An Ecosystem Model of Post Mining Land Use

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Background

- Mines have a large impact on their sites
  - Disturbed land, waste, employment
- Post mine land use (PMLU) plans develop new uses that maintain employment and rehabilitate the land
  - Using value drivers at the mine site, e.g., water, land, material
- Sustainable PMLU plans need a holistic view
  - Some PMLU activities will interfere with others
  - Some PMLU activities will reinforce others
- Five key value streams: Land, Water, Waste, Carbon and Energy, Social

Advantages

- Integrate extensive data to simulate processes and interactions across the five value streams
- Identify opportunities that eliminate waste and rehabilitate land
- Identify gaps in knowledge
- Improve understanding of the business ecosystem
  - Restrict projects and project starts based on resources available
- Simulate alternative options quickly and simply to inform PMLU decisions
- Support investment decisions

Conceptual vision of sustainable PMLU plan

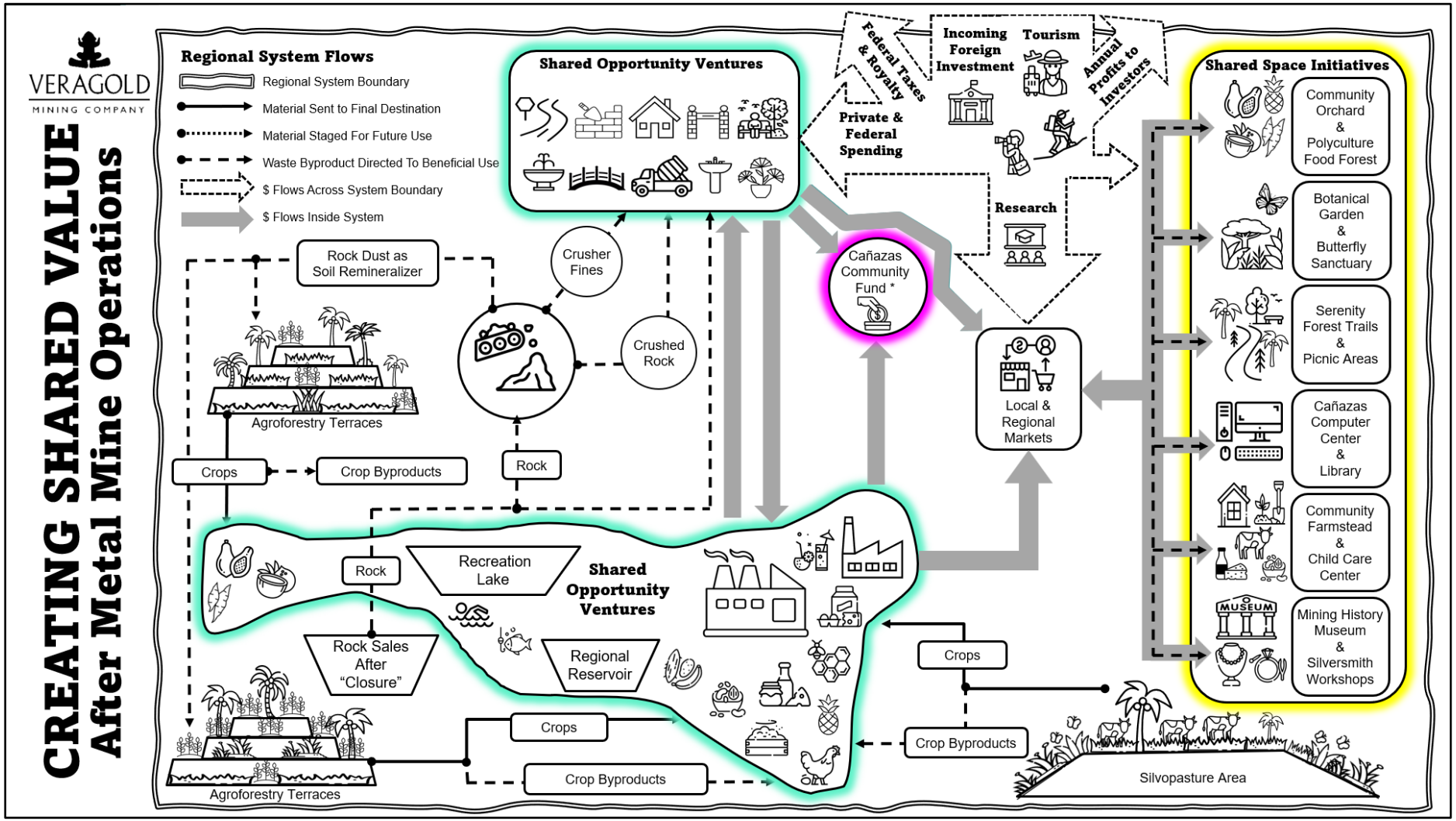

Figure 3 from Anderson et al 2023, "Creating Shared Value and Positive Legacies from a Transitional Working Landscape in Panama"

