FAO-GBEP Sustainability indicators for bioenergy

Indicator 10: Price and supply of a national food basket

Pilot testing in Indonesia

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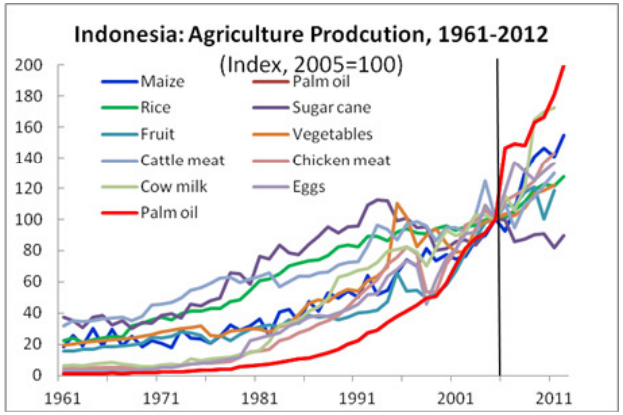
11 December 2013
GBEP annual meeting, FAO, Rome

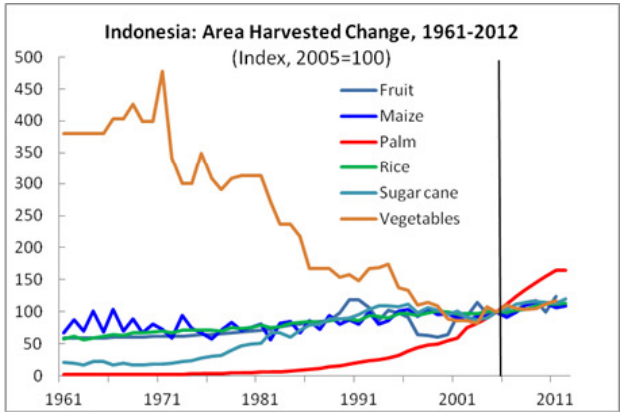
Content

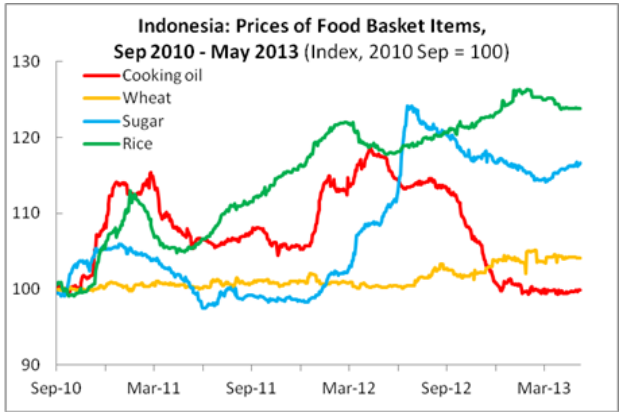
- Tier I approach
- Tier II: Simplest and Simulation approach
  - Methodology
  - Provisional results
- Provisional conclusions and policy recommendations
- Methodological improvements and adaptation
- Practicality, relevance, scientific basis of the indicator

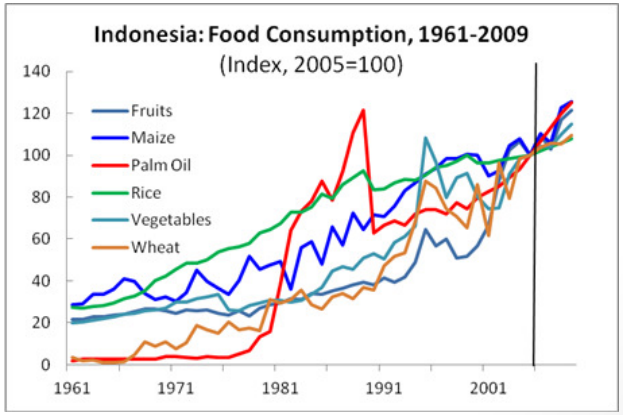
FAO-GBEP Indicator 10: Tier I: "Preliminary indication"

1) In the context of increased bioenergy demand and;
2) Based on historical data of price/supply:
3) **Is there an increase in price and/or a reduction in supply of the food basket(s) and/or of its components ?**

