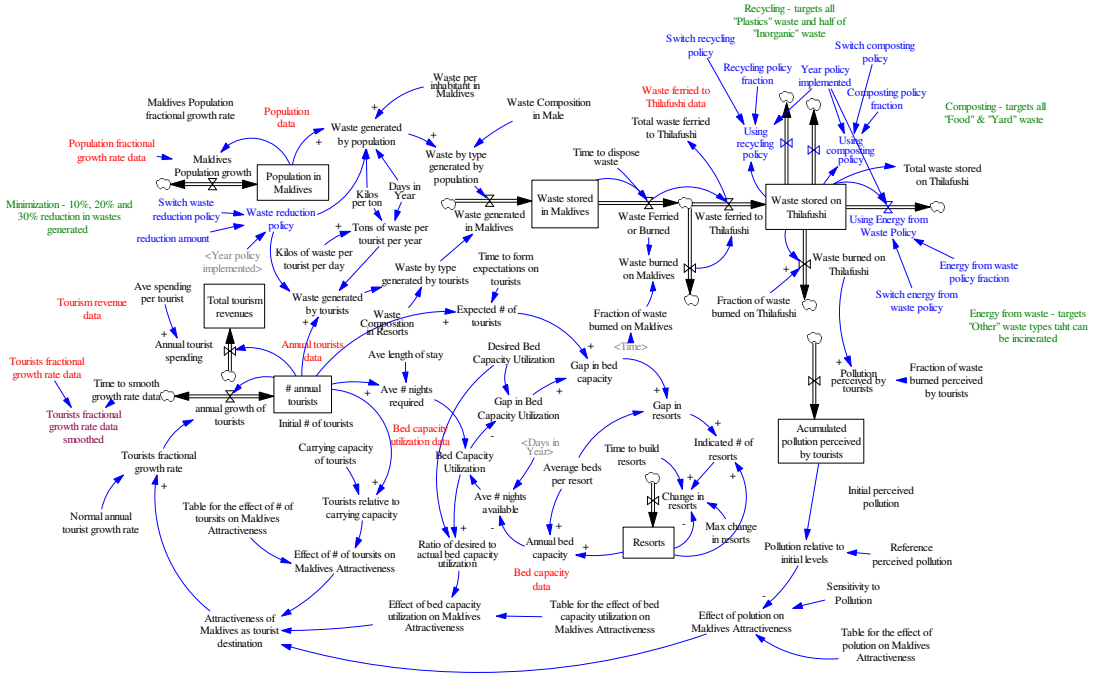
Appendix

Wasted Paradise – Imagining the Maldives Without The Garbage Island of Thilafushi

Model equation, Vensim DSS, Version 6.1c



Model equation, Vensim DSS, Version 6.1c

Sensitivity to Pollution=

1

~ Dmnl

~ This parameter can change the sensitivity of tourists on pollution. If \
they are not sensitive, it is 0, if they are very sensitive, it is 1.

|

Effect of polution on Maldives Attractiveness=

(Table for the effect of polution on Maldives Attractiveness (Pollution relative to initial levels\
))^Sensitivity to Pollution

~ Dmnl

~ The more the Maldives are polluted, the higher is their effect on \
Attracttiveness.

|

Pollution relative to initial levels=

Reference perceived pollution/ Acumulated pollution perceived by tourists

~ Dmnl

~ This variable calculates the relative pollution.

|

Reference perceived pollution=

3000

~ Tons

~ This parameter sets the reference pollution for the pollution perception.

|

Year policy implemented=

STEP(1, 2015)

~ Dmnl

~ It is assumed that all policies are implemented in 2015.

|

Using Energy from Waste Policy[waste type]=

Energy from waste policy fraction[waste type]*Switch energy from waste policy* Year policy implemented\

*Waste stored on Thilafushi[waste type]

~ Tons/Year

~ This flow calculates how much waste is tranformed into energy.

|

Using composting policy[waste type]=

Switch composting policy*Year policy implemented*Composting policy fraction[waste type\

