اللجنة الاقتصادية والاجتماعية لغربي آسيا

Optimization Model Development for Poverty Reduction

Work done by consultant (Majd OLLEIK) and ESCWA

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Assumptions

1. The overall goal is to reach a preset target MPI (lower than the existing MPI) while minimizing the total effort.
2. For each indicator, the policy maker is able to specify a measure of effort required to remove a single household from deprivation.
3. The indicators that will be used in optimization are assumed to be independent.
4. The optimization model generates:
   a. Whether the MPI reduction target can be achieved or not, given the available resources
   b. Total effort required per indicator (and by geographic cell)

Overall, this provides the user with a policy tool to optimize resource allocation (By indicator/ sector, and by geographical targeting), while aiming to reach a target MPI.

Mathematical formulation

❑ **Objective function:** Minimize total efforts across all active indicators:

$$min \sum_{J} E_j$$

❑ **Constraints:**

1. Each element of the new deprivation matrix is at most the corresponding element in the old deprivation matrix.

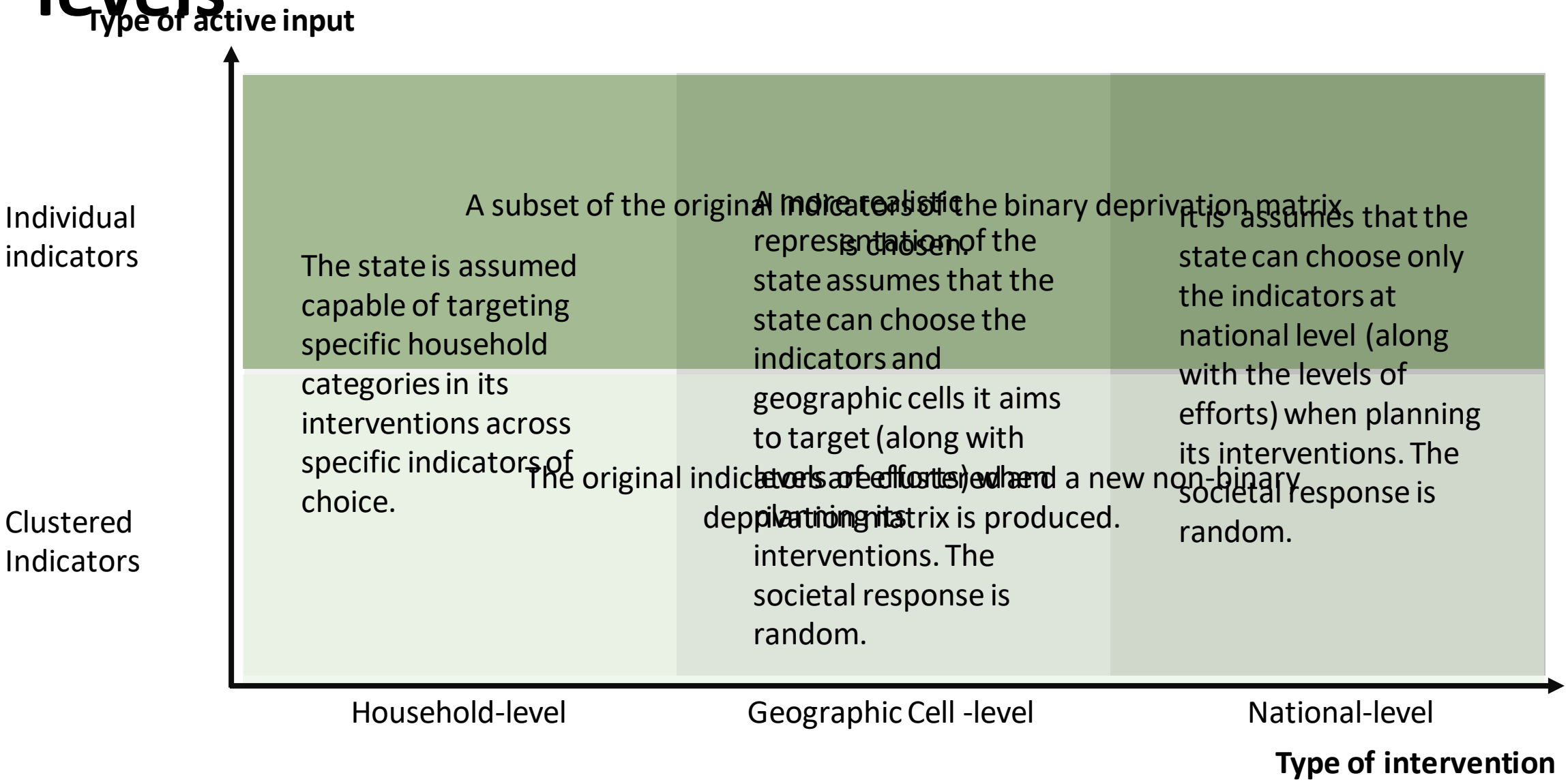
2. If after optimization a household category is poor, then it will contribute to the resulting MPI (according to the AF method rules and axioms).