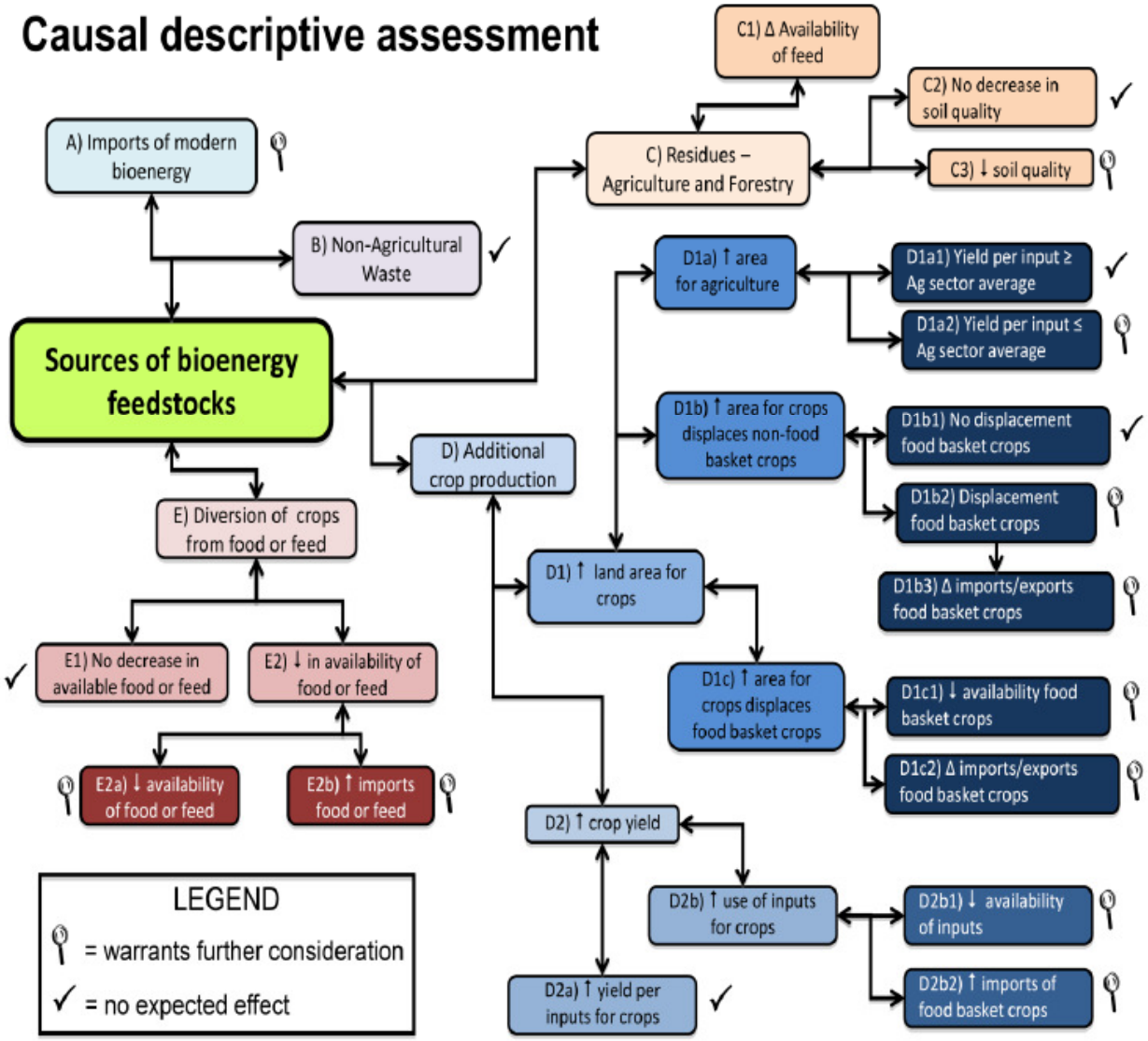








FAO-GBEP Indicator 10: Tier II: "Causal descriptive assessment"



Objective of the Tier II approach

- **Assessment of the probability of a decrease in supply/increase in price of a food basket crop subjected to an increase in domestic demand for modern bioenergy.**
  - Define the **role of modern bioenergy** (in the context of other factors).
  - Define the **share** of the demand for modern bioenergy met by each national **supply strategy**.
  - Define **scenarios for which further analysis** (Tier III) is required, based on the effect of other relevant factors.
  - **Provide policy recommendation** and explore corrective actions, based on alternative bioenergy supply strategies.
- **Tier II Simplest approach: "Preliminary assessment"**
- **Tier II Simulation approach: "Simulation-based assessment"**

Tier II: Simplest approach

Demand for modern bioenergy	2001	2008	2012	Units
Biodiesel domestic consumption	0	46	582	kton
Biodiesel exports	0	0	1350	kton
Biodiesel demand	*0*	*46*	*1932*	*kton*
D) Additional crop production				
Additional FFB production for biodiesel	*0*	*487*	*15868*	*kton*
D1) Increased land area for crops				
Additional area of oil palm for biodiesel	*0*	*12*	*430*	*kHa*
D1a) Increased area for agriculture	0	6	224	kHa
D1b) Increased area from non-FBC	0	5	174	kHa
D1c) Increased area from FBC	0	1	20	kHa

FFB: Fresh fruit bunches
FBC: Food basket crop

Contribution of system dynamics simulation

- **Time-dependent analysis**
  - Historical data availability and harmonization.
- **Assessment of price/supply interactions**
  - Link feedstock supply to the demand for modern bioenergy.
- **Relation with other relevant factors**
  - Define interaction with land-use, agricultural, industrial and energy domestic and international markets.
- **System dynamics (SD) simulation**
  - Description of the system through feedback interactions over time (in the context of other external factors).
- **Alternative scenarios/strategies**
  - Identifying points (“magnifying class”) for further analysis (Tier III).
- **Recommendations**
  - Understand the level of pressure of bioenergy demand on price/supply of food basket items, the factors that affect the most and provide actions recommended for policy.

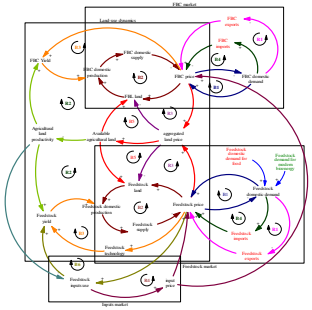
Challenges to indicator measurement encountered

- **Data availability and consistency**
  - Decentralized data and lack of coordination
  - Lack of data and consistency
  - Heterogeneous data and estimations

- **Modelling approach**
  - Variables representation in system dynamics
  - Type of simulation and “reading” of results
  - Calibration of model

System dynamics simulation approach

- **Conceptual model**
  - Causal loop diagram

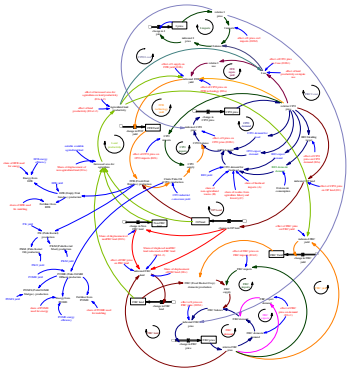


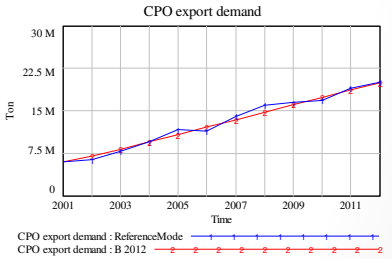
- **Model specifications**
  - Generic model equations
  - Case specific model equation

$$q^{bio,c}{}_t = \alpha^{e,s,bio}{}_t \cdot q^{e,s}{}_t$$

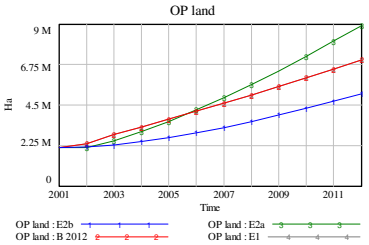
$$q^{mb}{}_t = q^{i,mb}{}_t + q^{w,mb}{}_t + q^{r,mb}{}_t + q^{p,mb}{}_t + q^{d,mb}{}_t$$

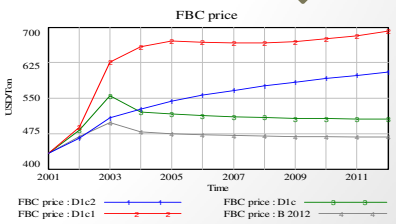
- **Simulation model**
  - Software and time frame
  - Stock and flow diagram
  - Model calibration





- **Simulation experiments**
  - Biodiesel demand scenarios
  - Alternative supply strategies
  - Alternative other relevant factors