]*Waste stored on Thilafushi[waste type]

~ Tons/Year

~ This flow calculates how much waste is composted.

|

reduction amount=

0.2

~ Dmnl

~ This parameter indicates how much of the waste is being reduced.

|

Using recycling policy[waste type]=

Switch recycling policy*Year policy implemented*Recycling policy fraction[waste type\

]*Waste stored on Thilafushi[waste type]

~ Tons/Year

~ This flow calculates how much waste is recycled.

|

Waste generated by tourists=

"# annual tourists" * Tons of waste per tourist per year *Waste reduction policy

~ Tons/Year

~ |

Switch waste reduction policy=

0

~ Dmnl

~ This is a switch

0 = policy off

1 = policy on

|

Waste reduction policy=

(1 - reduction amount * Switch waste reduction policy*Year policy implemented)

~ Dmnl

~ This variable calculates how much waste is reduced.

|

Total waste stored on Thilafushi=

SUM(Waste stored on Thilafushi[waste type!])

~ Tons

~ This variable calculates the total waste on the Thilafushi (all waste \

types).

|

Waste generated by population=

(Days in Year*Waste per inhabitant in Maldives * Population in Maldives *Waste reduction policy\

)/ (Kilos per ton)

~ Tons/Year

~ This variable caculates the total waste generated by the population

|

Waste stored on Thilafushi[waste type]= INTEG (

+Waste ferried to Thilafushi[waste type] -Waste burned on Thilafushi[waste type] - Using Energy from Waste Policy\

[waste type]- Using recycling policy[waste type]- Using composting policy[waste type\

],
0)
~ Tons
~ This stock indicates the total waste on Thilafushi by waste type.
|

Switch composting policy=
0
~ Dmnl
~ This is a switch
0 = policy off
1 = policy on
|

Switch energy from waste policy=
0
~ Dmnl
~ This is a switch
0 = policy off
1 = policy on
|

Energy from waste policy fraction[waste type]=
0,0,0,0,1
~ 1/Year
~ This parameter indicates which waste types are affected by the enrgy from \
waste policy.
|

Recycling policy fraction[waste type]=
0,0,1,1,0
~ 1/Year
~ This parameter indicates which waste types are affected by the recycling \

policy.
|

Total waste ferried to Thilafushi=
SUM(Waste ferried to Thilafushi[waste type!])
~ Tons/Year
~ This variable indicates the sum of all waste types ferried to Thilafushi.
~ :SUPPLEMENTARY
|

Switch recycling policy=
0
~ Dmnl
~ This is a switch
0 = policy off
1 = policy on
|

Composting policy fraction[waste type]=
1,1,0,0,0
~ 1/Year
~ This parameter indicates which waste types are affected by the composting \
policy.
|

waste type:
Food, Yard, Plastics, Inorganic, Other
~ Dmnl
~ |

Waste Composition in Resorts[waste type]=
0.4, 0.38, 0.05, 0.11, 0.06
~ Dmnl

~ |

Waste by type generated by population[waste type]=

Waste generated by population * Waste Composition in Male[waste type]

~ Tons/Year

~ This variable calculates the waste generated by the population - by waste \
type.

|

Waste by type generated by tourists[waste type]=

Waste generated by tourists * Waste Composition in Resorts[waste type]

~ Tons/Year

~ This variable calculates the waste generated by tourists - by waste type.

|

Waste generated in Maldives[waste type]=

Waste by type generated by population[waste type] + Waste by type generated by tourists\
[waste type]

~ Tons/Year

~ This flow changes the stock of waste generated in Maldives.

|

Waste Composition in Male[waste type]=

0.22, 0.528, 0.025, 0.18, 0.047

~ Dmnl

~ Thie parameter indicates the waste composition in Male.

|

Change in resorts=

MIN(Max change in resorts ,("Indicated # of resorts" - Resorts) / Time to build resorts\
)

~ resorts/ Year

~ This flow changes the stock of resorts.

|

Maldives Population growth=

Population fractional growth rate data * Population in Maldives

~ people/Year

~ This flow changes the stock of Maldives population.