3. The total effort per indicator must be within the minimum and maximum values.

4. The resulting MPI must be at most equal to the preset target MPI.

The above optimization model is linear as the objective function and constraints are linear (after linearizing the logical constraints) with respect to the decision variables

Optimization models – along two levels



Example of indicators vs. clustered indicators

Original deprivation matrix

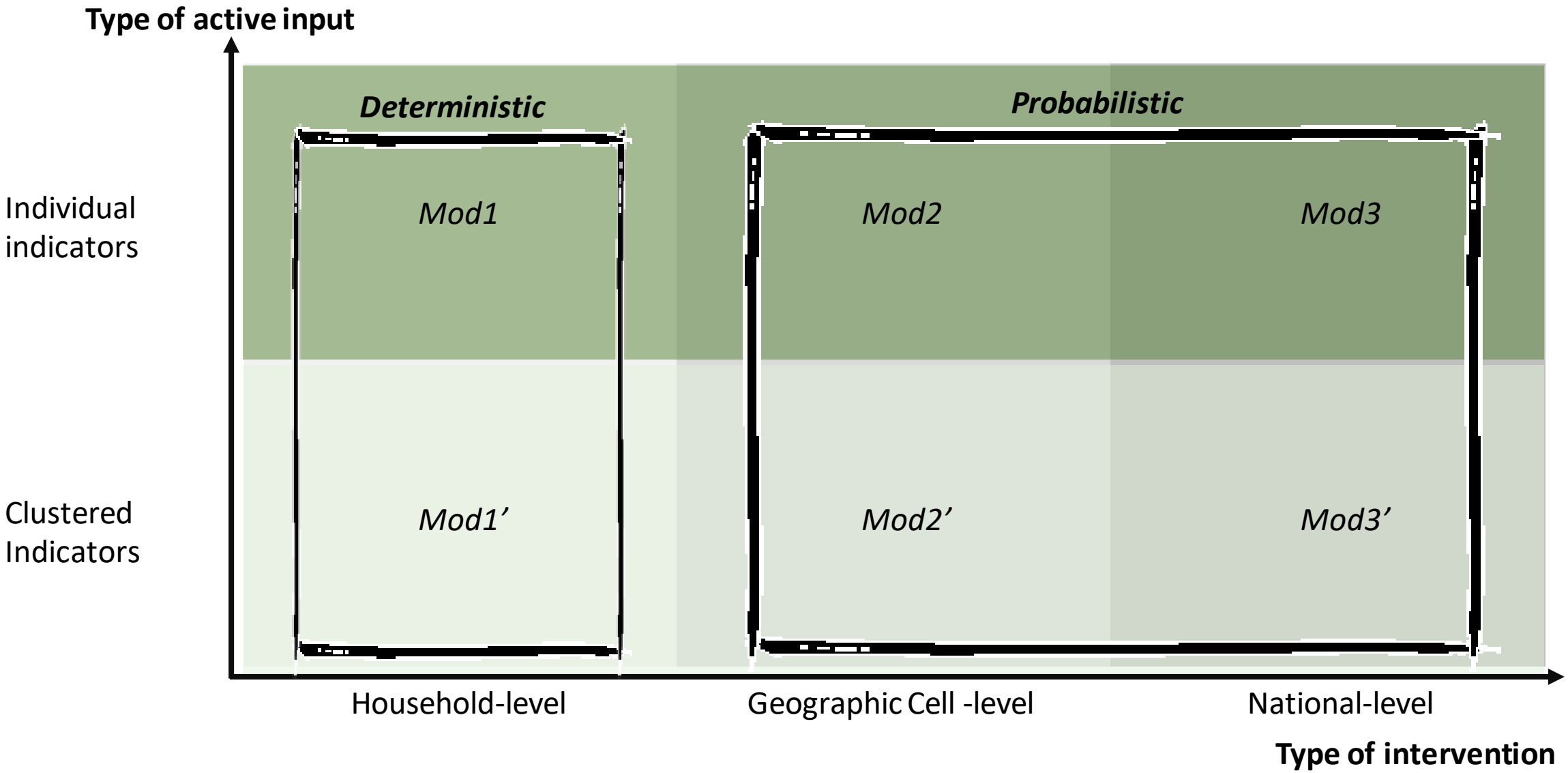
Household	Indicator 1	Indicator 2	Indicator 3	Indicator 4
1	1	0	0	1
2	1	0	0	0
3	1	1	1	1
Weights	*0.25*	*0.25*	*0.25*	*0.25*

Household	***Clustered indicator 1***	***Clustered indicator 2***
1	1	1
2	1	0
3	2	2
Weights	*0.25*	*0.25*

Clustered indicators are assumed:

- Externally fully independent
- Composed of internally fully dependent indicators

Six optimization models



Application on Lebanon – Survey 2019, target setting MPI reduction for a certain year in the future

Data inputs [1/2]

- Binary deprivation matrix, 2019 survey:
  - 38,929 Households and 20 Indicators
  - Each Household is characterized by a household size and by geographic information (governorate).
- Indicators belong to six dimensions.
- Each dimension is equally weighted (in terms of contribution to the MPI) and each indicator within a dimension is equally weighted.
- The poverty cut-off is 0.17.