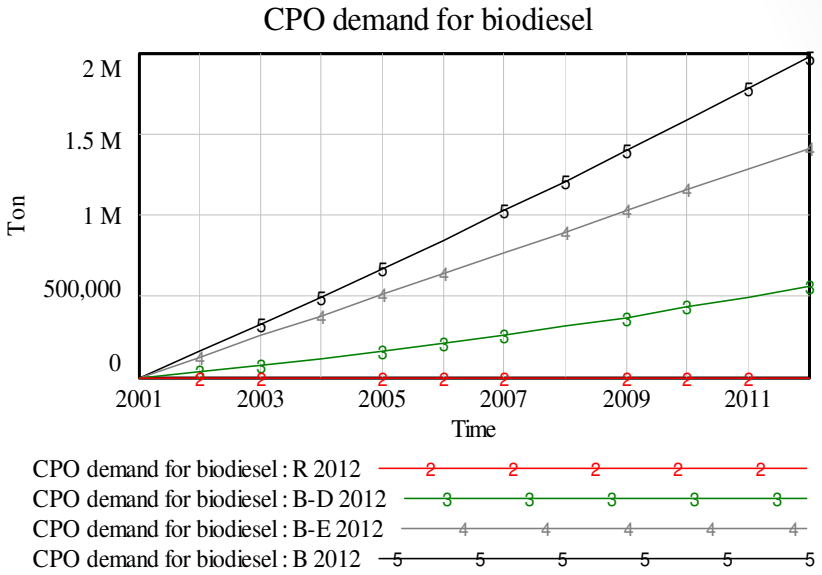
Reference and alternative scenarios

SCENARIOS:

- R 2012: Without biodiesel demand
- B 2012: With biodiesel demand
- B-D 2012: Biodiesel domestic demand
- B-E 2012: Biodiesel export demand

DATA:

- FAPRI Agricultural Outlook 2012
- FAO-OECD Agricultural Outlook 2012
- ID Min.Trade
- ID. Min. Energy



- CPO demand for biodiesel increase with increasing **diesel consumption** and increasing **blending targets** in the domestic market and with increasing biodiesel demand for the **export market**.

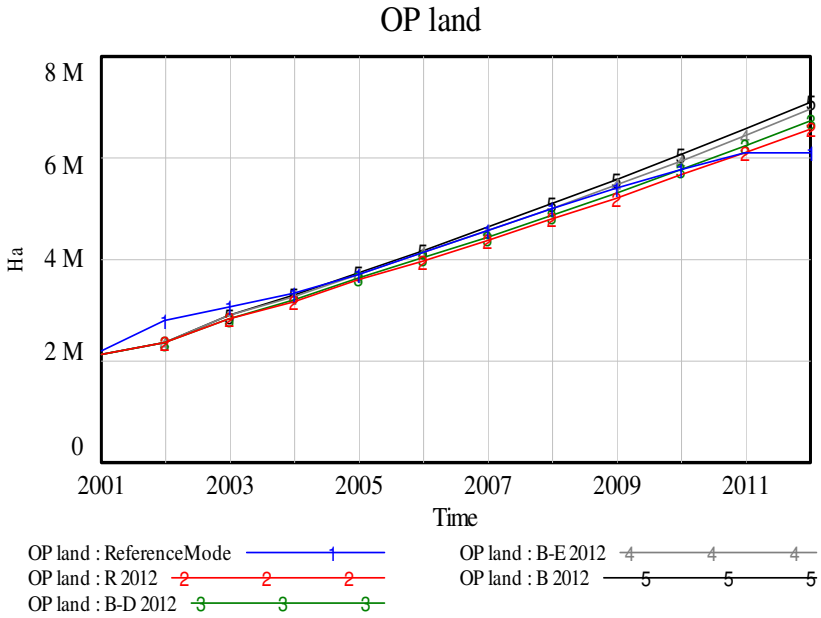
Simulation experiments: Alternative scenarios/strategies/effects

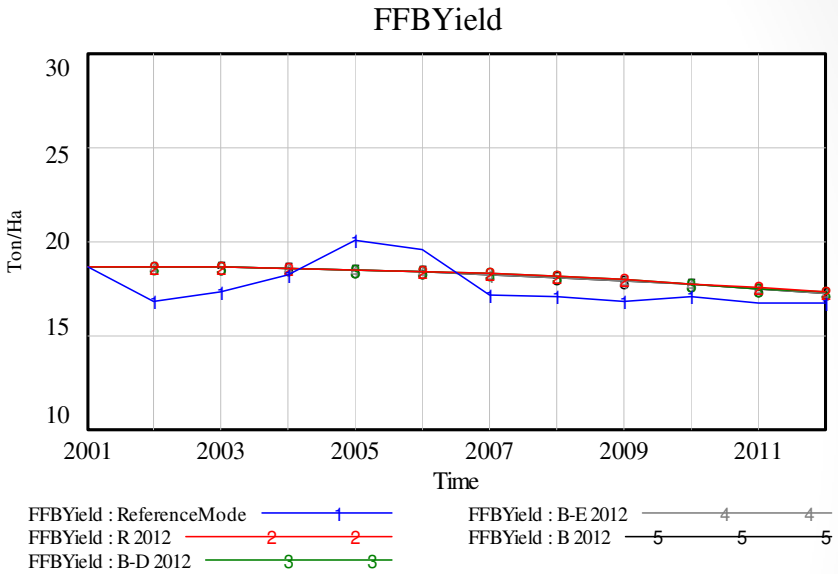
CDA components

Model parameters

	Reference value	Range for values	Imports	Non-agricultural Wastes	Residues from agriculture, fisheries and	Increased area for crops	Increased area for agriculture	Increade land productivity	Decreased land producvity	Displacement of non-FBC	No displacement of FBC	Displacement of FBC	FBC supply covered by imports	Displacement of FBC	Decrease availability of FBC	FBC supply covered by imports	Increased crop yield	Improved technology/management	Increased use of inputs	Decrease availability of inputs	Increase imports of inputs	No decrease in feedstock supply for food	Decrease supply of FBC	Feedstock supply covered by imports
Parameter	**Ref**	**Range**	**A**	**B**	**C**	**D1**	**D1a**	**D1a1**	**D1a2**	**D1b**	**D1b1**	**D1b2**	**D1b3**	**D1c**	**D1c1**	**D1c2**	**D2**	**D2a**	**D2b**	**D2b1**	**D2b2**	**E1**	**E2a**	**E2b**
share of biodiesel imports	0.00	(0,1)	1																					
share of non-agricultural wastes	0.00	(0,1)		1																				
share of resides from agriculture fishery and forestry	0.00	(0,1)			1																			
effect of CPO price on OP land	0.78	(0,1)				1																		
share of displacement of non agricultural land	0.75	(0,1)					1			0				0										
effect of land productivity on yield	0.10	(-1,1)						1	-1															
share of displacement of nonFBC land	0.10	(0,1)					0			1				0										
share of displaced nonFBC land relocated on FBC land	0.20	(0,1)									0	1												
effect of FBC price on FBC imports	0.22	(0,1)											1			1								
share of displacement of FBC land	0.15	(0,1)					0			0				1										
effect of FBC price on demand	-0.22	(-1,0)													-1	0								
effect of CPO price on FFB technology	0.01	(0,1)															1	1						
effect of I supply on FFB yield	0.01	(0,1)																	1					
effect of CPO price on I use	0.20	(0,1)															1		1					
effect of I price on CPO price	0.20	(0,1)																	1					
effect of I price on FBC price	0.20	(0,1)																	1					
effect of I price on I imports	0.20	(0,1)																		0	1			
effect of CPO price on CPO demand	-0.20	(-1,0)																				0	-1	
effect of CPO price on CPO imports	0.20	(0,1)																						1