|

Max change in resorts=

5

~ resorts/Year

~ At maximum, 5 resorts can be opened in a year.

|

Ave length of stay=

9.5

~ day

~ On average, tourists stay 9.5 days on the Maldives.

|

Bed Capacity Utilization=

MAX (0, "Ave # nights required"/"Ave # nights available")

~ Dmnl

~ Bed capacity utilization puts the nights required and the nights available \
into relation with each other.

|

"Ave # nights available"=

Annual bed capacity * Days in Year

~ people*day

~ This variable translates the annual bed capacity into the nights available.

|

"Ave # nights required"=

"# annual tourists"* Ave length of stay

~ people*day

~ |

Time to smooth growth rate data=

3

~ Year

~ The smoothing is 3 years.

|

Tourism revenue data

~ Rufiyaa/Year

~ ~ :SUPPLEMENTARY

|

Tourists fractional growth rate=

Normal annual tourist growth rate * Attractiveness of Maldives as tourist destination

~ 1/Year

~ Actual tourist fractional growth rate is the product of the Normal annual \
tourist growth rate and the Attractiveness of the Maldives as tourist \
destination.

|

annual growth of tourists=

Tourists fractional growth rate * "# annual tourists"

~ Tourists/Year

~ |

Tourists fractional growth rate data smoothed=

SMOOTHI(Tourists fractional growth rate data, Time to smooth growth rate data , Tourists fractional growth rate data\

)

~ 1/Year

~ The data are smoothed to get the strong fluctuations out.

~ :SUPPLEMENTARY

|

Population fractional growth rate data

~ 1/Year

~ This is the DATA for polulation fractional growth rate.

|

Annual tourists data

~ people

~ This is the DATA for annual tourists traveling to the Maldives.

~ :SUPPLEMENTARY

|

Waste ferried to Thilafushi data

~ Tons/Year

~ This is the DATA for waste ferried to Thilafushi.

~ :SUPPLEMENTARY

|

Population data

~ people

~ This is the DATA for population.

~ :SUPPLEMENTARY

|

Tourists fractional growth rate data

~ 1/Year

~ This is the DATA for fractional growth rate.

|

Bed capacity data

~ people

~ This is the DATA for bed capacity.

~ :SUPPLEMENTARY

|

Bed capacity utilization data

~ Dmnl

~ This is the DATA for bed capacity utilization.

~ :SUPPLEMENTARY

|

"# annual tourists"= INTEG (

annual growth of tourists,

"Initial # of tourists")

~ Tourists

~ The number of tourists traveling to the Maldives per year.

|

{UTF-8}

Time to form expectations on tourists=

5

~ Year

~ It takes 5 years for tourists to decide to travel to the Maldives.

|

Acumulated pollution perceived by tourists= INTEG (

Pollution perceived by tourists,

Initial perceived pollution)

~ Tons

~ This is the accumulated pollution that the tourists perceive.

|

Effect of bed capacity utilization on Maldives Attractiveness=

Table for the effect of bed capacity utilization on Maldives Attractiveness (Ratio of desired to actual bed capacity utilization\

)

~ Dmnl

~ The higher the bed capacity utilization, the more attractive the Maldives \

as a tourist destination.

|

"Expected # of tourists"=

SMOOTH3I("# annual tourists" , Time to form expectations on tourists , "# annual tourists"\

)

~ Tourists

~ This variable calculates how many tourists are expected to travel to the \

Maldives. It is a SMOOTH3 function.

|

"Initial # of tourists"=

33124

~ Tourists

~ |

Attractiveness of Maldives as tourist destination=

"Effect of # of toursits on Maldives Attractiveness" * Effect of bed capacity utilization on Maldives Attractiveness\

* Effect of polution on Maldives Attractiveness

~ Dmnl

~ Attractiveness is the product of three effects: Effect of tourists, Effect \

of bed capacity utilization, and Effect of pollution, all ranging between \

0 and 1.