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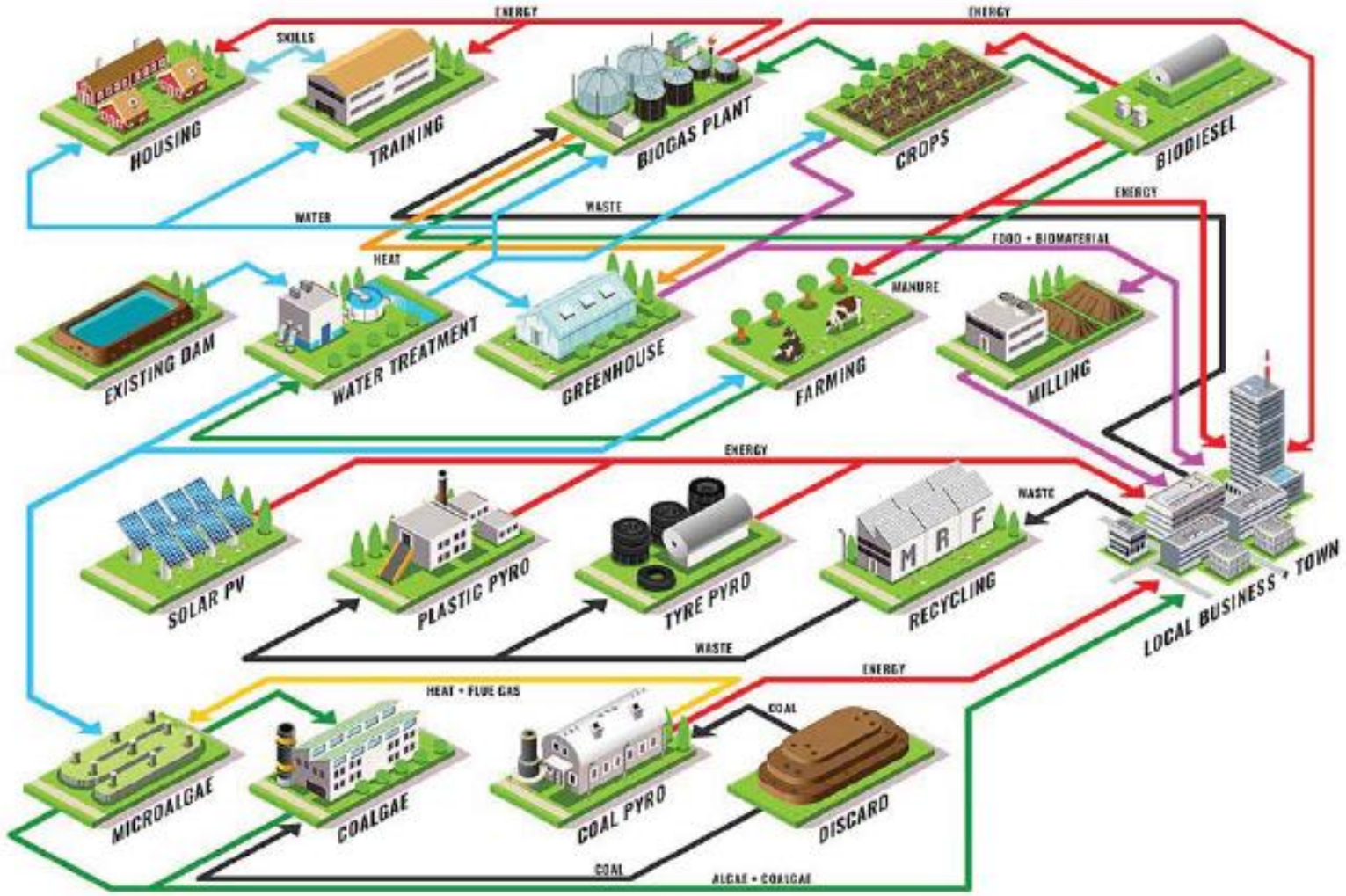
Green Engine project



Muhlbauer 2019, www.thegreenengine.co.za

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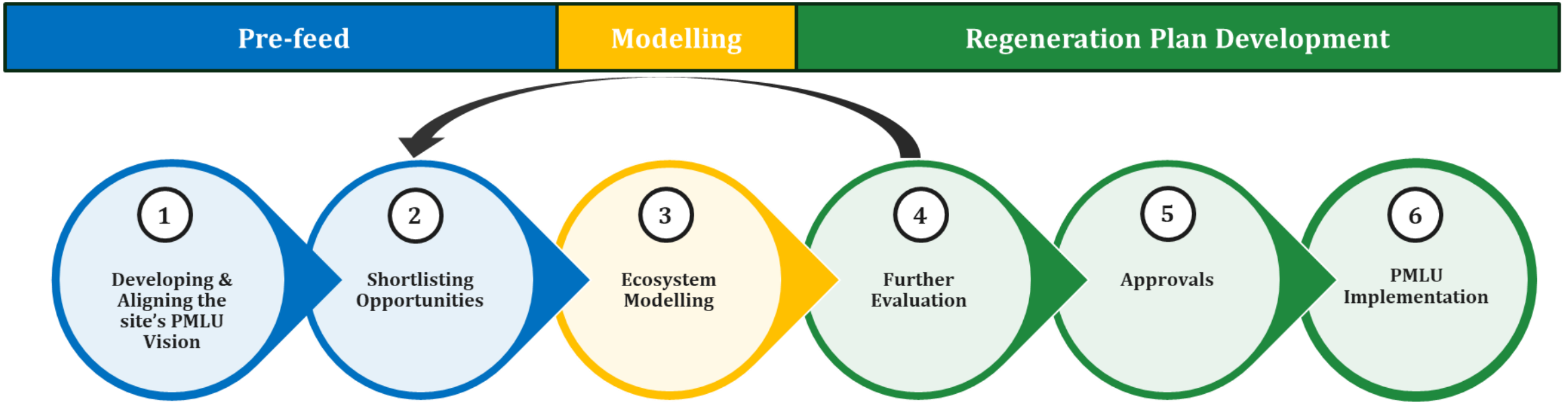
PMLU planning process



- Entry of site level and project data information
- Iterative basket assessment / modelling of key parameters to determine effect on resource base and value created
- Definition of values derived

Supported projects

- Circular economy
  - Waste to product
  - Waste to land
  - Non-mineral waste
  - Reprocess tailings
- Green Energy
  - Solar farm
  - Wind park
  - Biomass feedstock
  - Energy storage (mine shaft)
  - Nature-based solution
- Social development
  - Agricultural crops
  - Greenhouse
  - Livestock
  - Residential
  - Tourism/education
  - Commercial
- Other
  - Anthropogenic aquifer
    - Backfill open pit
    - Flood soils