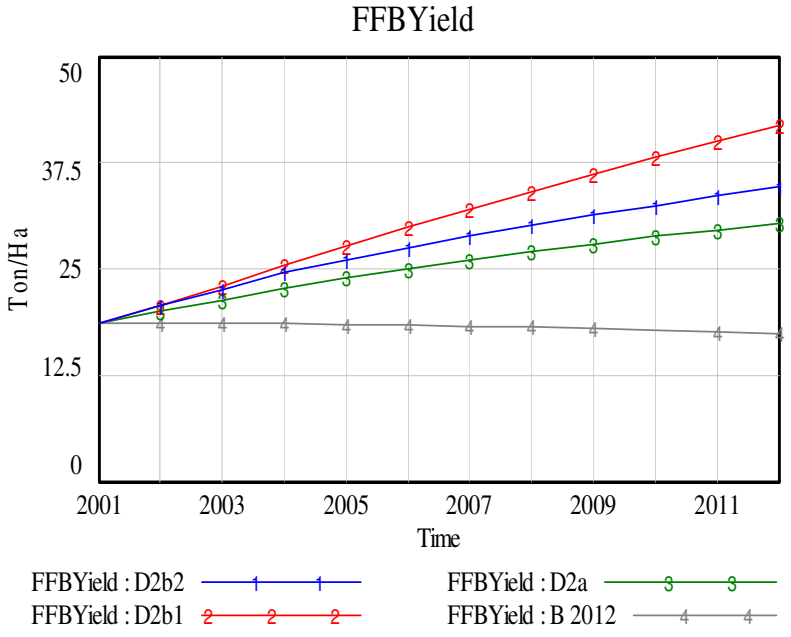
Simulation results: Reference and alternative scenarios

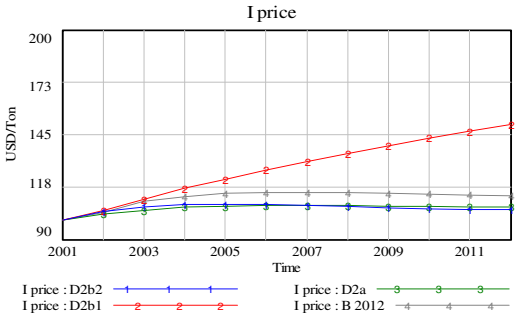


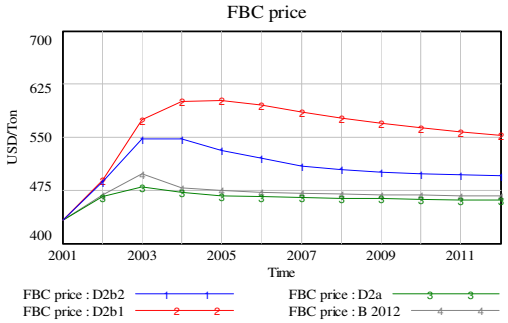


- Simulation results adjust to the **historical data** for the B 2012 scenario.
- The **contribution of CPO demand for biodiesel** to the supply of land for palm oil is small compared with demand for other uses of CPO.
- **FFB agricultural yield** decrease due to decrease land productivity from agricultural land expansion into less productive land.
- FFB agricultural yield **slightly decrease due to the additional demand** for CPO for biodiesel.

Simulation results: **D2) Increased crop yield**







- Increasing oil palm agricultural yield through **improved technology/management** practice (D2a) reduce pressure on land supply for oil palm with no effects on the FBC price.
- If **decrease in the availability of inputs** (D2b1) and **additional cost of inputs** is transferred to the FBC the FBC price increase.
- If compensated by increased **imports** (D2b2), pressure on the inputs price, and consequently on the FBC price, decrease.
- **International effects** should be further assessed if inputs supply is covered by imports.

Provisional conclusions and recommendations for institutions, policies and practices (1)

- While alternative bioenergy and feedstock production strategies have been promoted, **CPO-based biodiesel** production thought **increased land area** for oil palm is the main bioenergy pathways being developed in Indonesia.
- The current feedstock supply strategy is based on the expansion of oil palm area into **non-agricultural land** (forest, shrub and grassland) and **non-FBC** (agroforestry and plantations). The direct expansion of oil palm plantations into food basket crop is very limited. **No diversion of CPO** from the food/feed market was evidenced.
- The produced **biodiesel quantities are insufficient** to achieve blending target obligations.
  - While the effective biodiesel production **reduces impacts on food security** compared with the required quantities to achieve mandates, also benefits of biodiesel use are reduced.
  - On the other hand, **supplies strategies need to be reinforced** to allow the country comply with their National Energy Policy.
- **Possible ways to increase CPO production** to achieve biodiesel national blending targets include expanding oil palm land area (as the main strategies currently in use), increasing agricultural yields (and possible industrial conversion efficiency) or diverting CPO from other markets (mainly CPO or biodiesel exports).

Provisional conclusions and recommendations for institutions, policies and practices (2)

- **Expansion into primary and secondary forest** should be avoided, in order to conserve natural ecosystems and the ecological services associated with them.
- The improvement of agricultural yield thought **technological improvements**, should be promoted.
- **Diverting CPO from other uses** may not be the best strategy, as this diversion will probably result in increased CPO prices that will mainly create additional incentives to increase land supply for oil palm plantations.
- Reducing biodiesel or **CPO exports** will be reflected in the **international market**, resulting in a loss of competitively of the Indonesian oil palm sector and a reduction on the country's market share for CPO.
- Additional effort then should be directed to **develop alternative feedstock** for biodiesel and the promotion of other forms of modern bioenergy.
- Cultivation of alternative feedstocks, such as *jatropha curcas* in **degraded lands** may also reduce pressure on more productive lands.
- The promotion of the **use of non-agricultural wastes**, such as straight vegetable oils can also reduce pressure on the use of CPO as feedstock for biodiesel.
- The development of **more advanced biofuels**, such as micro-algae based biodiesel or lignocelulosic ethanol seems to be possible, but in a medium long time horizon. Further policy incentives and research is required to develop technologies capable of processing advances biofuel feedstocks at acceptable costs.

Recommendations for methodological improvement and adaptation

- Cover **data gaps** and harmonize data.
- Increase national **modelling/simulation** capabilities.
- Define a **commission** on biofuels sustainability.
- Widespread “free” **software** availability.
- **Recalibrate** model based on more consistent and sourced-based data.
- Run **alternative scenarios/supply strategies** for future projections and alternative historical values.
- Run **optimization/sensitivity** analysis.
- **Expand model** boundaries to include other linked GBEP indicators.
- Assess effects of CPO **co-products** increment and FBC and non-FBC co-products reduction.
- Determine the share of **non-FBC relocated in FBC land** (Tier III analysis).

