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Rain water-based integrated agricultural system: A model for ensuring food security and adaptation in coastal Bangladesh

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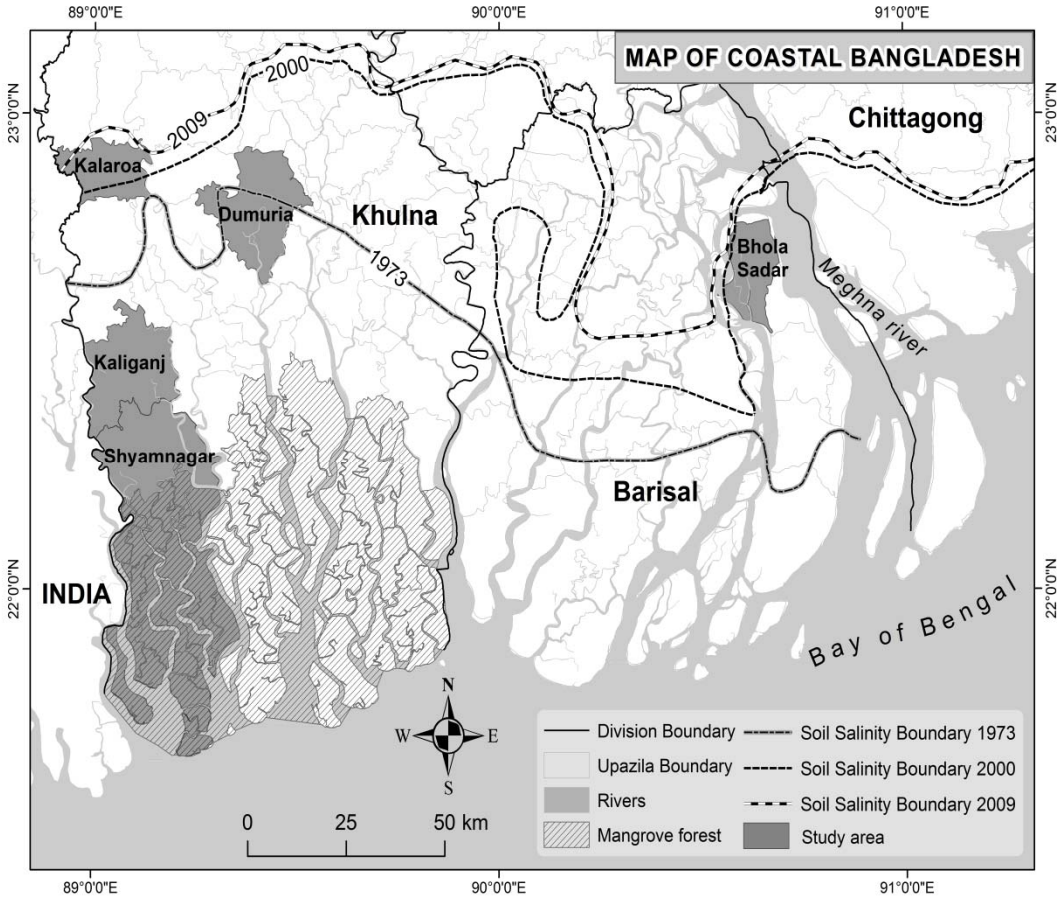
Background



- Climate change impacts (e.g., rising sea level, increased salinity, coastal erosion)
- Natural calamities (e.g., cyclone, storm surges, floods, riverbank erosion, drought)
- Human interventions (embankment, industries, urban growth etc.)