|

Ratio of desired to actual bed capacity utilization=

Desired Bed Capacity Utilization / Bed Capacity Utilization
~ Dmnl
~ |

"Table for the effect of # of toursits on Maldives Attractiveness"(
[(0,0)-(0.7,1)],(0,0.35),(0.05,0.36),(0.65,0.98),(0.7,1),(1,1),(10,1))
~ Dmnl
~ The more tourists travel to the Maldives, the more they talk about the \
Maldives, kicking off the Word-of-Mouth loop, increasing the \
attractiveness.
|

Carrying capacity of tourists=
30000
~ Tourists
~ The carrying capacity is assumed to be 30,000 tourists.
|

Table for the effect of polution on Maldives Attractiveness(
[(0,0)-(1,2)],(0,0.1),(0.02,0.11),(0.95,0.99),(1,1),(10,1))
~ Dmnl
~ The more the Maldives are polluted, the higher is their effect on \
Attracttiveness.
|

"Effect of # of toursits on Maldives Attractiveness"=
"Table for the effect of # of toursits on Maldives Attractiveness"(Tourists relative to carrying capacity\
)
~ Dmnl
~ The more tourists travel to the Maldives, the more they talk about the \
Maldives, kicking off the Word-of-Mouth loop, increasing the \
attractiveness.

|

Initial perceived pollution=

100

~ Tons

~ |

Normal annual tourist growth rate=

0.25

~ 1/Year

~ Normal fractional growth rate is 0.25.

|

Table for the effect of bed capacity utilization on Maldives Attractiveness(

[(0,0)-(1,1)],(0,0.05),(0.1,0.05),(0.95,0.99),(1,1),(10,1))

~ Dmnl

~ The higher the bed capacity utilization, the more attractive the Maldives \
as a tourist destination.

|

Tourists relative to carrying capacity=

Carrying capacity of tourists / "# annual tourists"

~ Dmnl

~ This variable puts the actual number of tourists in relation to the \
carrying capacity.

|

{UTF-8}

Annual bed capacity=

Resorts * Average beds per resort

~ people

~ |

Maldives Population fractional growth rate=

0.023

~ 1/Year

~ Normal fractional growth rate is 0.023.

~ :SUPPLEMENTARY

|

Annual tourist spending=

"# annual tourists" * Ave spending per tourist

~ Rufiyaa/Year

~ |

Fraction of waste burned on Thilafushi=

0.4

~ 1/Year

~ 40% of the waste is burned on Thilafushi.

|

Ave spending per tourist=

1500

~ Rufiyaa/(Year*tourist)

~ On average, each tourists spends 1,500 Rufiyaa.

|

Average beds per resort=

160

~ people/resort

~ Average number of beds per resort

|

Time to dispose waste=

0.5

~ Year

~ Average time to dispose waste in the island. 6 months is the time that \
waste sits around before it is disposed.
|

Days in Year=
365
~ days/Year
~ There are 365 days in a year.
|

Desired Bed Capacity Utilization=
0.5
~ Dmnl
~ 75% desired bed capacity utilization
|

Fraction of waste burned on Maldives=
IF THEN ELSE(Time>=2013, 0.6, IF THEN ELSE(Time>=2006, 0.8, IF THEN ELSE(Time>=1992\
, 0.8 , 1)))
~ Tons/Year
~ Prior to 1992 no waste was sent to Thilafushi. after 1992, the fraction of \
waste burned was 85% (15% shipped to Thilafushi). Then in 2006 it was \
decreased to 75%, amount shipped increased to 25%). Then, from 2013 it was \
decreased to 60% (amount shipped was increased to 40%).
|

Fraction of waste burned perceived by tourists=
0.001
~ Dmnl
~ 0.1% of the entire waste is burned.
|

Gap in bed capacity=

"Expected # of tourists" * Gap in Bed Capacity Utilization

~ people

~ This variable calculates how many beds are needed in the near future.

|

Gap in Bed Capacity Utilization=

ABS(Desired Bed Capacity Utilization - Bed Capacity Utilization)