Conclusions regarding the relevance, practicality and scientific basis of the GBEP indicator

- **Relevance at the country level depends on:**
  - Type of feedstock
  - Competing land-uses
  - Link to international markets
  - Domestic policies
- **Practicality depends on:**
  - Data availability and consistency
  - Modelling and simulation capabilities/availability
  - Government support
- **Scientific basis depends on:**
  - Robustness of data
  - Robustness of models
  - Capability of experts

Thank you! Terima kasih!

Workshop on Indicator 10 with Indonesian stakeholders, organized by GBEP-Ministry of Energy

Discussion at Bogor University on system dynamics simulation approach

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Conceptual model

SECTORS

- Food basket crop (FBC) market
- Feedstock market
- Inputs market
- Land supply and competition

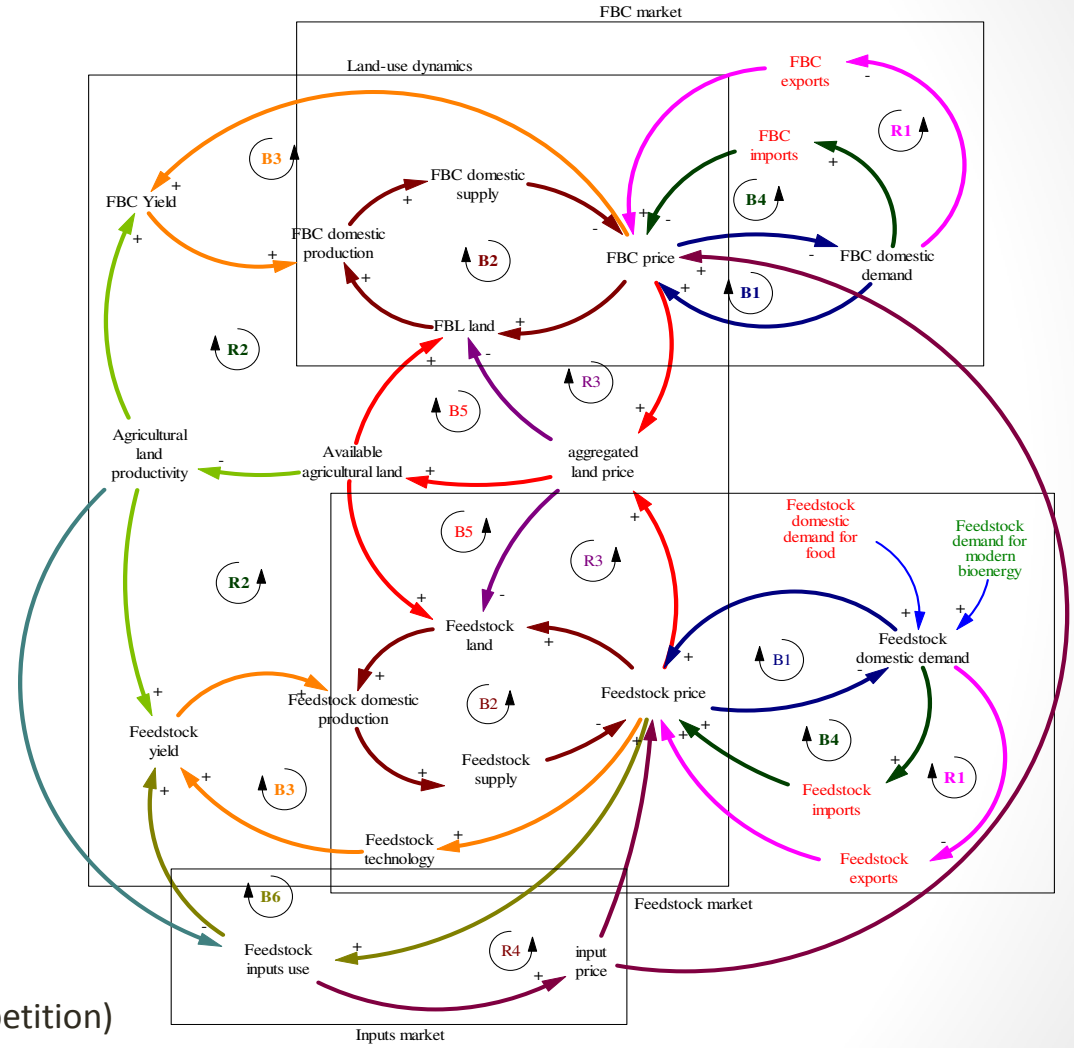
FEEDBACK LOOPS

Balancing loops

- B1: FBC/Feedstock domestic demand
- B2: FBC/Feedstock land
- B3: FBC/Feedstock yield (technology)
- B4: FBC/Feedstock imports
- B5: Agricultural land supply
- B6: FBC/Feedstock yield (inputs)

Reinforcing loops

- R1: FBC/Feedstock exports
- R2: FBC/Feedstock land productivity
- R3: FBC/Feedstock land supply (competition)
- R4: Feedstock/FBC costs (inputs)



Model specifications

- **Demand for modern bioenergy:**

$$q^{bio,c}{}_t = \alpha^{e,s,bio}{}_t \cdot q^{e,s}{}_t$$

- Fuel domestic consumption
- Bioenergy blending targets

- **Other relevant demand:**

$$q^{f}{}_t = \sum_{u}^{U} q^{f,u}{}_t$$

- Demand for domestic food/feed use
- Demand for food/feed exports
- Demand for bioenergy exports

- **Feedstock supply strategies:**

$$q^{mb}{}_t = q^{i,mb}{}_t + q^{w,mb}{}_t + q^{r,mb}{}_t + q^{p,mb}{}_t + q^{d,mb}{}_t$$

- Bioenergy imports
- Non-agricultural wastes
- Residues from agriculture, fisheries and forestry
- **Additional crop production:**
  - Land
  - Yield
- Diversion of crops