The coastal areas of Bangladesh face challenges to sustaining agriculture, food and nutrition security

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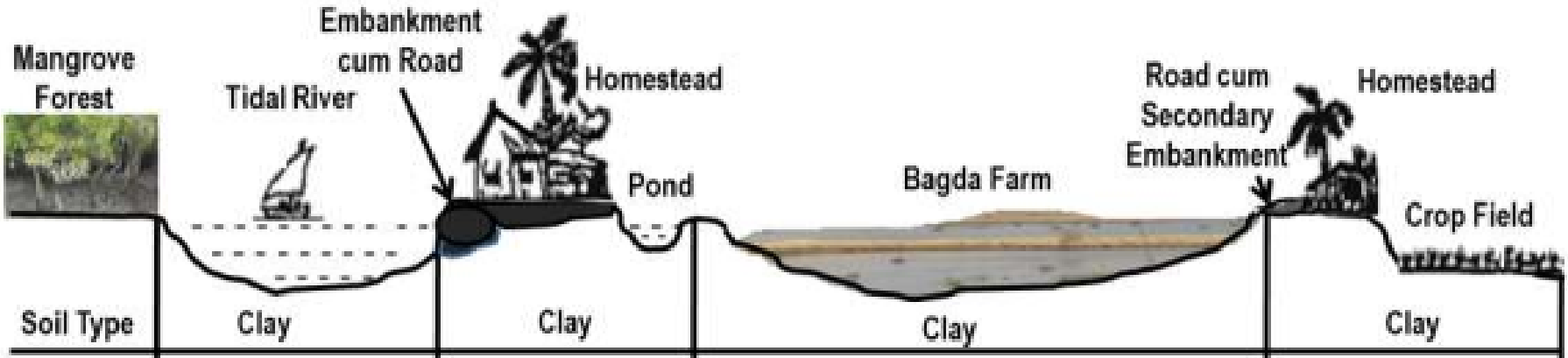
Shrimp-based agricultural systems



Soil Type	Clay	Clay	Clay	Clay
Water Resources	Tidal	Rain Water	Tidal	Rain Water
Crops		Coconut, Mangrove Trees & Vegetables etc.	No Crops	Rice in Rainy Season
Livestock		Chicken & Duck		Cow, Goat & Chicken
Fish	Natural Shrimp and White Fish	Shrimp and Whitefish	Cultural Shrimp and Natural and Cultural Whitefish (Tilapia and Other Local Species)	

Fig. Large-scale transect of shrimp-based agricultural systems

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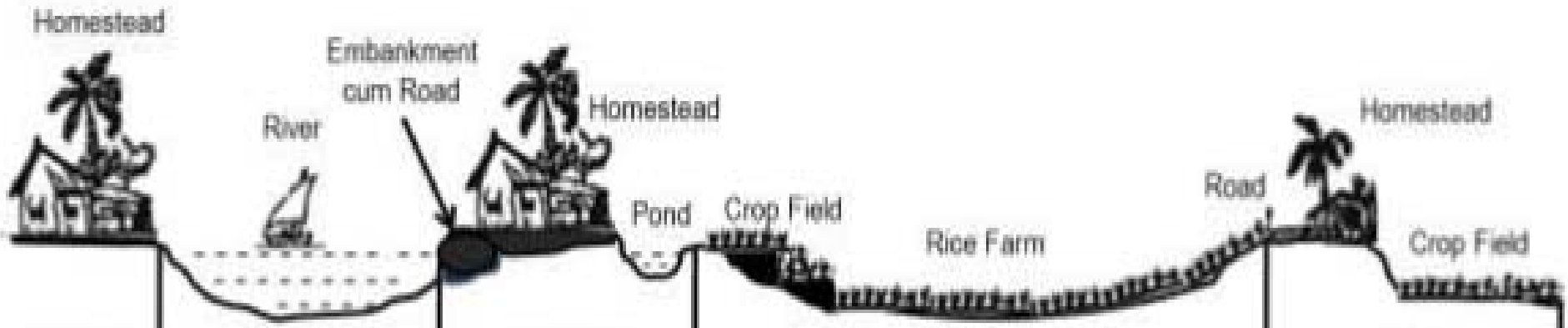
Rice-based agricultural systems



Soil Type	Clay Loam	Clay Loam	Clay Loam	Clay
Water Resources	Rain and Tidal	Rain Water	Rainwater	Rain Water
Crops		Coconut, Mango Jackfruit, & Vegetable etc.	Rabi Crops & Rice	Rabi Crops and Rice
Livestock		Cow, Goat, Duck & Chicken		Cow, Goat, Duck and Chicken
Fish	Fresh Water Fish	Fresh Watersh (Carp, tilapia and local varieties)		