Mine site characteristics

- Land area (GIS)
  - Open pit
  - Tailings
  - Waste rock facilities
  - Processing areas
  - Open land – steep
  - Open land – flat or moderate
  - Disturbed land
  - % built infrastructure
- Jobs displaced
- Water
  - Contaminated groundwater abstraction
  - Contaminated runoff capture
  - Rainfall runoff capture
  - Groundwater rights
  - Surface water rights
  - Potable water stored
  - Waste water stored
  - Gray water stored
- Waste rock and materials

Entry of site and project data

- Linked Excel spreadsheet
  - Default values for all variables

Home
General
Waste to Product
Waste to Land
Non Mineral
Tailings
Agricultural
Greenhouse
Livestock
Tourism
Residential

Value Creation Projects

Site: Amandelbult

Category	N	Applicable	Archetype	Description
		☑	General	Mine description based on its domains and resources available.
Circular Economy	1	☑	Waste to product	This archetype considers reprocessing waste rock material with adequate physical and chemical properties to be reused as construction products and sold to third parties. The project will require land and water to reprocess the material, it is expected that the product will be sold to cover local demand, which might vary during the project's lifetime.
	2	☑	Waste to land	This archetype considers reprocessing waste rock material with adequate chemical properties to be applicated as an agricultural land fertiliser; material will be reprocessed on-site and will be collected at a certain frequency.
	3	☑	Non mineral waste with a by-product	Non-mineral waste stored on-site can be reprocessed and sold to third parties; usually, not all of the waste can be reused; therefore, a % should be assigned to define the reproachable part of the material available. Archetype also incorporate the possibility to add an external provider with a defined volume per month.
	4	☑	Tailings to reprocess	Old tailings might have mineral content with enough economic value to be reprocessed. Archetype includes the volume to be reprocessed and the water demand and jobs to be created for each step (excavation, process and deposit).
Social development projects	5	☑	Agriculture	This archetype considers the use of rehabilitated land as agricultural land, giving it a repurpose; it also has incorporated an option to add land outside the mine to the project. Irrigation can be performed with fresh water or a combination of fresh and grey water. The project will request water demand for a number of crops per year and will differentiate between permanent and seasonal jobs.
	6	☑	Agriculture with energy input (Greenhouse)	This archetype proposed to develop a greenhouse in remediated land giving it a repurpose; this project will request an average yearly production rate and a monthly water demand. Irrigation can be performed with fresh water or a combination of fresh and grey water.
	7	☑	Livestock	This archetype is considering using remediated land to build a livestock project, which can be complemented with land outside the mine. The project has been set up to include two products (meat and milk); each of them will have a production rate and will differentiate the water demand for the grassland and the livestock.
	8	☑	Tourism / education	This archetype proposed to develop a tourism circuit on remediated land, which might be complemented with external land. The project will require an established amount of visitors per hectare of land, freshwater that will be required for visitors and employees and the amount of grey water required for maintenance activities.
	9	☑	Residential	This archetyped considers constructing houses on remediated land, giving it a repurpuse. Construction will be developed across an established number of years based on the housing demand; with a construction monthly rate, energy and water demand per household will be required.

Sample input page

Attribute	Attribute Guidance	Pessimistic	Realistic	Optimistic	Estimate Rationale	Value	Units	Default values
Residential.land desired	land from the mine site that will be used in the project					9	Ha	9
Residential.housing demand	Number of houses required for the project					250	houses	250
Residential.housing density	Number of housed that will be built for each hectare					33.3	houses/ha	33.3
Residential.household size	Average family members per household				Local Municipality: 52,793 (2021 est), Number of Households: 15,064 (2021	3.5	people/ house	3.4
Residential.individual water demand	Water demand per household per month				1.05 - 1.5 m3/person/month (based on 35 - 50 L per day). Thabazimbi	4.55	m3/person/month	7.11
Residential.crew productivity	Number of houses that will be built per month per crew					0.6	house/month/crew	0.6
Residential.household electricity demand	Energy demand pero house per month				Average Eskom residential customer monthly usage = 450kWh, reduced to	0.3	MWh/house/month	0.2382
Residential.crew size	Number of people per crew					10	people/crew	10
Residential.starting month	The month when the construction will begin. Month 0 = When the final closing begins					0	month	0
Residential.construction period	Months that the construction period will last					60	month	60
Residential.indirect jobs per house	Numbers of indirect jobs that will be generated as part of the project					0.25	people/ house	0.25
Residential.repurposed infrastructure	Existing infrastructure (buildings) that will remain after closure to be use in the project					0	m2	0

Global data lab - household size

https://globaldatalab.org/areadata/table/2

Worldometer - Water use by country

https://www.worldometers.info/water/

Electricity consumption per capita worldwide in 2022, by selected country

https://www.statista.com/statistics/383633/worldwide-consumption-of-electricity-by-country/

https://www.statista.com/statistics/383633/worldwide-co Electricity consumption per capita by country 2022 | Statista

