchases of inputs					Total final demand (D)				
		Agriculture – conventional	Green agriculture	Manufacturing – conventional	Green manufacturing	Services	Household demand	Private investment	Government demand	Exports	Output (sales)
Total domestic production of outputs: Industry by industry	Agriculture – conventional	O_{11}	O_{12}	O_{13}	O_{14}	O_{15}	C_1	I_1	G_1	EX_1	X_1
	Green agriculture	O_{21}	O_{22}	O_{23}	O_{24}	O_{25}	C_2	I_2	G_2	EX_2	X_2
	Manufacturing – conventional	O_{31}	O_{32}	O_{33}	O_{34}	$O4_{35}$	C_3	I_3	G_3	EX_3	X_3
	Green manufacturing	O_{41}	O_{42}	O_{43}	O_{44}	O_{56}	C_4	I_4	G_4	EX_4	X_4
	Services	O_{51}	O_{52}	O_{53}	O_{54}	O_{33}	C_5	I_5	G_5	EX_5	X_5
IMPORTS	Imports	M_1	M_2	M_3	O_4	M_5	M_C	M_I	M_{CG}		M
Gross value of output	Taxes minus subsidies	T_1	T_2	T_3	T_4	T5					T
Gross value added	Wages and salaries	W_1	W_2	W_3	W_4	W5					W
	Profit[1]	GOS_1	GOS_2	GOS_3	GOS_4	GOS_5					GOS
Total input (payment)		X_1	X_2	X_3	X_4	X_5	Consumption	Investment	Government	EXPORTS	

- ISIC Rev 4 does not distinguish between “environmental” activities.
- In conventional statistics, green and conventional are grouped together.
- The SEEA Guidance on the Environmental Goods and Services Sector (EGSS) provides guidance to distinguish the two.

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Expanding the IO table (Columns & Rows)

Tab. Example for calculating the production structure of the green industries

	Parent agriculture	**Conventional agriculture**	**Organic agriculture**
Agriculture	....	...	...
Chemical industry	P = P1 + P2	P1	P2
Totals	X = X1 + X2	X1	X2

Tab. Row expansion for agriculture

	Parent agriculture	**Conventional**	**Green**
Parent agriculture	12.50		
Conventional		12.06	0.00
Green		0.00	0.44

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Full green IO expansion for green agriculture and green manufacturing

	Conventional agriculture	Green	Conventional manufacturing	Green	Household demand	Services	Private investment	Government demand	Exports	Output (sales)
Conventional agriculture	12.06	0.00	26.42	0.07	39.26	58.89	4.42	80.49	268.95	490.58
Green	0.00	0.44	0.51	0.00	0.74	1.11	0.08	1.51	5.05	9.43
Conventional manufacturing	23.75	0.00	50.79	0.00	114.46	71.54	566.58	15.26	15.26	857.64
Green	1.15	0.10	0.00	3.21	5.54	3.46	27.42	0.74	0.74	42.36
Services	48.84	1.16	49.81	4.19	80.00	15.00	4.50	85.30	461.20	750.00
Imports	75.00	0.00	108.00	0.00	160.00	30.00	297.00	206.70		876.70
Taxes minus subsidies	12.25	0.25	17.95	0.05		15.00				45.50
Wages & salaries	244.02	5.98	505.42	34.58		450.00				1 240.00
Gross operating surplus	73.50	1.50	98.74	0.26		105.00				279.00
TOTAL	490.58	9.43	857.64	42.36	400.00	750.00	900.00	390.00	751.20	

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Input–output modelling

		Industry-by-industry Total domestic purchases of inputs			Total final demand (D)				
		Agriculture	Manufacturing	Services	Household demand	Private investment	Government demand	Exports	Output (sales)
Industry by industry Total domestic production of outputs	Agriculture	O_{11}	O_{12}	O_{13}	C_1	I_1	G_1	EX_1	X_1
	Manufacturing	O_{21}	O_{22}	O_{23}	C_2	I_2	G_2	EX_2	X_2
	Services	O_{31}	O_{32}	O_{33}	C_3	I_3	G_3	EX_3	X_3
IMPORT	Imports	M_1	M_2	M_3	M_C	M_I	M_G		M
Gross value of output	Taxes minus subsidy	T_1	T_2	T_3					T
Gross value added	Wages and salaries	W_1	W_2	W_3					W
	Profit[1]	$Profit_1$	$Profit_2$	$Profit_3$					Profit
Total input (payment)		X_1	X_2	X_3	C	I	G	EX	

X1 = O11 + O12 + O13 + C1 + I1 + G1 + EX1
X2 = O21 + O22 + O23 + C2 + I2 + G2 + EX2
X3 = O31 + O32 + O33 + C3 + I3 + G3 + EX3
…

All sectors are a fixed share (aij, or technical coefficient) of its total output