Fig. Large-scale transect of rice-based agricultural systems

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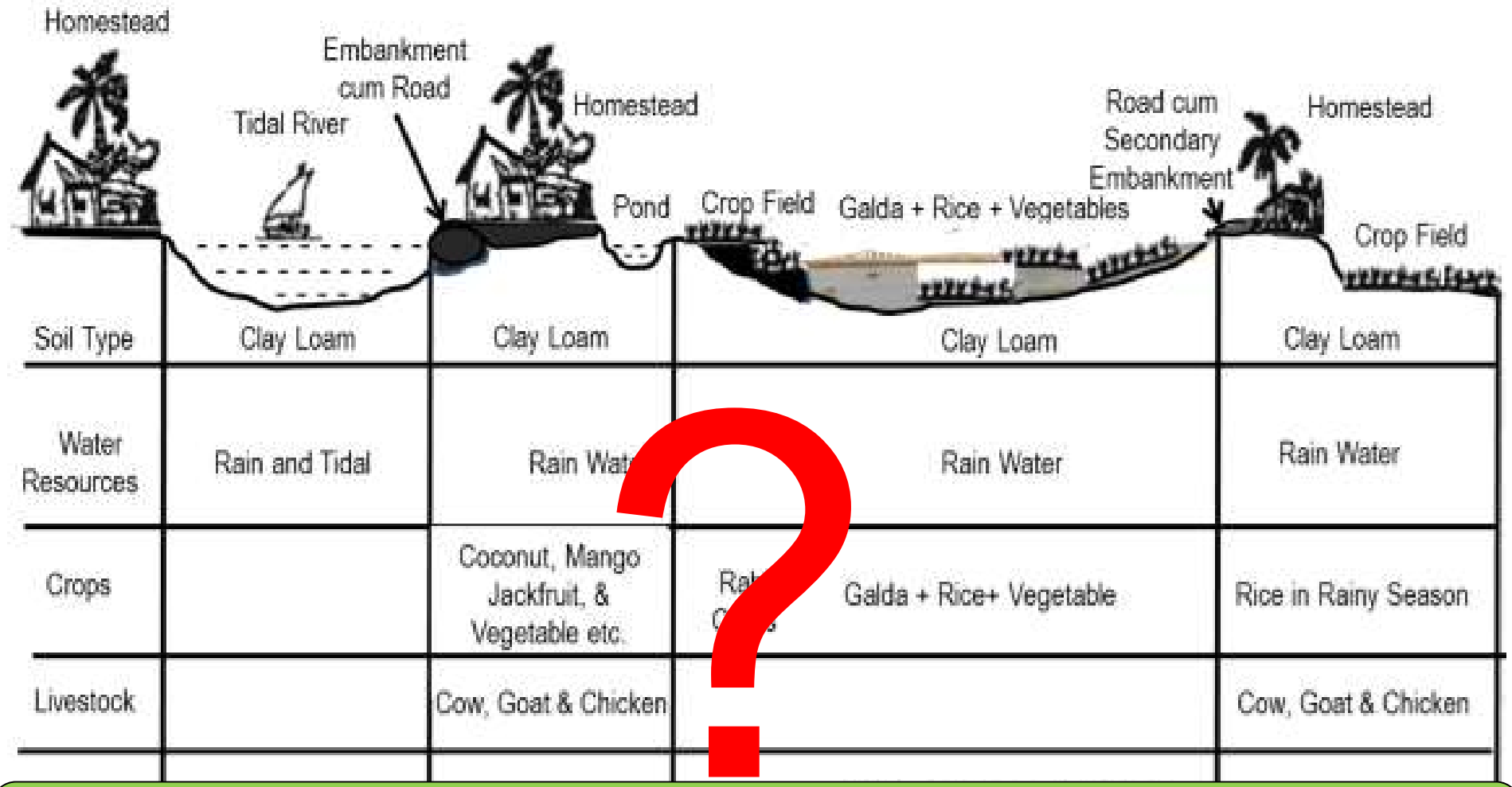
Rain water/fresh water-based integrated (rice-shrimp-vegetables) agricultural systems



What are the sustainability features of this agricultural systems and how does it help in adaptation and ensuring food security?