Resource base
Simulation driven Value
Archetype based
Economic Factor

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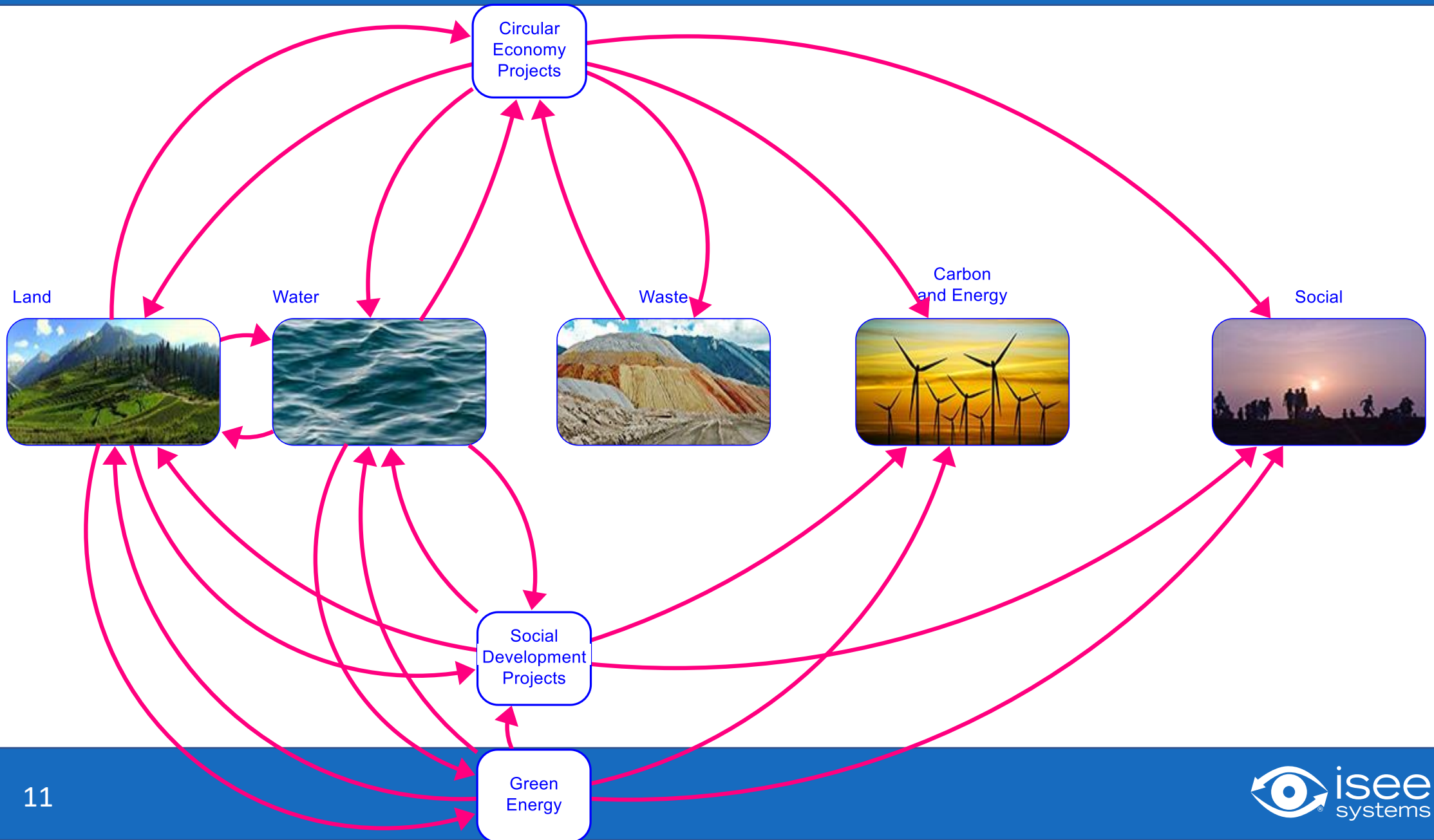
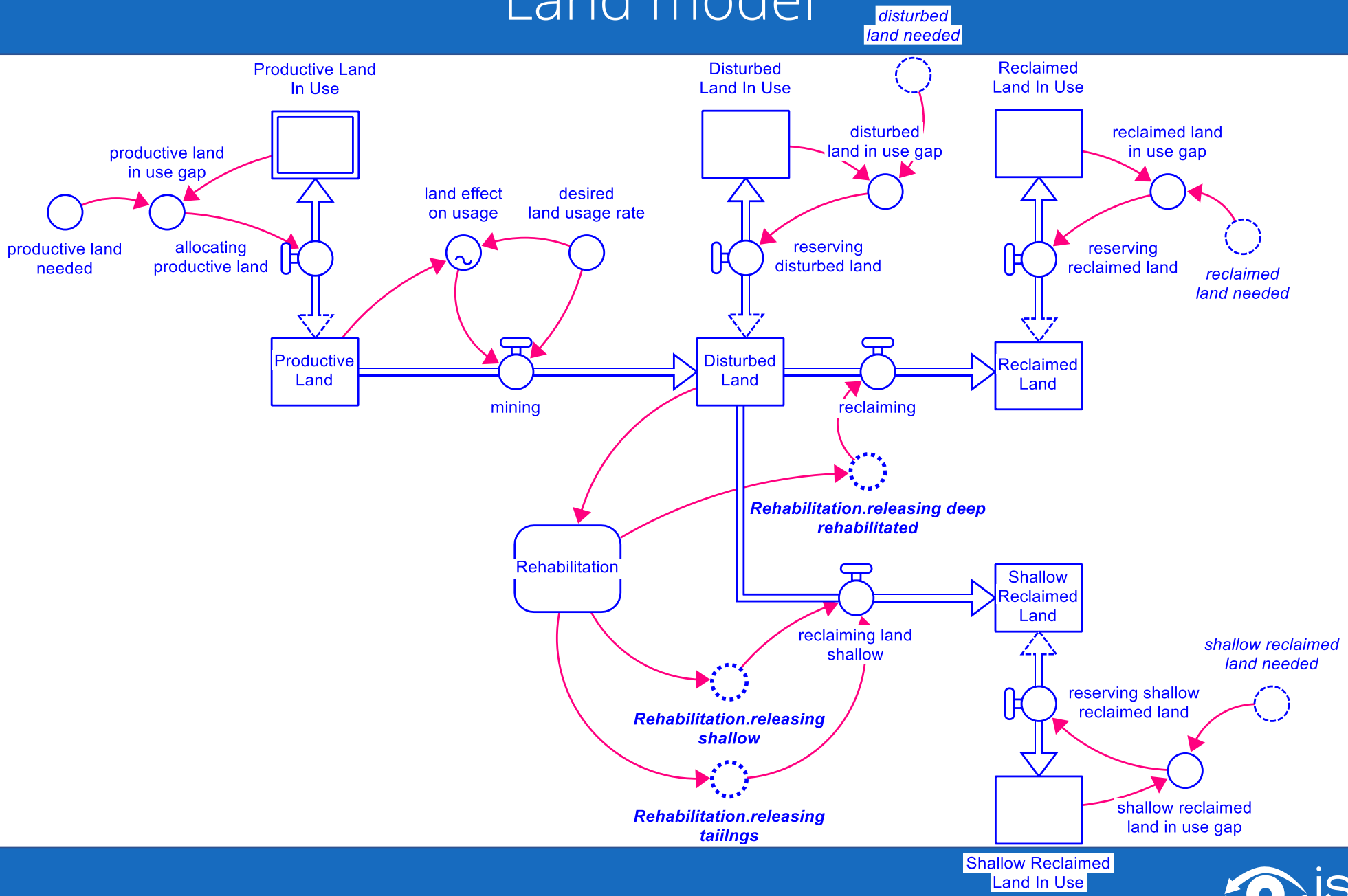
Model overview