~ Dmnl

~ This variable calculates the gap in bed capacity utilization.

|

Gap in resorts=

Gap in bed capacity / Average beds per resort

~ resorts

~ This variable calculates the resorts needed in the near future.

|

"Indicated # of resorts"=

Resorts + Gap in resorts

~ resorts

~ This variable is the sum of all resorts plus the required resorts.

|

Waste burned on Maldives[waste type]=

Waste Ferried or Burned[waste type] * Fraction of waste burned on Maldives

~ Tons/Year

~ This flow indicates the waste burned on the Maldives.

|

Kilos per ton=

1000

~ kg/ton

~ There are 1,000 kilograms in a ton.

|

Waste Ferried or Burned[waste type]=

Waste stored in Maldives[waste type] / Time to dispose waste

~ Tons/Year

~ Part of the waste is ferried to Thilafushi or burned.

|

Waste stored in Maldives[waste type]= INTEG (

Waste generated in Maldives[waste type] - Waste Ferried or Burned[waste type],

0)

~ Tons

~ This stock indicates the total waste on the Maldives.

|

Pollution perceived by tourists=

SUM(Waste burned on Thilafushi[waste type!])* Fraction of waste burned perceived by tourists

~ Tons/Year

~ This accumulation calculates how much pollution is perceived by the \

tourists.

|

Resorts= INTEG (

Change in resorts,

10)

~ resorts

~ It is assumed that there are 10 resorts in 1979.

|

Time to build resorts=

4

~ Year

~ Average time to build a resort is 4 years.

|

Tons of waste per tourist per year=

Days in Year*Kilos of waste per tourist per day/ (Kilos per ton)

~ Tons/tourist/Year

~ Each tourist of Maledives generates 3.5 kg of garbage per day.
Source: \
http://www.welt.de/vermischtes/article131144033/Im-tuerkisblauen-Wasser-ein\
e-Insel-aus-Muell.html

|

Waste burned on Thilafushi[waste type]=

Waste stored on Thilafushi[waste type] * Fraction of waste burned on Thilafushi

~ Tons/Year

~ This flow indicates the waste burned on Thilafushi.

|

Waste ferried to Thilafushi[waste type]=

Waste Ferried or Burned[waste type] - Waste burned on Maldives[waste type]

~ Tons/Year

~ An average of 330 tonnes of rubbish are brought to Thilafushi every day, most of \
which are from MalÃƒÂ©.
Source: \
https://globalvoicesonline.org/2014/10/24/theres-an-island-made-of-toxic-tr\
ash-rising-out-of-the-sea-in-the-maldives/

|

Total tourism revenues= INTEG (

+Annual tourist spending,

0)

~ Rufiyaa

~ The accumulation of revenues since simulation start.

|

Kilos of waste per tourist per day=

3.5

~ kg/tourist/day

~ Each tourist of Maledives generates 3.5 kg of garbage per day.
Source: \
http://www.welt.de/vermischtes/article131144033/Im-tuerkisblauen-Wasser-ein\
e-Insel-aus-Muell.html

|

Waste per inhabitant in Maldives=

1.2

~ kg/person/day

~ Each inhabitant of Maledives generates 1.2 kg of garbage per day. Source: \
http://www.welt.de/vermischtes/article131144033/Im-tuerkisblauen-Wasser-ein\
e-Insel-aus-Muell.html

|

Population in Maldives= INTEG (

Maldives Population growth,
152143)

~ people

~ 394.000 people in 2014
Source: \
http://www.welt.de/vermischtes/article131144033/Im-tuerkisblauen-Wasser-ein\
e-Insel-aus-Muell.html

|

****

.Control

**~

Simulation Control Parameters

|

FINAL TIME = 2050

~ Year

~ The final time for the simulation.

|

INITIAL TIME = 1979

~ Year

~ The initial time for the simulation.

|

SAVEPER = 1

~ Year [0,?]

~ The frequency with which output is stored.

|

TIME STEP = 0.015625

~ Year [0,?]

~ The time step for the simulation.

|