Fig. Large-scale transect of shrimp-rice-vegetables based agricultural systems

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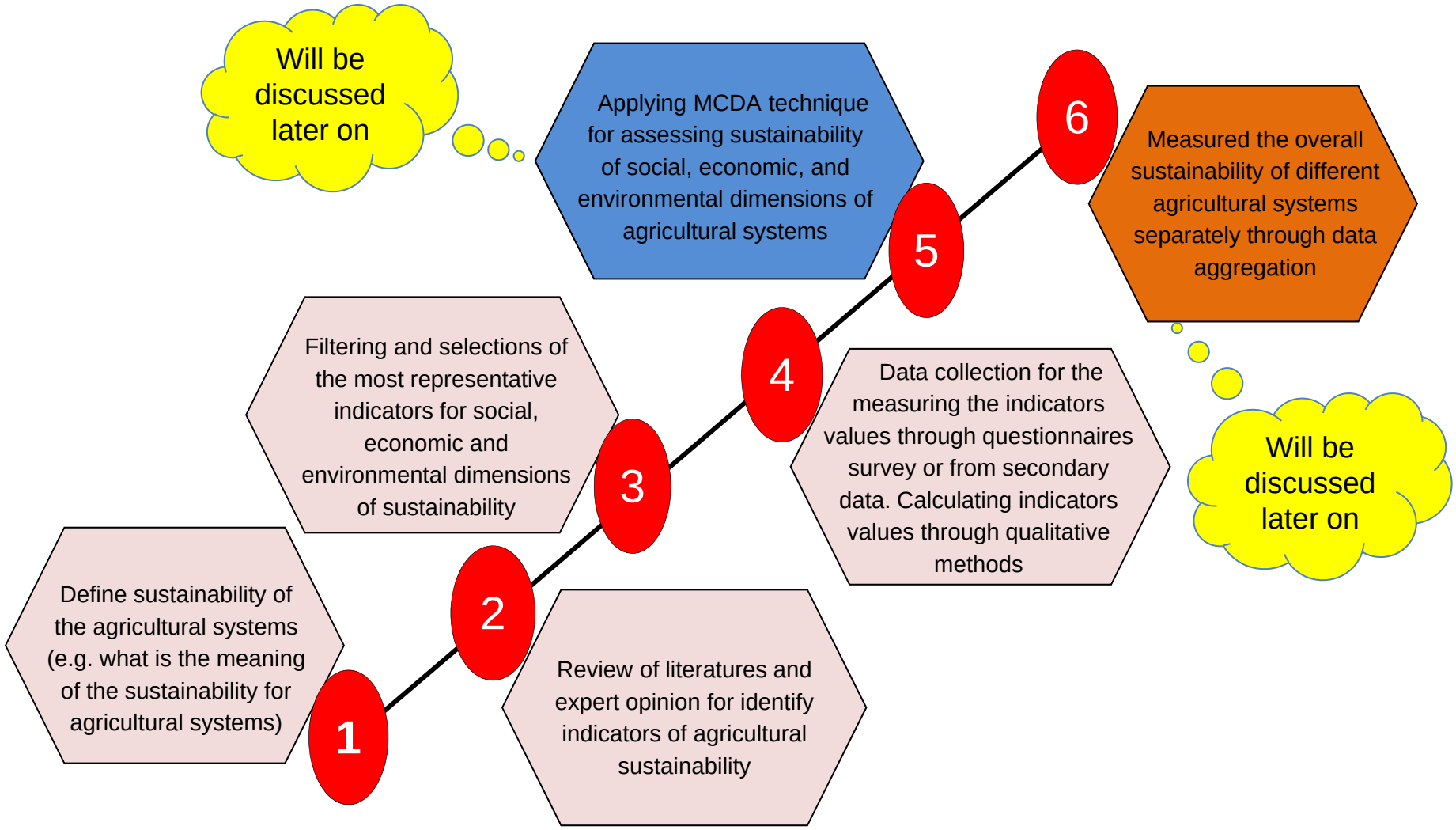
Generalized structure and six steps of holistic approach (MCDA based framework) for agricultural sustainability assessment