Land model


disturbed land needed
Productive Land In Use
Disturbed Land In Use
Reclaimed Land In Use
productive land in use gap
disturbed land in use gap
reclaimed land in use gap
productive land needed
allocating productive land
land effect on usage
desired land usage rate
reserving disturbed land
reserving reclaimed land
reclaimed land needed
Productive Land
mining
Disturbed Land
reclaiming
Reclaimed Land
Rehabilitation.releasing deep rehabilitated
Rehabilitation
Shallow Reclaimed Land
reclaiming land shallow
shallow reclaimed land needed
reserving shallow reclaimed land
Rehabilitation.releasing shallow
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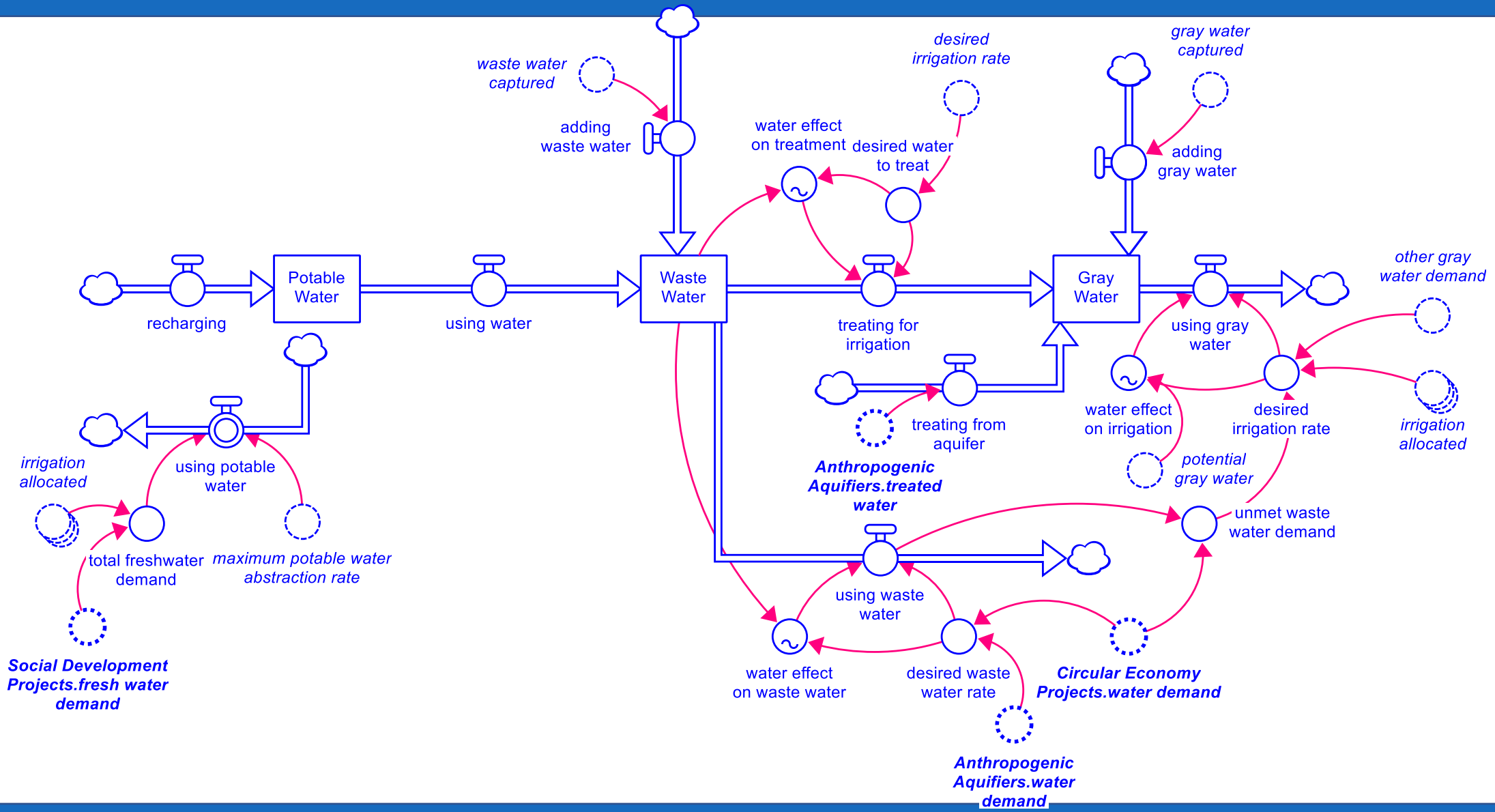
shallow reclaimed land in use gap
Shallow Reclaimed Land In Use

Water model


waste water captured
adding waste water
desired irrigation rate
water effect on treatment
desired water to treat
gray water captured
adding gray water
Potable Water
recharging
using water
Waste Water
treating for irrigation
Gray Water
using gray water
other gray water demand
irrigation allocated
using potable water
treating from aquifer
water effect on irrigation
desired irrigation rate
irrigation allocated
potential gray water
Anthropogenic Aquifers.treated water
unmet waste water demand
total freshwater demand
maximum potable water abstraction rate
using waste water
water effect on waste water
desired waste water rate
Circular Economy Projects.water demand
Social Development Projects.fresh water demand
Anthropogenic Aquifers.water demand