2019 – MPI results

MPI	**0.112**
H	0.411
A	0.273

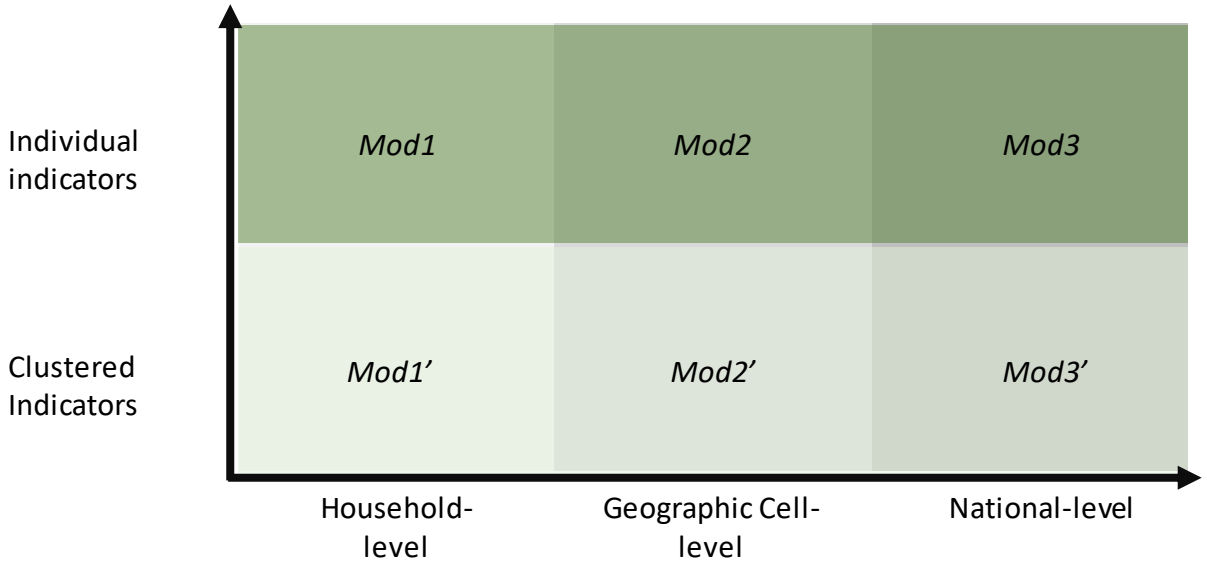
Indicator	% contribution to MPI	Indicator	% contribution to MPI
LF04 - Health Insurance	16.01%	LF02 - Educational Attainment	4.05%
LF20 - Income (2019) - 368,000LL	13.90%	LF06 - Access to Medical Services	3.62%
LF14 - Internet Access and ICT	10.86%	LF08 - Drinking Water	3.27%
LF01 - Access to Education	9.24%	LF17 - Heating devices	2.33%
LF11 - Overcrowding rate	6.27%	LF12 - Housing type	1.62%
LF09 - Sanitation	6.24%	LF15 - Means of transport	1.41%
LF03 - School Attendance	5.30%	LF19 - Employment Informality (ALL)	1.38%
LF05 - Access to Medicines	4.57%	LF10 - Waste Collection	1.24%
LF07 - Electricity	4.46%	LF13 - Having a toilet	0.15%
LF18 - Employment deprivation	4.06%	LF16 - Household electrical devices	0.02%

Additional assumed input parameters

- Desired reduction in MPI: 20%

- For Mod1, Mod2, Mod 3:
  - Active individual indicators
  - Measure of effort per flip per active indicator

- For Mod1', Mod2' and Mod3':
  - Active clustered indicators (*dimensions*)
  - Measure of effort per flip per active clustered indicator (*dimension*)



Active individual indicators (Mod1, Mod2, Mod3)

- Contribute to 50.02% of MPI
- Removing deprivation in them reduces MPI by 79%

Indicator	% contribution to MPI	Indicator	% contribution to MPI
Ind2: Health Insurance	16.01%	Educational Attainment	4.05%
Ind20: Income (2019)	13.90%	Access to Medical Services	3.62%
Ind18: Internet Access and ICT	10.86%	Drinking Water	3.27%
Ind13: Access to Education	9.24%	Heating devices	2.33%
Overcrowding rate	6.27%	Housing type	1.62%
Sanitation	6.24%	Means of transport	1.41%
School Attendance	5.30%	Employment Informality (ALL)	1.38%
Access to Medicines	4.57%	Waste Collection	1.24%
Electricity	4.46%	Having a toilet	0.15%
Employment deprivation	4.06%	Household electrical devices	0.02%

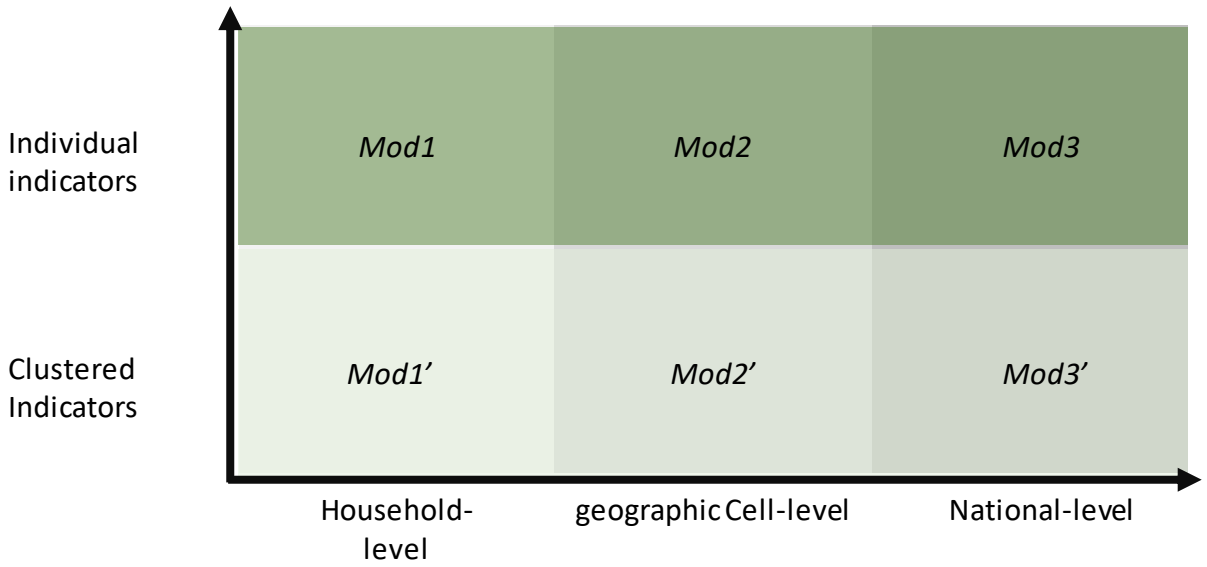
Effort per flip (*EpF*)