$$q^{p,mb}{}_t = \alpha^{p,mb}{}_t \cdot q^{p}{}_t \cdot Y^{p-a}{}_t$$

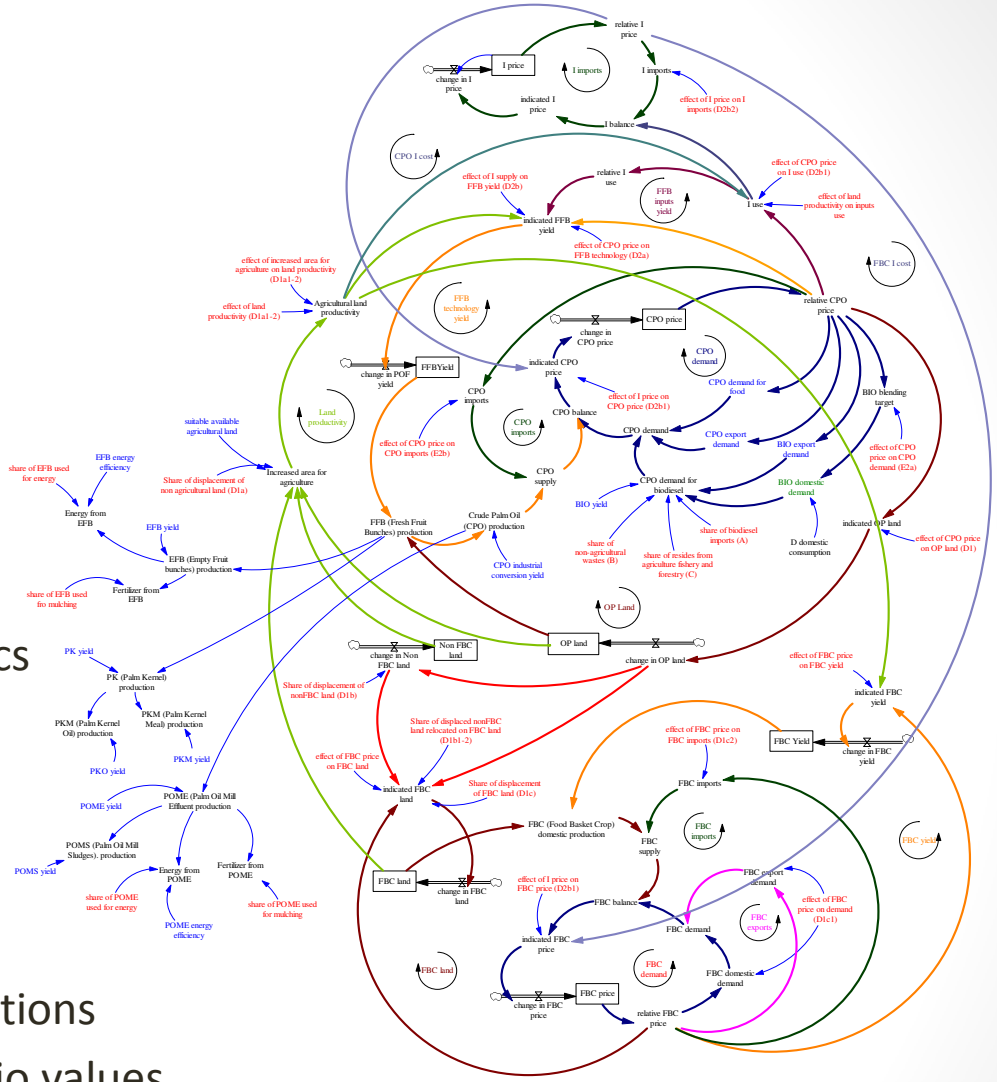
- **Effects on food security:**

$$S^{fbc}{}_t = q^{p,fbc}{}_t(p^{fbc}{}_t) + q^{i,fbc}{}_t$$

- Availability of food in domestic market
- Food price in domestic market

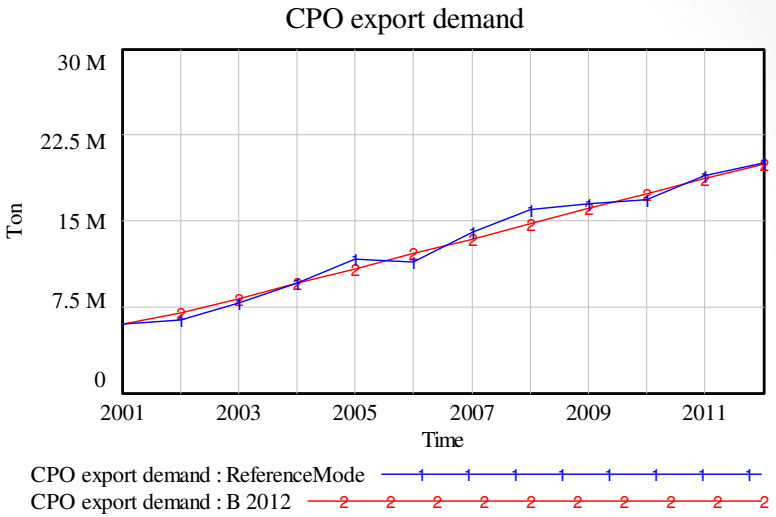
Simulation model

- **System**: CPO-based biodiesel
- **Software**: Vensim DSS
- **Time horizon**: 2001-2012
- **Simplifications** (exogenous):
  - International market dynamics
  - Non-FBC market
  - Land-use dynamics
  - Co-products
- **Components:**
  - Initial values: Set initial conditions
  - Additional values: Set scenario values
  - Effects: Define impacts on food security