Resource allocation

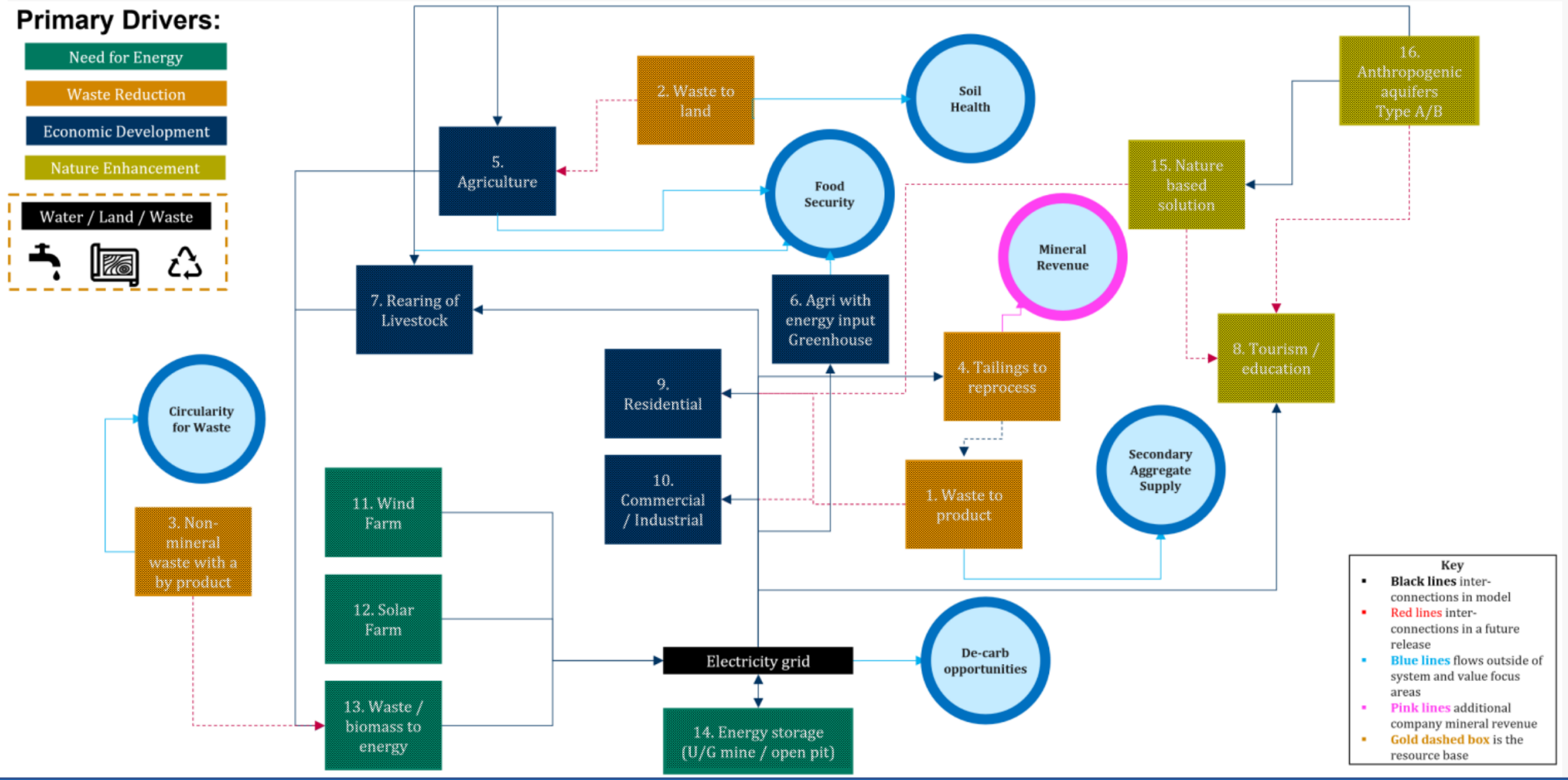
- Multiple projects may demand the same resources
- Fresh water demand priorities:
    1. People – residential and tourism
    2. Livestock
    3. Forestry nursery and greenhouse
    4. Crops
    5. Commercial
- Productive land priorities:
    1. Farming
    2. Residential
    3. Tourism
    4. Commercial

Selecting projects to simulate

ERM

This diagram provides a series of Post Mining Land Uses that are interconnected to provide a future business ecosystem that utilises the mines resources (water, land, waste). This ecosystem develops social and environmental value through these resources, providing an additive view of how value could be developed.

Global | Dashboard



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Turning projects on/setting parameters