For Mod1, Mod2 and Mod3

Individual indicator	***EpF***
Ind2: Health Insurance	6
Ind13: Access to Education	5
Ind18: Internet Access and ICT	3
Ind20: Income (2019)	6

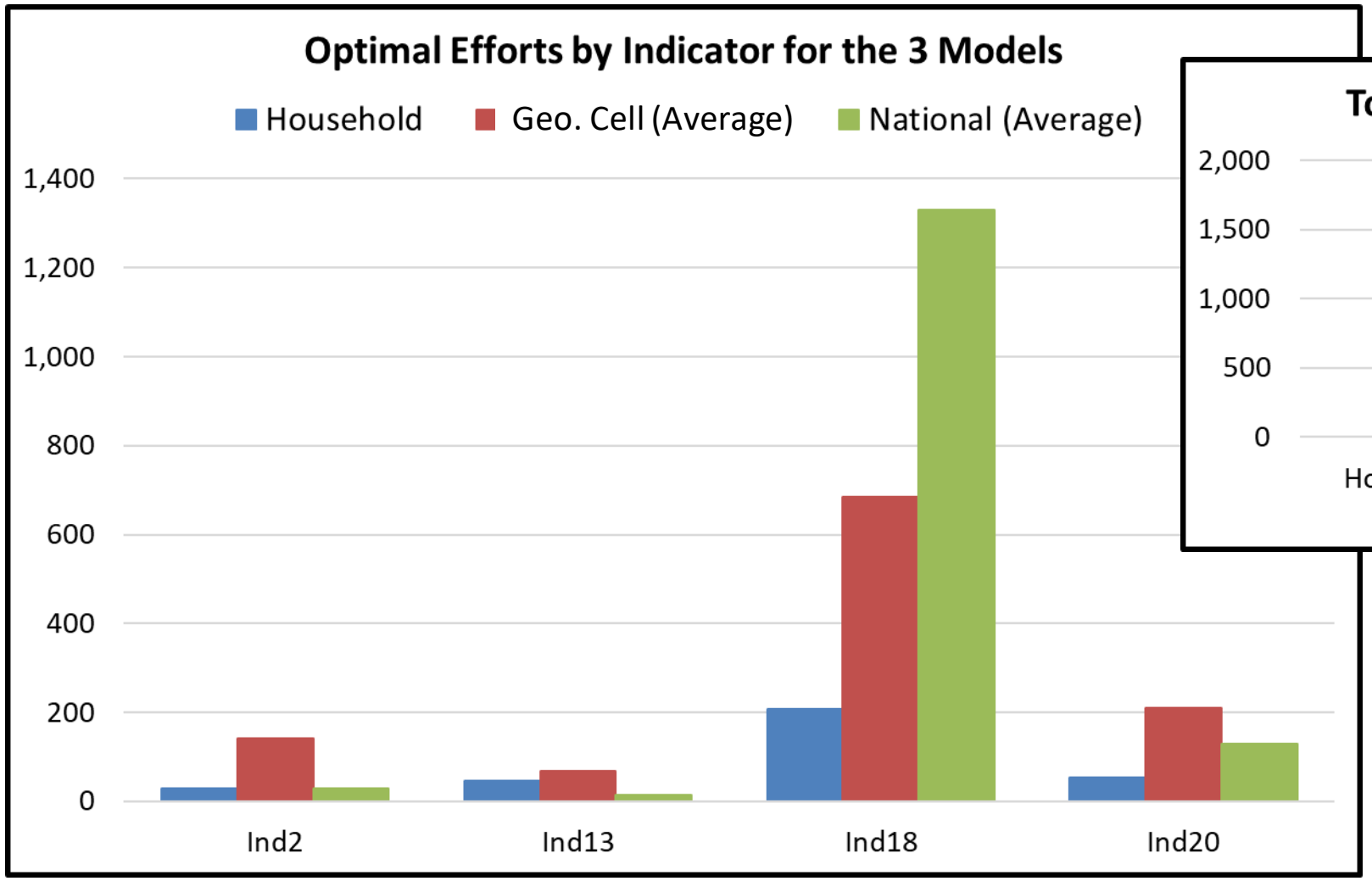
For Mod1', Mod2' and Mod3'

