FAOWATER

AGWATER SOLUTIONS
Improved livelihoods for smallholder farmers

INVESTMENT BRIEF

Mapping and assessing the potential for investments in agricultural water management

Madhya Pradesh State

IWMI International Water Management Institute

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Background

The Agricultural Water Solutions Project

The Agricultural Water Solutions Project aims to unlock the potential of smallholder farming by identifying, evaluating and recommending a variety of agricultural water management (AWM) solutions - including technologies as well as the necessary supporting policies, institutions, financing arrangements and associated business models. This is being achieved through a series of interlinked activities in the seven project sites in Africa (Burkina Faso, Ethiopia, Ghana, Tanzania and Zambia) and in India (Madhya Pradesh and West Bengal). These activities include:

- in-depth case studies,
- mapping areas to identify where solutions are likely to be most viable and have greatest impact,
- discussing AWM solutions and project findings with stakeholders, and
- formulating business models to turn these findings into practical plans.

The national level analysis

This note presents the result of the national analysis. The analysis gathers available thematic maps and district statistics, and combines them with national livelihood maps which have been established through an in-depth consultation process to identify opportunities to invest in AWM in support to rural livelihoods. The suitability of different AWM solutions is then assessed and quantified in terms of investment opportunities and potential number of beneficiaries.

The methodology

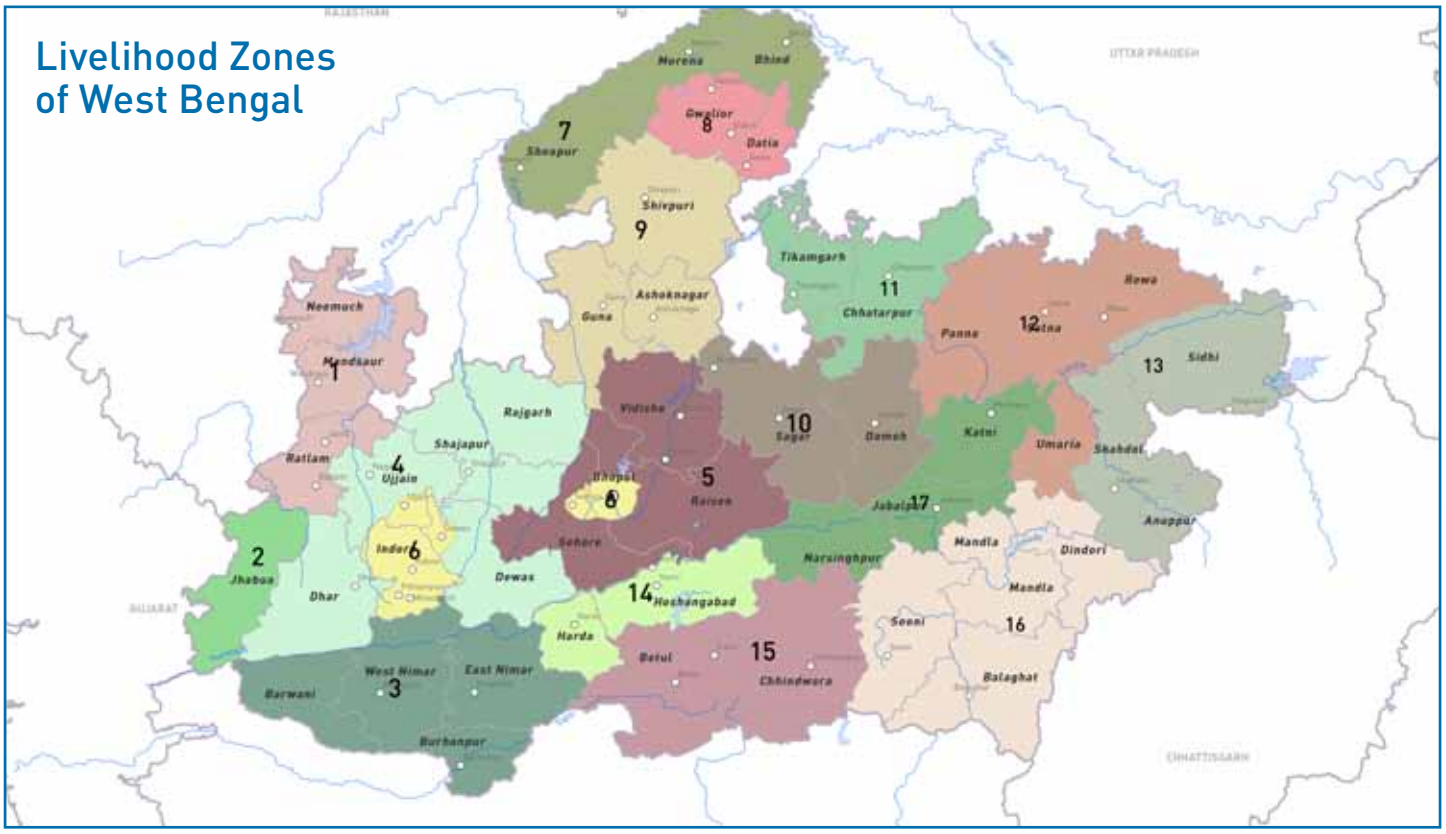
Contrarily to classical water investment planning processes, this approach focuses on addressing poor rural people's needs rather than focusing on the development of potentially suitable resources. In so doing, the demand for investments in water is compared to the supply (availability of water). The demand for investments in water varies according to the needs of the population. In order to capture this demand, the project has adopted a *livelihood mapping* approach. This note presents the different steps followed in the national analysis:

1. Map the main livelihood zones, responding to the following questions:
   - what are the different farmer typologies and rural livelihood strategies?
   - what are the main water-related constraints and needs in the different rural livelihood contexts?
2. Map the potential and opportunities to improve smallholders' livelihood through water interventions: estimate the number and percentage of rural households who could potentially benefit from AWM interventions.
3. Map the suitability and demand for a series of specific AWM solutions, showing where they have the highest potential impact on rural livelihoods.
4. Estimate the potential number of beneficiaries, the potential application area and total investment costs for each AWM solution in each livelihood zone.

FAO has conducted and coordinated a participatory AWM mapping process in each project country in close collaboration with national partners. These products have been developed through a stepwise approach including national level data collection and processing, case study analysis, and local consultation. The livelihood map was developed during a participatory mapping workshop which gathered a large number of national experts from different fields (agriculture, water, social sciences, geography, etc.) and institutions (government, universities, NGOs, etc.) as well as farmers groups. This process was organised in two phases: 1) the purpose of a first workshop was to set up the basis for the analysis and start depicting the relationships between rural livelihoods and AWM and 2) a second or series of events - both at national and regional levels - to review the maps and refine the criteria used to define the potential for AWM and the suitability of different technologies. The outputs of the workshop have been enhanced through further consultation with national and international experts and through secondary data analysis using available national and sub-national datasets and statistics.

Mapping the livelihood context

Different people in different places have different needs



1. North Malwa-Chittor zone - Opium-silica production
2. Western Malwa Hill Zone - Bhil tribe predominant
3. Nimar Plains Zone - Hot dry Cotton Chilli Banana Sugarcane
4. Malwa Plateau plain zone - Traditional agriculture (spices production)
5. Eastern malwa extension zone - quality wheat and pigeon pea production
6. Industrial/Urban Sub Zone of Malwa (Indore and Bhopal)
7. Northern Chambal Ravines Zone - Irrigated mustard predominant
8. Gwalior Zone - Pastoral and dry degraded mining area
9. South Chambal Zone - Progressive farming, wheat-soya
10. Lower Bundelkhand Zone – low socioeconomic development, low productivity wasteland
11. Upper Bundelkhand Zone – low socioeconomic development, low productivity wasteland
12. Western Baghelkhand zone - Forest, game reserve and energy production
13. Eastern Baghelkhand zone - Forest, game reserve and energy production
14. Central Narbada Sub Zone - Irrigated Intensive agriculture production (horticulture)
15. Satpura Hills Mahakaushal Zone – Tribal forest gatherers and dry land farmers
16. Mahakaushal Maikal Hill Zone – Forest, water rich, subsistence (millet) tribal zone
17. Upper Narbada Sub Zone – Mixed commercial tribal farmers, industrial activities