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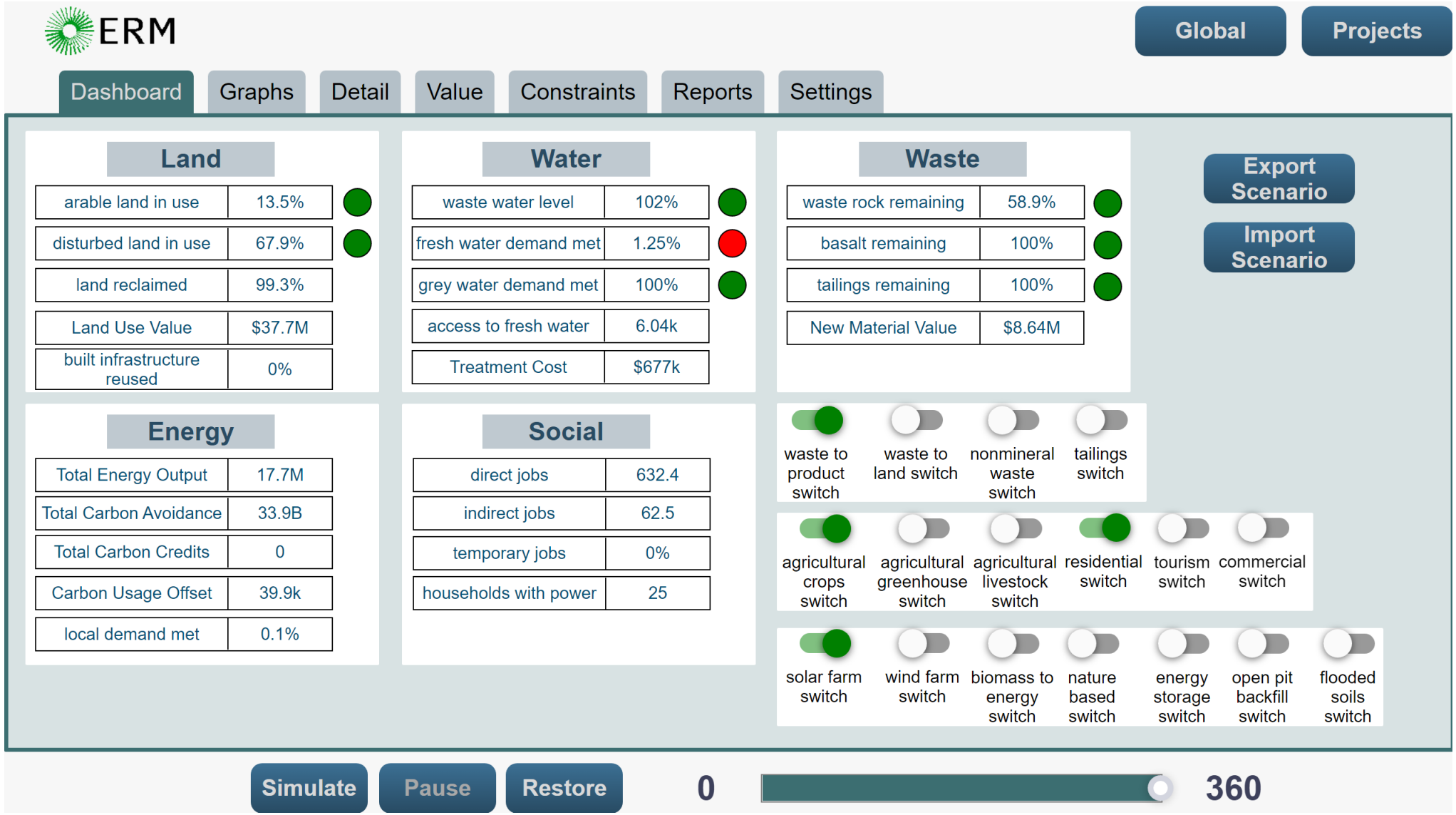
Simulation dashboard



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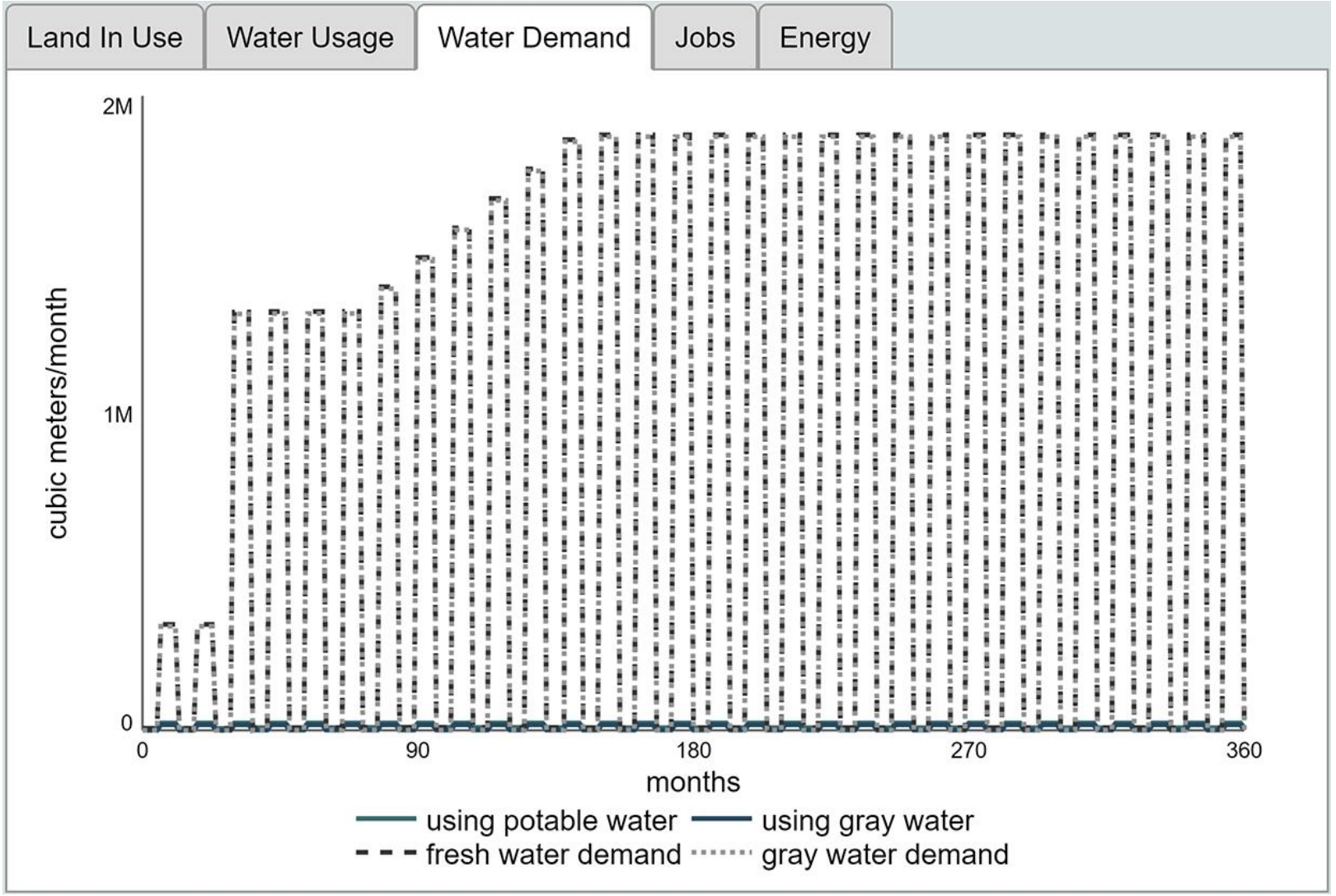
Not enough fresh water