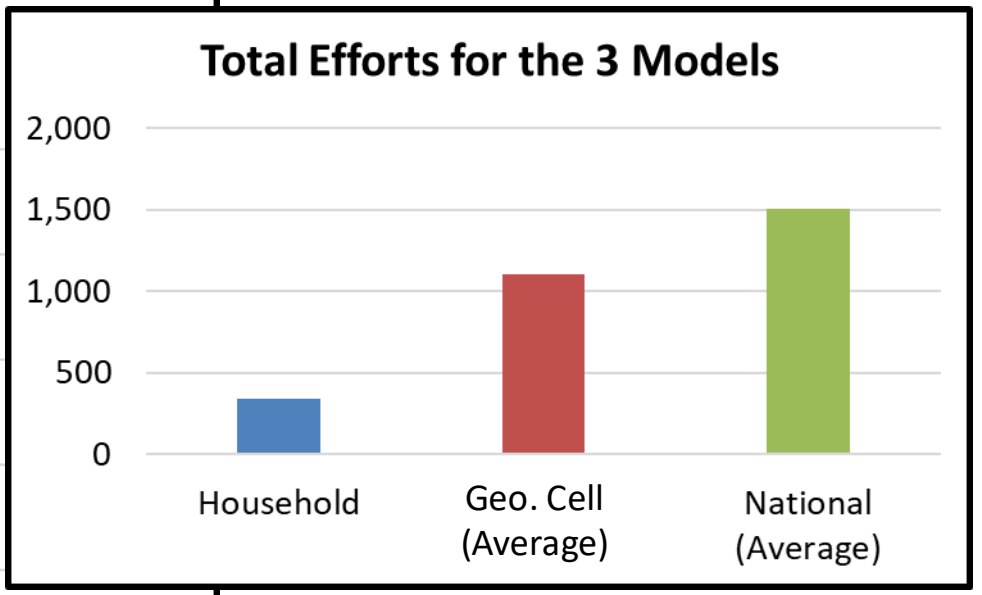
Dimensions	***EpF***
Dim1: Health	6
Dim2: Education	5
Dim5: ICT and Appliances	3
Dim6: Employment and Income	6



Results for Individual Indicators (post-optimization)