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Input–output modelling

The contents of IO table can be presented as follows:

X1 = a11 X1 + a12 X2 + a13 X3 + a14 C + a15 I + a16 G + E1

X2 = a21 X1 + a22 X2 + a23 X3 + a24 C + a25 I + a26 G + E2

X3 = a31 X1 + a32 X2 + a33 X3 + a34 C + a35 I + a36 G + E3

Imports (M) = a41 X1 + a42 X2 + a43 X3

Taxes = a51 X1 + a52 X2 + a53 X3

Wages (W) = a61 X1 + a62 X2 + a63 X3

Profits = a71 X1 + a72 X2 + a73 X3

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Input–output modelling

Input–output model expressed in vector

X is a vector of sectoral outputs.

$$X = \begin{bmatrix} X_1 \\ X_2 \\ X_3 \end{bmatrix}$$

A is a matrix of technical coefficients, or direct requirements coefficients

$$A = \begin{bmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{32} & a_{33} \end{bmatrix}$$

D is a vector of final demand per sector

$$D = \begin{bmatrix} D_1 \\ D_2 \\ D_3 \end{bmatrix}$$

With: D1 = C1+ I1 + G1 + E1,
D2 = C2 + I2 + G2 + E2
D3 = C3 + I3 + G3 + E3

Input–output modelling

The input–output model in vector

$$X = AX + D$$

$$\Rightarrow D = (I - A)X$$

where I is an identity matrix.

$$\Rightarrow X = (I - A)^{-1} D$$

$(I - A)^{-1}$ is called the Leontief inverse.

Impact analysis

$$(I - A)^{-1} \Delta D = \Delta X$$

$$A = \begin{bmatrix} 0.02 & 0.00 & 0.03 & 0.00 & 0.08 \\ 0.00 & 0.05 & 0.00 & 0.00 & 0.00 \\ 0.05 & 0.00 & 0.06 & 0.00 & 0.10 \\ 0.00 & 0.01 & 0.00 & 0.08 & 0.00 \\ 0.10 & 0.12 & 0.06 & 0.10 & 0.02 \end{bmatrix}$$

$$(I - A)^{-1} = \begin{bmatrix} 1.04 & 0.01 & 0.04 & 0.01 & 0.09 \\ 0.00 & 1.05 & 0.00 & 0.00 & 0.00 \\ 0.06 & 0.01 & 1.07 & 0.01 & 0.11 \\ 0.00 & 0.01 & 0.00 & 1.08 & 0.01 \\ 0.11 & 0.13 & 0.07 & 0.11 & 1.04 \end{bmatrix}$$

Adding up the columns of Leontief inverse gives the output multipliers

Conventional agriculture	Green agriculture	Conventional manufacturing	Green manufacturing	Services (no distinction between green and conventional)
1.21	1.22	1.18	1.22	1.24

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Impact analysis

- Employment model

$$\Delta E = e[(I - A)^{-1}\Delta D]$$

- GDP/VA or income model

$$\Delta GDP = gdp[(I - A)^{-1}\Delta D]$$

- CO_2 model

$$\Delta \boldsymbol{CO_2} = \boldsymbol{co_2}[(I - A)^{-1}\Delta D]$$

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Employment analysis

Employment model formula $\Delta E = e[(I - A)^{-1}\Delta D]$

Employement Coefficiant (e)

	Ag	Green Ag	Manuf	Green Manuf	Service
Total employment	122	3	90	6	89
Total output	490,57	9,43	857,64	42,36	750,00
Empl.Coeff	**0,25**	**0,32**	**0,10**	**0,14**	**0,12**

Diagonal Employement Coefficiant (e)

	Ag	Green Ag	Manuf	Green Manuf	Service
Conv Agri	0,25	0	0	0	0
Green Agri	0	0,32	0	0	0
Conv. Manuf.	0	0	0,10	0	0
Green Ind	0	0	0	0,14	0
Service	0	0	0	0	0,12

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Employment analysis

- Employment Coefficient

Employment multiplier (e(I -A)-1)

	Agri.	Green Agri.	Manuf.	Green Manuf.	Service
Conv Agri	0,26	0,01	0,01	0,00	0,02
Green Agri	0,00	0,32	0,00	0,00	0,00
Conv. Manuf.	0,01	0,00	0,11	0,01	0,01
Green Ind	0,00	0,00	0,00	0,14	0,00
Service	0,01	0,02	0,01	0,01	0,12
Employment multiplier	0,28	0,35	0,13	0,17	0,16

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Employment analysis

employment creation – a green agricultural growth scenario and a conventional agricultural growth scenario, both anticipating a 6 per cent (or 30-unit) increase in total agricultural production next year.

	Conventional agriculture	Green agriculture
	7.73	0.08
	0.00	10.02
	0.20	0.05
	0.01	0.05
	0.39	0.48
Total employment	8.34	10.68

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Thank!

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