Six steps

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Table: Comparison of sustainability indicators

Sustainability issues	Indicators	Agricultural Systems		
		Shrimp	Rice	S-R-V
Productivity				
Rice	Yield (t/ha) [Weighted average]	2.26	5.23	6.51
Agro-ecosystem	Net income ($/ha)	311.15	1585.81	1806.04
	Protein yield (kg/ha)	68.42	552	373.01
	Energy yield (j/ha)	$7.6X10^{9}$	$1.2X10^{11}$	$7.2X10^{10}$
Efficiency				
Agro-ecosystem	Ration($output / $input)	1.53	2.78	6.67
	Overall energy efficiency (Ratio of energy output and input)	1.37	5.53	5.54
	Non-renewable energy efficiency	0.78	2.17	2.52
Biophysical compatibility				
Agro-ecosystem	Overall biodiversity indicator	1.75	6.13	4.4
	Percentage of non-crop area	7.54	23.01	15.73
	Condition of ecosystem services	1	2.5	3
	Crop richness	2	16	10

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Table: Comparison of sustainability indicators

Sustainability Issues	Indicators	Agricultural Systems		
		Shrimp	Rice	S-R-V
Human compatibility				
Agro-ecosystem	Illness from water	0.00	9	10
	Protected water supply	5	10	10
Agricultural knowledge				
Agro-ecosystem	Agricultural training	1.33	0.33	2.27
	Advices from Block Supervisor	0.66	0.51	0.45
	Soil test	0.67	1.69	1.36
	Climate change awareness	1.11	0.51	1.82
Economic issues				
Agro-ecosystem	Product price	8.44	4.58	4.55
	Availability of market	10.00	8.47	10.00
	Livelihood diversification	6.22	5.93	4.55
	Years of economic hardship	0.73	0.91	0.82
	Product price	8.44	4.58	4.55

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Table: Comparison of sustainability indicators

Sustainability Issues	Indicators	Agricultural Systems		
		Shrimp	Rice	S-R-V
Equity issues				
Agro-ecosystem	Average income from agro ecosystem (in $)	648.23	1371.32	1992.39
	Production of own staple food	2.00	6.44	6.36
	Average calorie intake by each family member from staple food	5.49	6.88	7.36
	Women participation in the agricultural activities of the household	3	5	6.5
	Access to electronic media	7.78	9.39	10.00
	Average daily wage of farm labourer (Tk.)	100	120	135
	Gender-based wage differentials	0.33	0.5	0.59