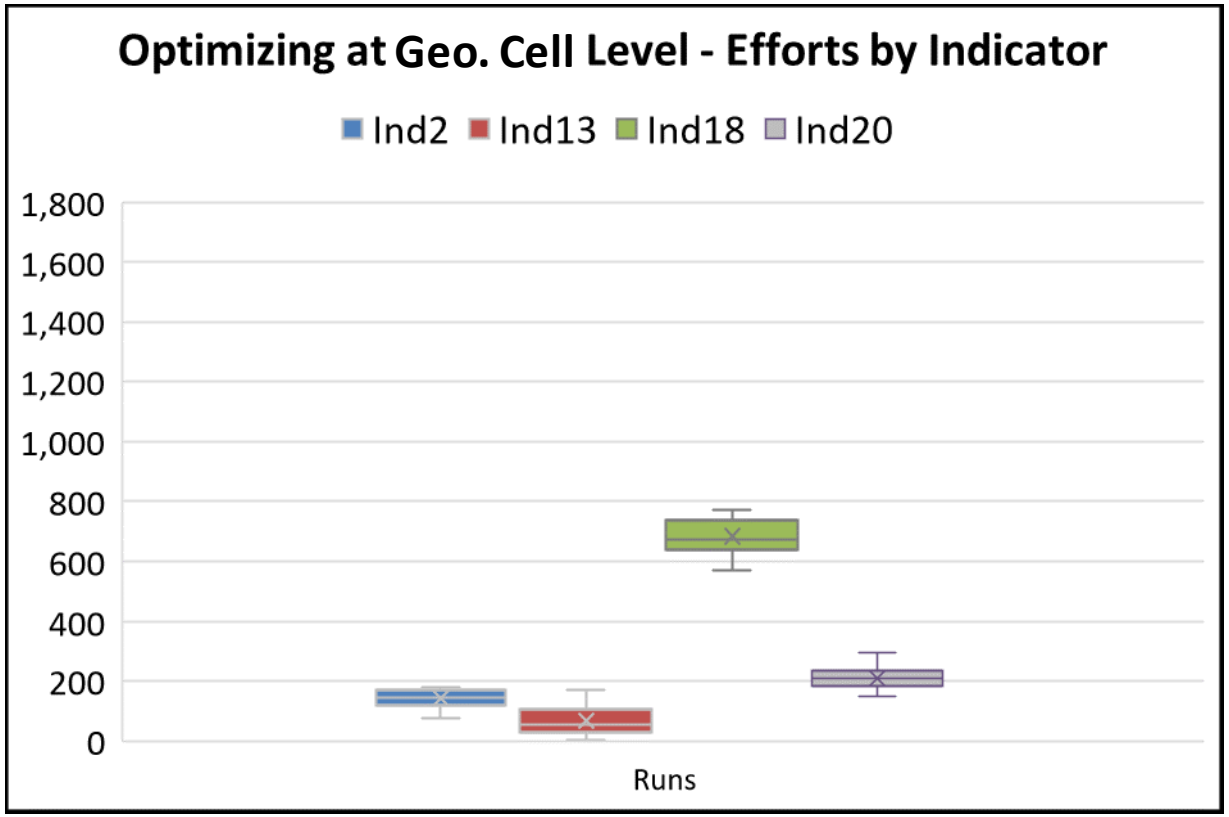
Comparison of Results – Three Models

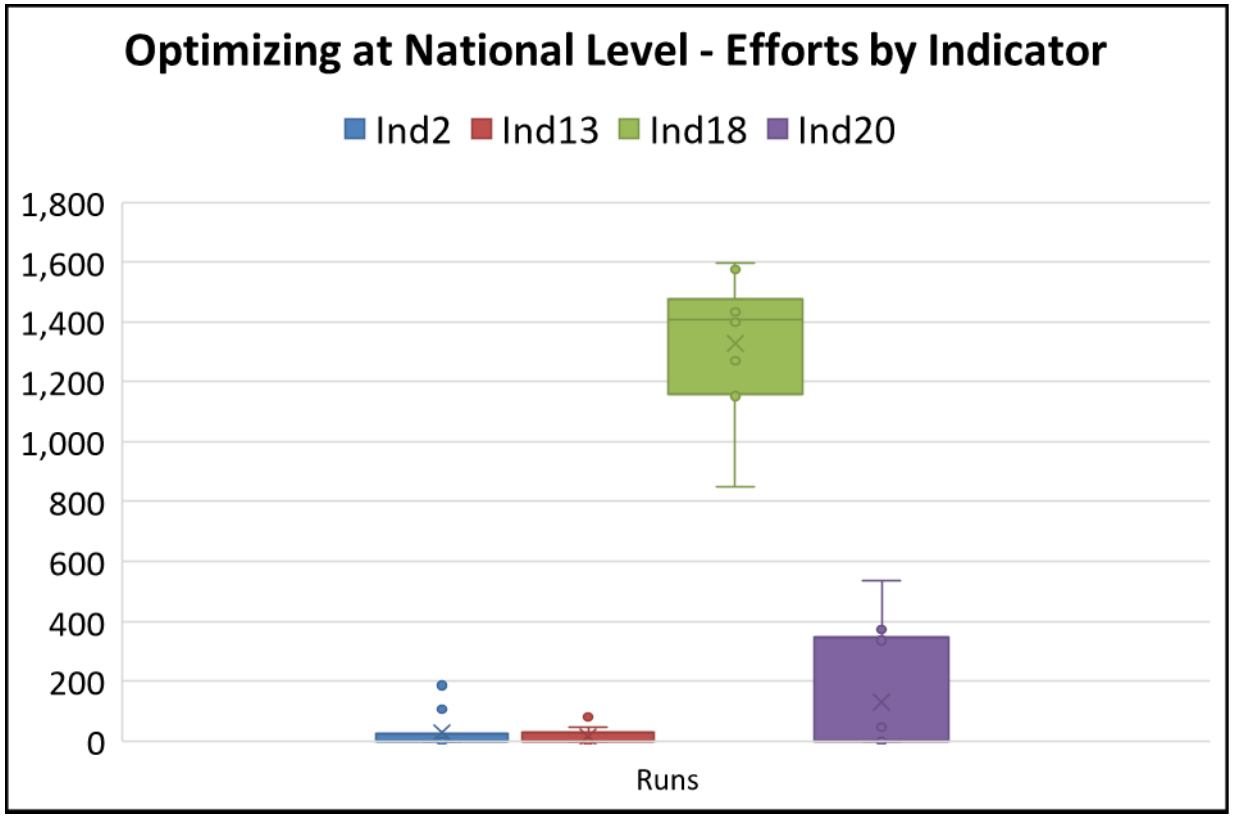




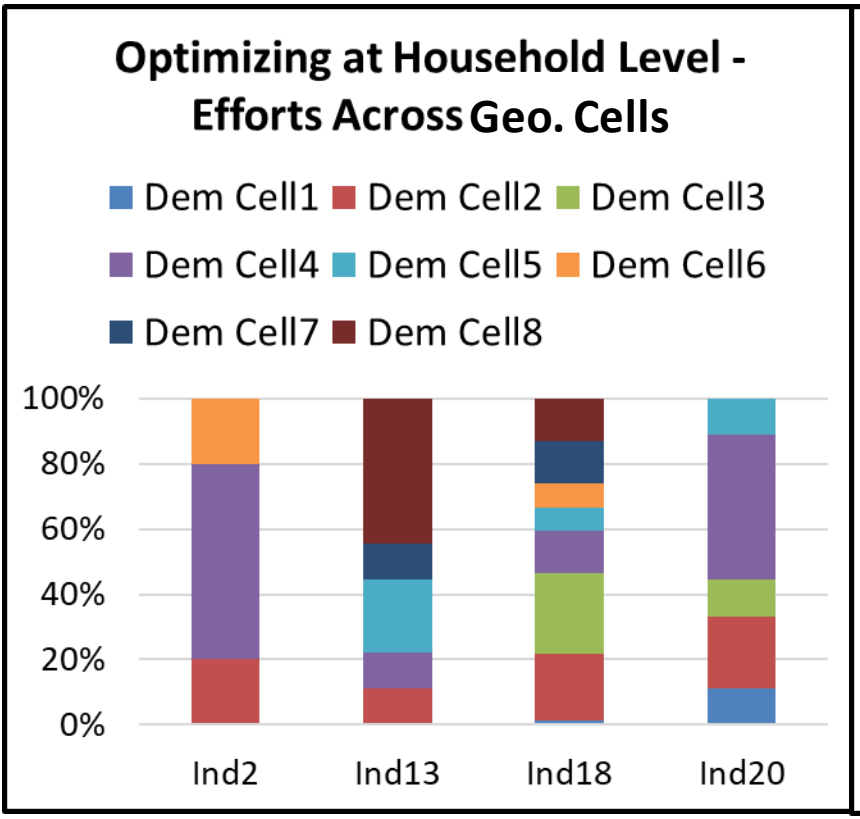
Individual indicator	*EpF*
Ind2: Health Insurance	6
Ind13: Access to Education	5
Ind18: Internet Access and ICT	3
Ind20: Income (2019)	6