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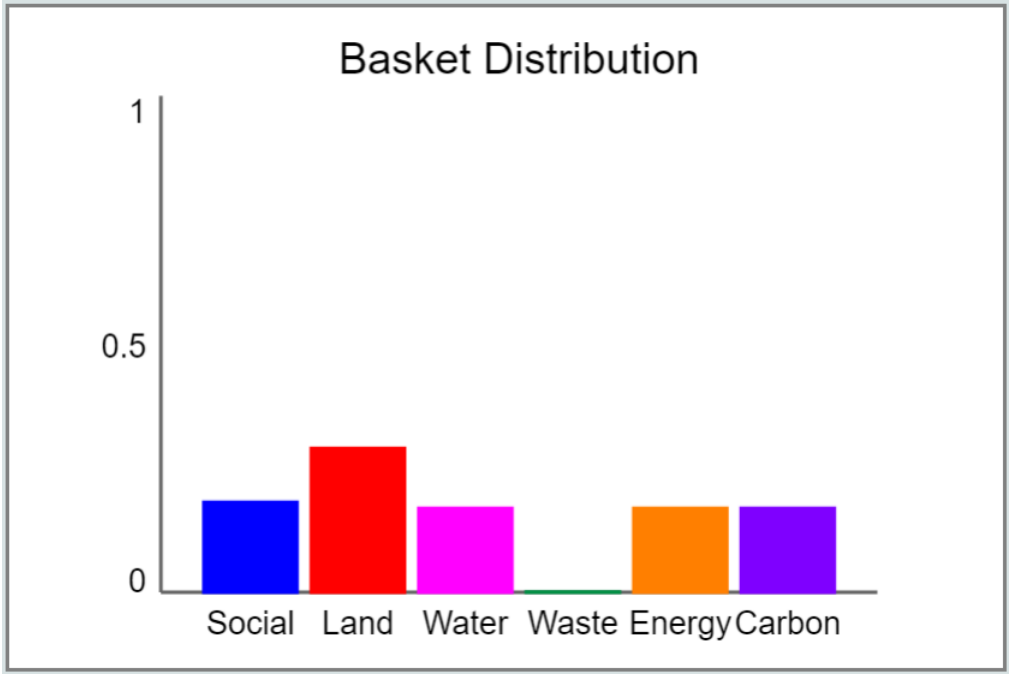
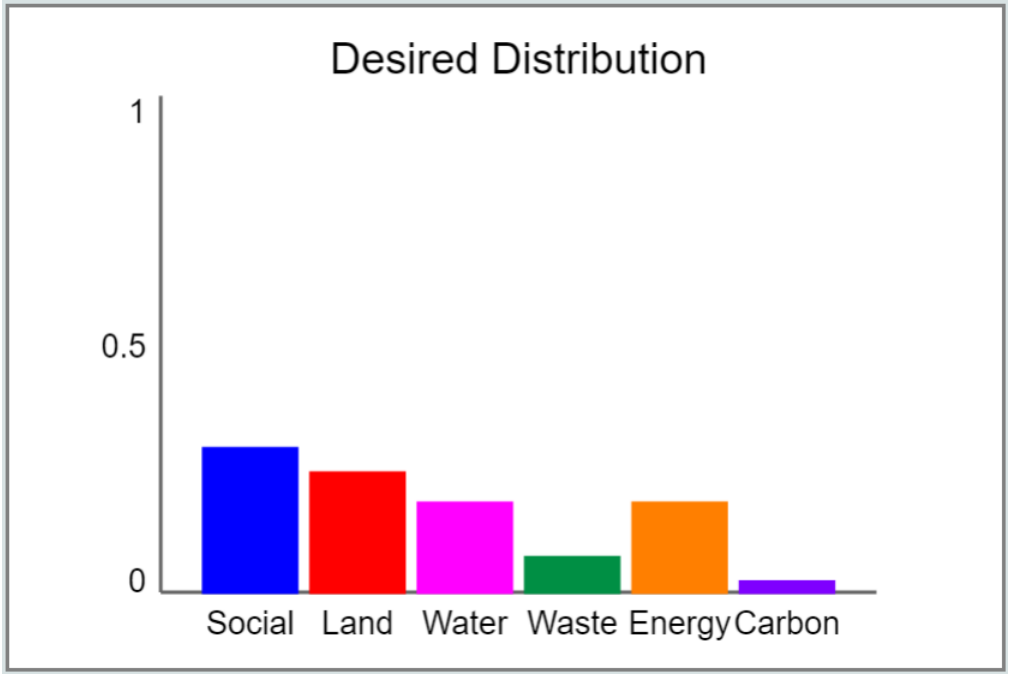
Value

- Evaluates whether meeting objectives (not $ value)
  - On a 0-1 scale, but also show each component
- Example basket's value = 0.8





Method for determining value

- Set targets for:
  - Social: Jobs
  - Social: Houses with electricity
  - Land: Repurposed
  - Land: Open developed
  - Land: Biodiversity
  - Water: Treatment avoided
  - Waste converted to product
  - Energy Produced
  - Carbon abated
  - Carbon credits
- For each value stream:
  - Define relevance
  - Define focus areas
- Product gives our *ambition*
  - I.e., desired distribution
- Basket distribution is determined against targets
- Value is goodness of fit of basket to ambition

Questions?