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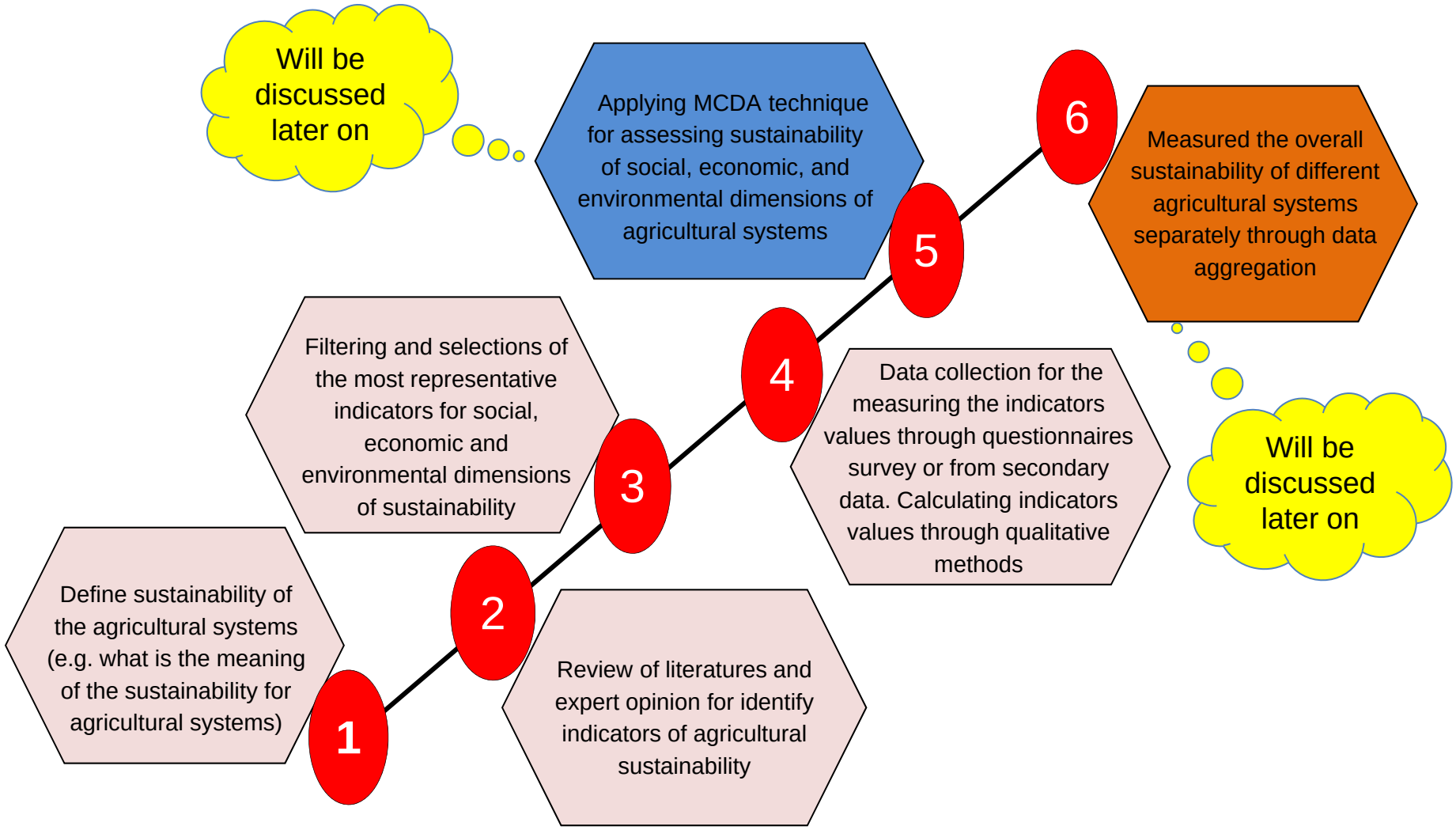
Generalized structure and six steps of holistic approach (MCDA based framework) for agricultural sustainability assessment



Six steps

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Suggested MCDA techniques to find best assessment methods

- Multiple attribute value theory (MAUT): The alternatives are evaluated with respect to each attribute and the attributes are weighted according to their relative importance in MAUT [Mustajoki et al., 2003].

$v(x) = \sum_{i=1}^{n} w_i v_i(x)$	**Where,** **n = The number of attributes,** **w_i = The weight of attribute $_i$, and** **$v_i(x)$ = The rating of an alternative x with respect to an attribute $_i$.**

- Preference Ranking Organization Method for Enrichment Evaluations (PROMETHEE): It provides a complete ranking of alternatives, from best to worst [Schwartz and Göthner, 2009].

- Elimination methods: “Handle both qualitative and quantitative criteria, Uses prioritization of criteria instead of quantitative weights, Has a simple decision rule for ranking alternatives” [Hipel, 2013, p.27].

Conclusion

- Rain/fresh water based integrated (shrimp-rice-vegetables) agricultural systems are adaptive and produce more food and good in terms of some sustainability criteria.
- S-R-V systems ensure diversity in agricultural systems which supports to produce varieties of foods.

Other conclusion

- Measuring agricultural sustainability in this way produces a useful summary of sustainability issues and also provides some vital learning experiences.
- This holistic and interdisciplinary approach has the potential to become useful as a framework for future analyses of sustainability.
- Further comprehensive assessment-based investigations are needed to understand current coastal agricultural practices and to facilitate improvements wherever possible in aspects identified within the sustainability issues, in order to close the sustainability gaps of different agricultural systems.

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Thank you

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