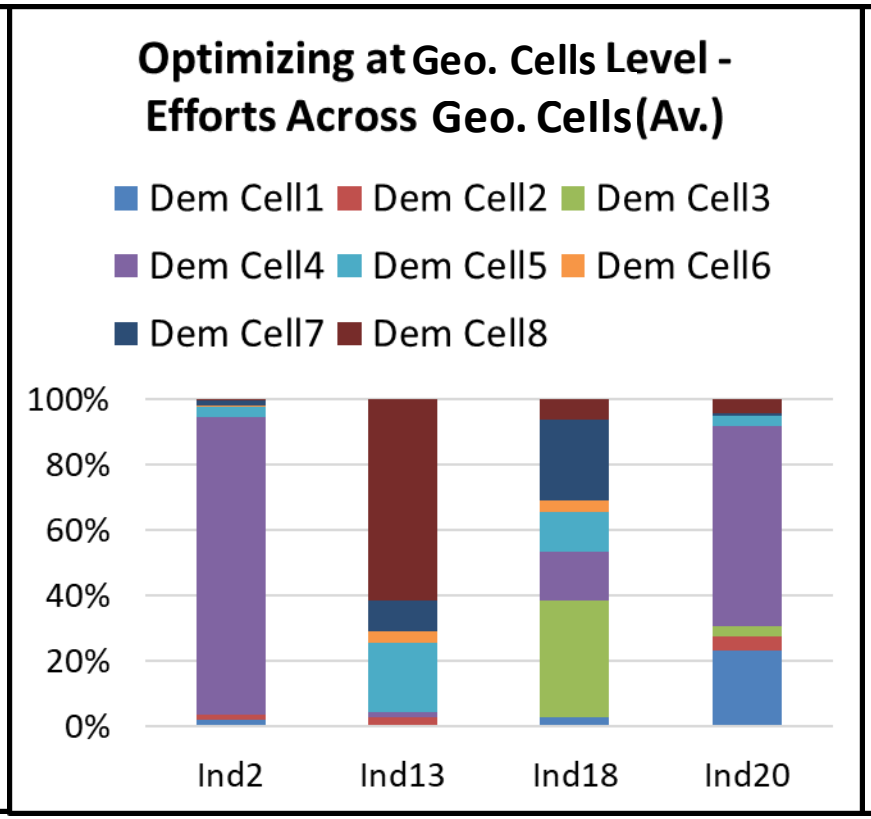
Comparison of Results – Spread of Efforts by Indicator over the Different Runs

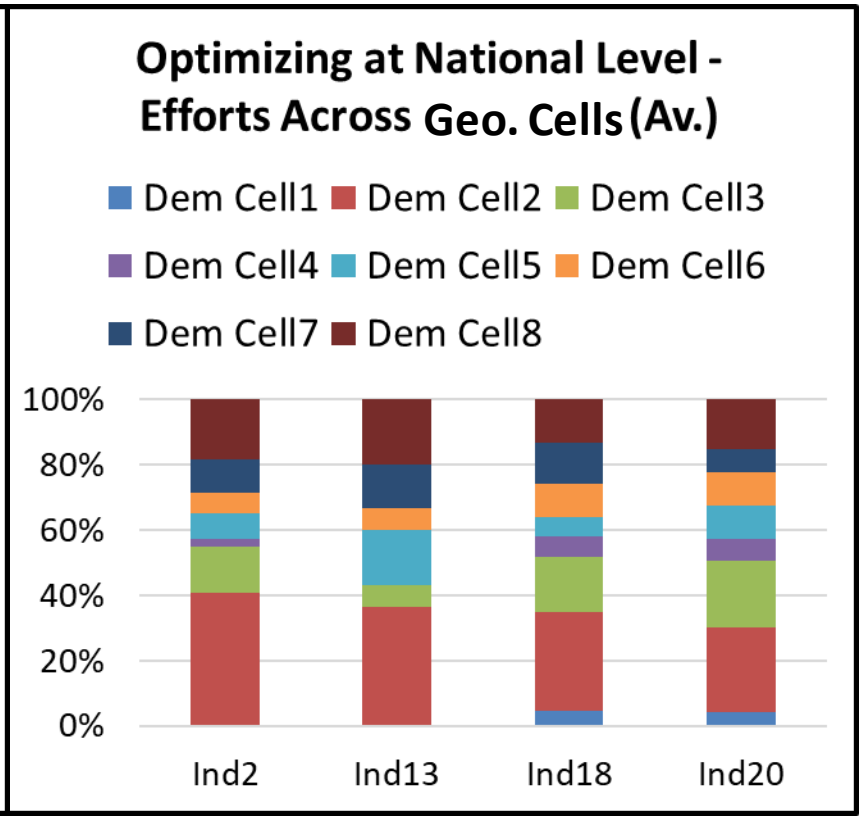




Comparison of Results – Distribution of Effort by Geographic Cell







Summary of Models

1. We presented 6 theoretical optimization models for MPI reduction.
    1. Mod1:
        - Targets individual households
        - Is very efficient
        - Yet is unrealistic => main value is to calculate a lower bound on effort and to check how efficient are other solutions.
    2. Mod2:
        - Targets indicators and geographic cells
        - Is practical and realistic
        - Provides solid solutions despite random societal response
    3. Mod3:
        - Targets indicators at national level
        - Is practical and realistic
        - Is less efficient than Mod2 but might be resorted to if focusing on geographic cell is not possible
    4. Mod1', Mod2' and Mod3' are variants of the previous models that consider a novel non-binary deprivation matrix that should be carefully studied.