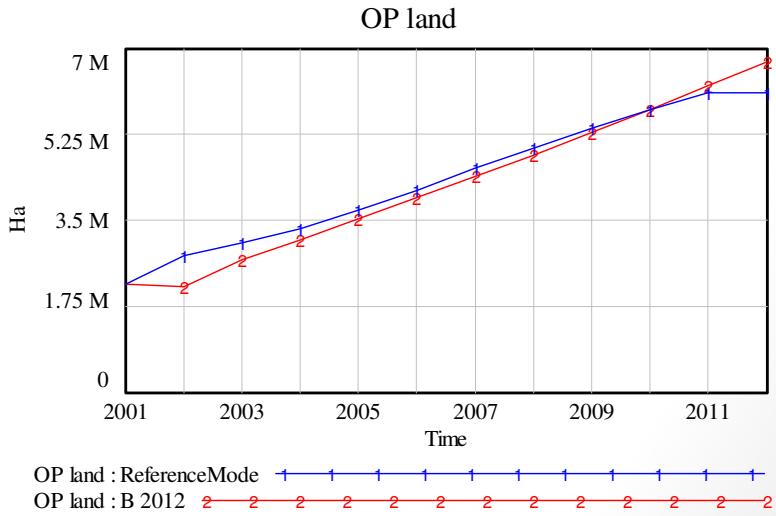


Model calibration

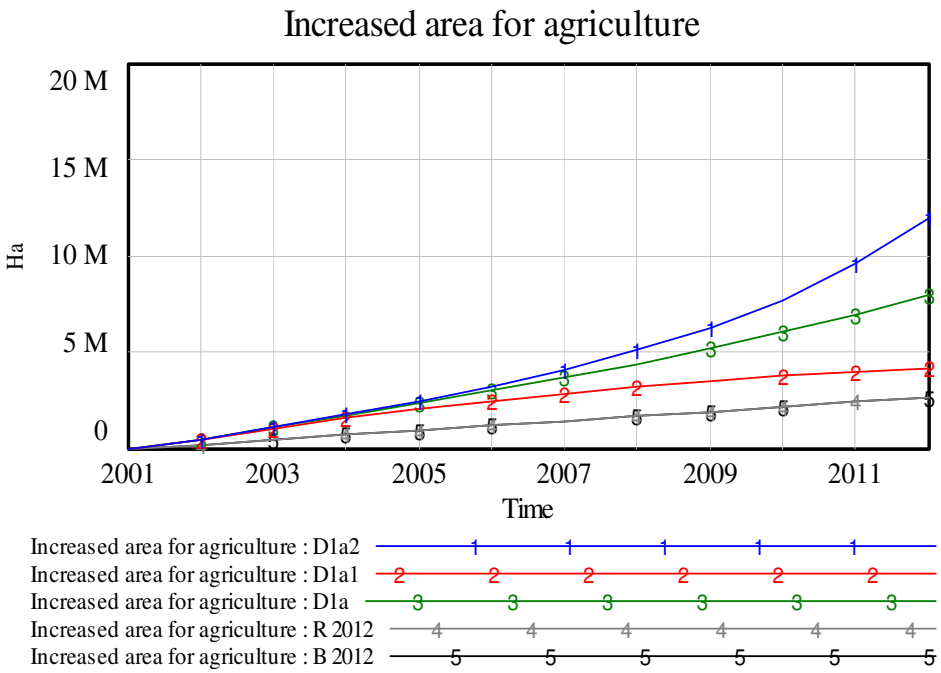
- Calibration of demand functions:
  - Initial value:
    - CPO export demand in 2001
  - Exogenous growth rate
    - CPO export demand growth rate (2001-2012)

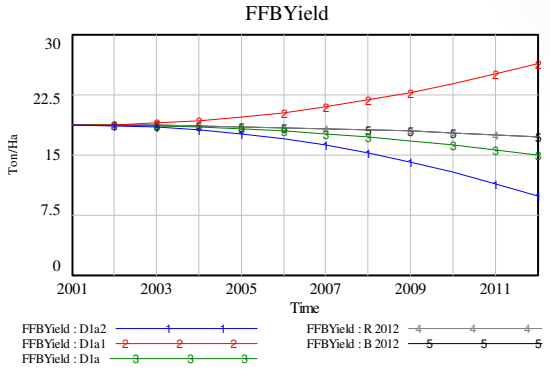


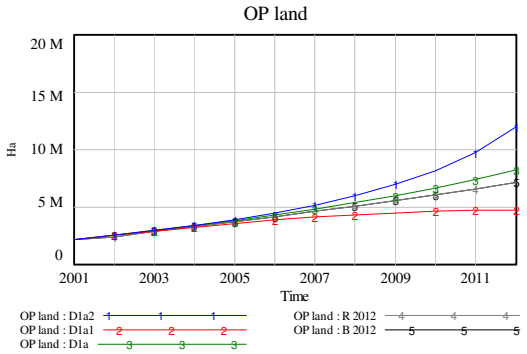
- Calibration of supply functions:
  - Initial values
    - Oil palm land in 2001
  - Parameters
    - Effect of CPO price on OP land



Simulation results: D1a) Increased area for agriculture

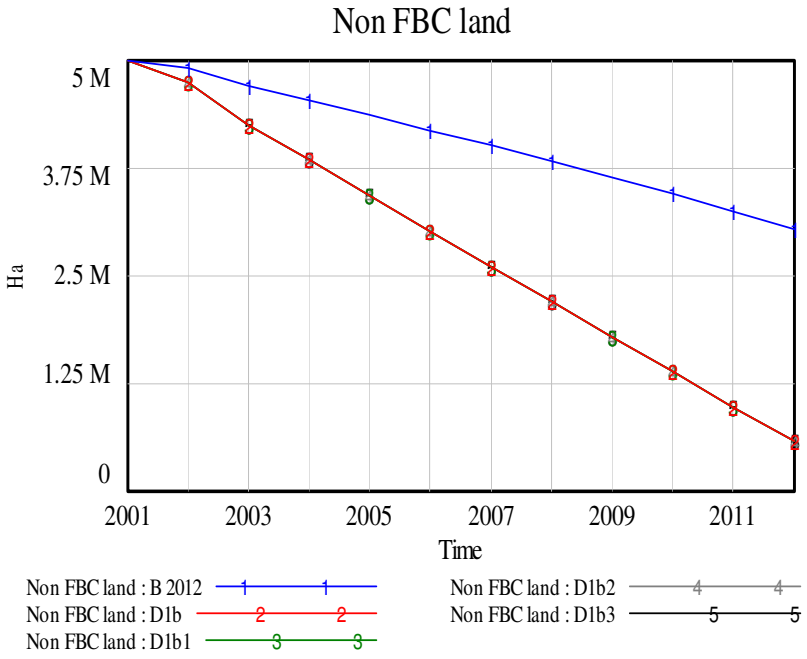


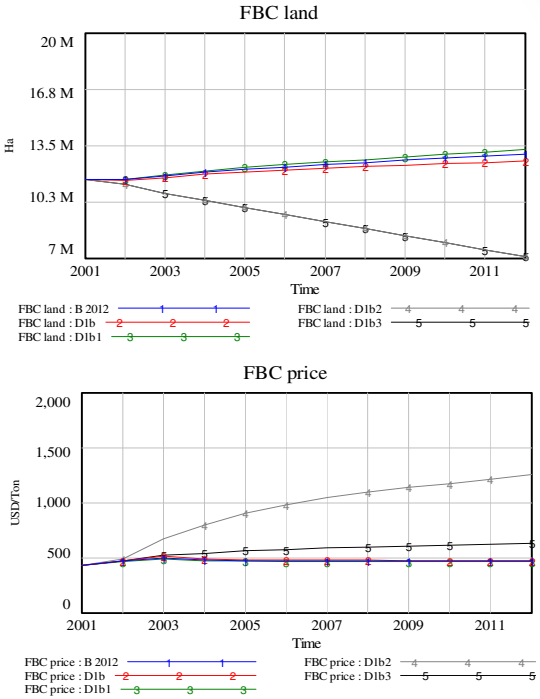




- Land area for agriculture increase from the R 2012 scenario to the B 2012 scenario due to the **additional agricultural land** (D1a) required for CPO for biodiesel production.
- If oil palm expands into **more productive land** (D1a1), the FFB yield increase requiring less land to produce CPO for biodiesel.
- If oil palm expands into **les productive land** (D1a2), the FFB yield decrease requiring more land to produce CPO for biodiesel.

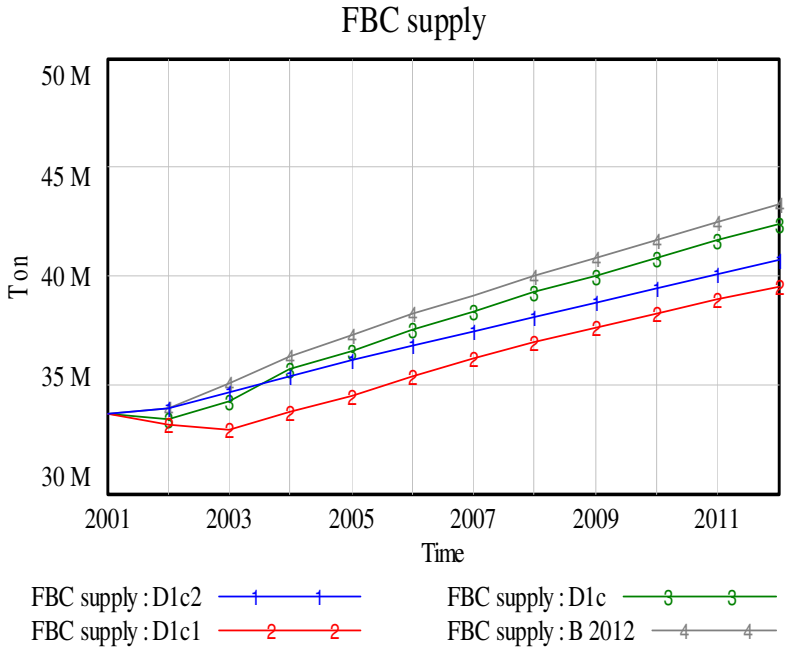
Simulation results: **D1b) Displacement of non-food basket crops**

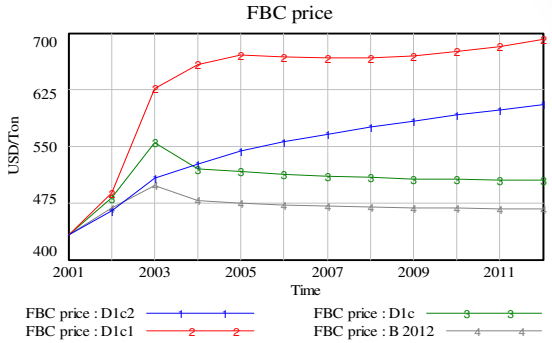


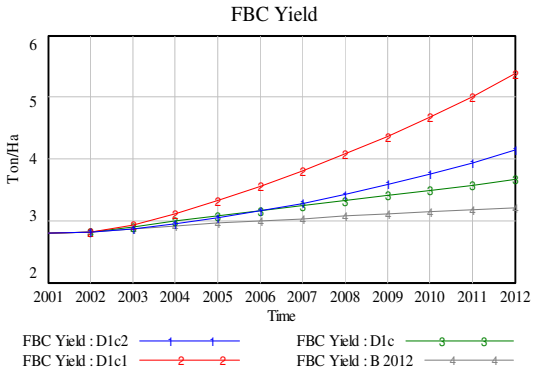


- Expansion of **oil palm into non-FBC crops** (D1b) decrease land supply for non-FBC crops.
- If the **non-FBC is not relocated in FBC land** (D1b1), there is no change in FBC land.
- If relocation of non-FBC in FBC land (D1b2) results in **decreased availability of the FBC**, pressure on FBC price increase.
- If compensated by **imports** (D1b3), pressure on FBC price decrease.

Simulation results: **D1c) Displacement of food basket crops**

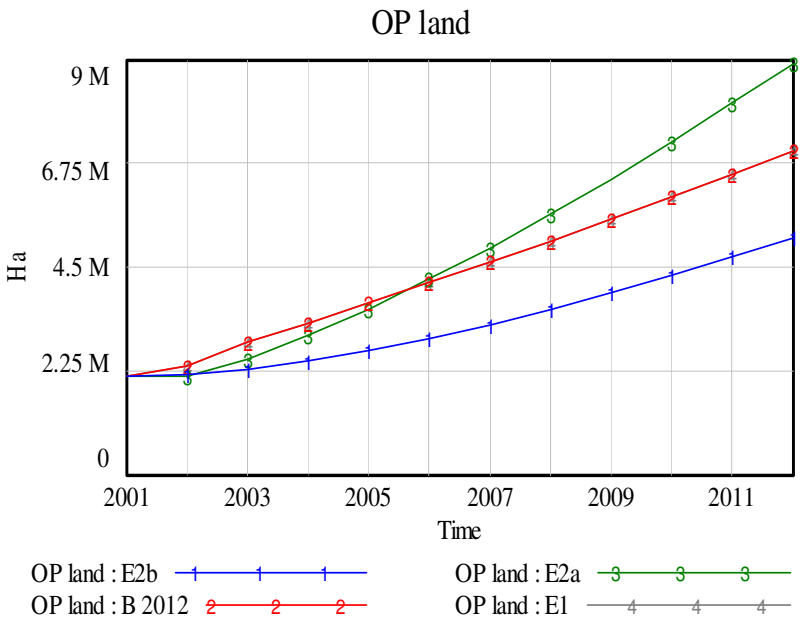


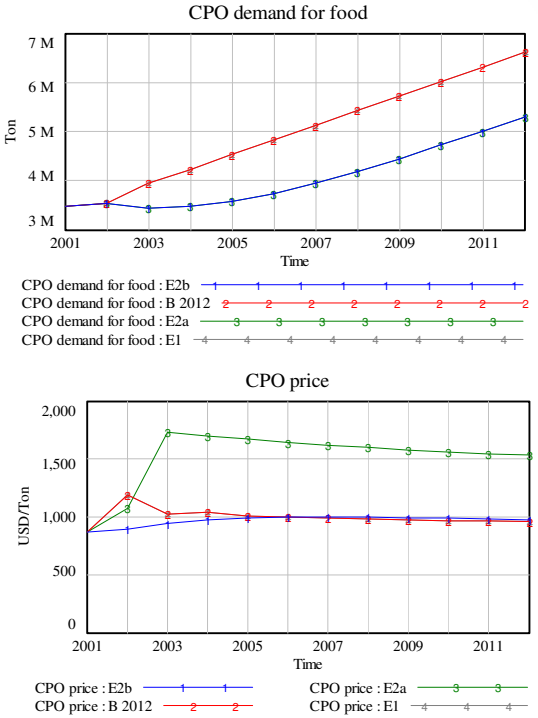




- **Expansion of oil palm into FBC crops** (D1c) decrease land supply for FBC crops and **decrease pressure on agricultural land expansion**, increasing **land productivity** of the FBC crop.
- If **decrease of FBC supply** (D1c1), the FBC price increases.
- If compensated by **imports** (D1c2), decreased pressure on the FBC price.
- **International effects** should be further assessed if FBC supply is covered by imports.

Simulation results: **E2) Diversion of crop from food/feed market**





- **Diverting CPO from the food market** (E) to produce biodiesel decrease pressure on land expansion for oil palm production.
- If **decrease in availability of CPO** (E2a), the pressure on the CPO price increases.
- If compensated by **imports** the pressure on CPO price decrease.
- **International effects** should be further assessed if CPO is diverted from the export market or decrease availability is covers by imports.