Conclusion

MPI

A. **Complement** monetary poverty statistics

B. **Track poverty** over time (official statistics) as SDG 1.2

C. **Allocate resources** by sector and by region

D. **Target** marginalized regions, groups, or households

E. **Coordinate** policy across sectors and subnational levels

F. **Adjust policies** by what works (measure to manage)

G. **Leave No One Behind** see the poorest & track trends

H. B**e Transparent** so all stakeholders engage

Optimization module

Allocate resources

- Does the state resource allocation match the levels of poverty (by sector and geographic units)? In fact, this could be used to spot mismatches between resource allocation and poverty measures
- Using this optimization model, will inevitably promote MPI as an essential measure that shall be used by the state in the future; more specifically in any resource allocation exercise/ plan

MPI target setting

- Constrained by the state financial capabilities, this model gives an idea about the level of MPI reduction that can be attained

Limitations and Future Work

Limitation 1: The deprivation matrix is assumed static over the planning horizon.

- The exercised efforts by indicator are the only inducing factor for modifying the deprivation matrix (in one direction only):
  - Households are assumed never flipping from non-deprived to deprived.
  - No households are entering the population.
  - No households are exiting the population.

- ***Only realistic for short planning horizons***
- ***Does not permit the consideration of indicators where households are stuck in deprivation status [E.g., Child Mortality]***

Limitation 1: Potential remedies

Original deprivation matrix

Indicator 1	Indicator 2	…	Indicator n
1	0	…	1
0	0	…	0
…	…	…	…
1	0	…	1

Forecasted deprivation matrix at end of planning horizon (no intervention)

Indicator 1	Indicator 2	…	Indicator n
0	0	…	1
0	1	…	0
…	…	…	…
1	1	…	1

Compute optimal intervention to achieve target MPI by:

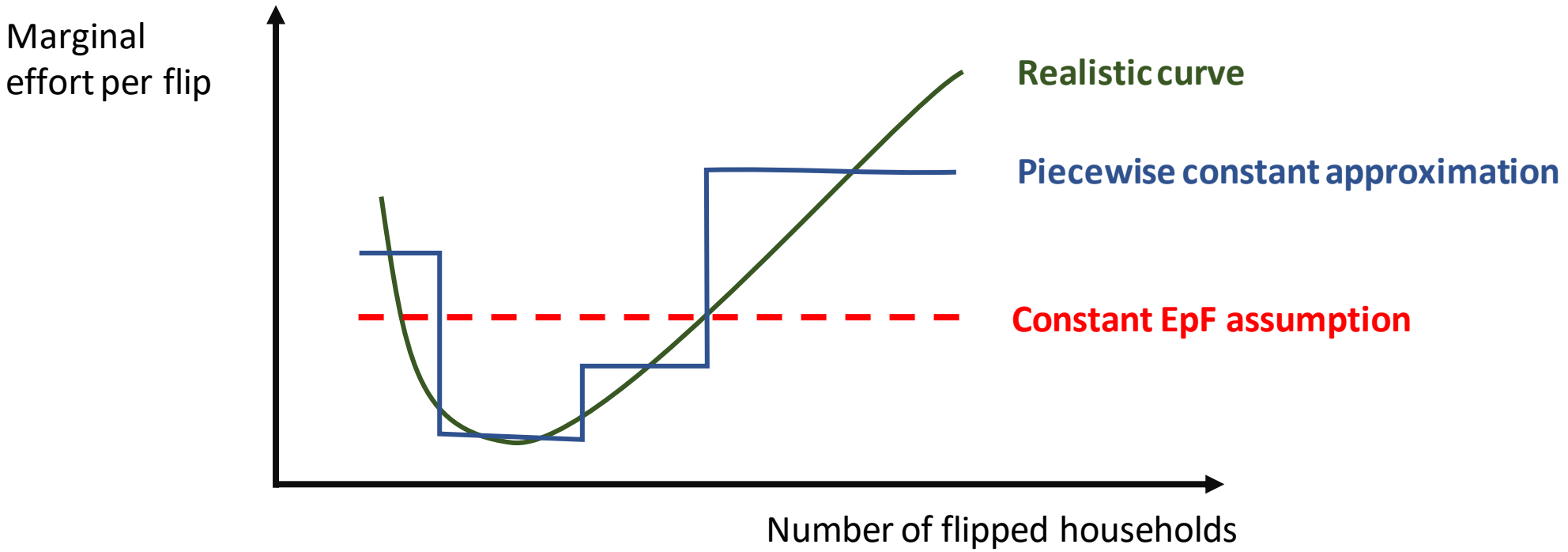
- Removing households from deprivation
- Protecting households from moving into deprivation

Limitation 2: The Effort per Flip is assumed constant (by indicator).

- The marginal cost of an additional flip is assumed constant.

- ***Only realistic for limited number of flips per indicator or for specific types of indicators.***
- ***Non-constant marginal cost functions cause non-linearities in the optimization model***

Limitation 2: Potential remedies



Limitation 3: How to populate reliable estimates of Effort per Flip by indicator?

- How to link efforts to flips?

Potential approach to follow:

- ***When constant Efforts per Flip are assumed by indicator, relative EpF measures are enough across the considered indicators.***
- ***Historical MPI data along with budget spent can offer initial starting points for estimating the EpFs.***
- ***National expertise can be built for estimating the EpFs based on the national context.***

Additional open-ended considerations

1. How to reasonably set target MPI reductions?
   - Generating good estimates of EpFs allows the policy-maker to check the feasibility of different target MPIs given a total budget.
   - What about the time dimension?
2. How to deal with the independence assumption across individual indicators?
3. How to deal with the full dependence assumption within a cluster of indicators and the full independence assumption with indicators outside the cluster?

Thank you