The purpose of livelihood maps

Livelihood mapping consists in identifying areas where rural people share relatively homogeneous living conditions, on the basis of a combination of biophysical and socio-economic determinants.

The main criteria to establish livelihood zones are: the predominant source of income (livelihood activities); the natural resources available to people and the way they are used; the prevailing agroclimatic conditions that influence farming activities, and access to markets.

In the absence of detailed local level statistics, the livelihood map is a useful tool to understand rural people dependence to water (access, vulnerability, resilience to shock) and the extent to which investments in water are critical to their development.

The map of livelihood zones is the result of a participatory mapping process involving a wide range of experts, professionals and farmers representatives. Each livelihood zone is described in details in terms of the main smallholders' livelihood strategies, dimensions of poverty, their water-related problems and other constraints for development, and the role agricultural water management plays for their livelihoods. Combined with the map of rural population, the livelihood map makes it possible to assess the demand for water-related interventions in each zone.

Generally, livelihood zone boundaries would coincide with administrative boundaries, but not always. In practice, homogenous agroecological and socio-economic zones often cross larger administrative units. In these cases the delineation is based on other criteria which better capture the delineation between different livelihoods patterns (topography, climatic data, land cover data, etc.).

Describing the livelihood context

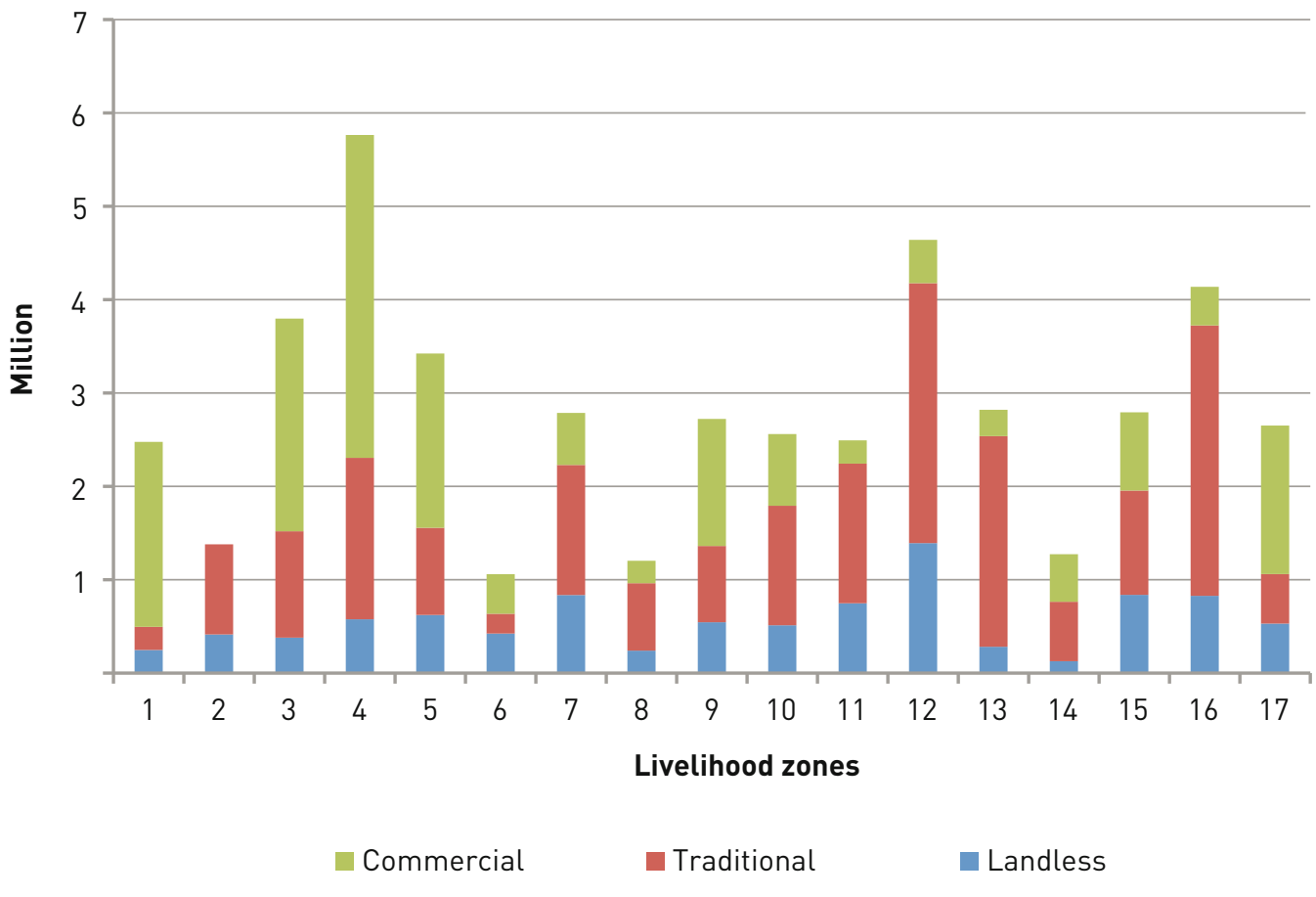
Key typologies of rural population

Landless:
These are farmers who does not possess any land, depends on other's land for cultivation by providing their labour

Traditional smallholder farmers:
These farmers produce mainly staple food (both crop and livestock) for household consumption and have relatively marginal connections to markets. The aim at stabilizing production and reduce risks of production failures.

Commercial (cash crop) smallholder farmers:
These farmers may partially subsist from their own production but whose principal objective is to produce a marketable surplus or are commercial farmers that are fully oriented towards internal and export markets

Rural population distribution



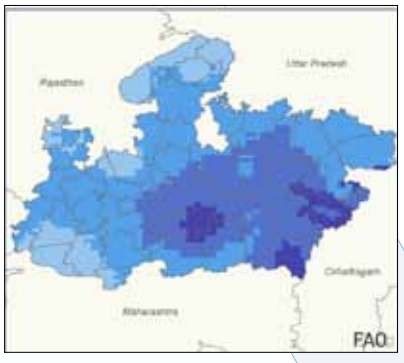
Key characteristics of livelihood zones

Zone	Key livelihood aspects	Main farmers typology	Rural population (,000)	Poverty rate	Main constraints for development	Vulnerability to droughts
1.	North Malwa-Chittor zone - Opium-silica production	Commercial farmers	2 476	Low	Lack of watershed management, groundwater recharge	High
2.	Western Malwa Hill Zone - Bhil tribe predominant	Traditional farmers and landless	1 379	High	Lack of watershed management, agricultural inputs	High
3.	Nimar Plains Zone - Hot dry Cotton Chilli Banana Sugarcane	Traditional and commercial farmers	3 797	Moderate	Water infrastructures and management, market regulation	High
4.	Malwa Plateau plain zone - Traditional agriculture (spices production)	Traditional and commercial farmers	5 764	Moderate	Lack of watershed management, groundwater recharge	High
5.	Eastern malwa extension zone - quality wheat and pigeonpea production	Traditional and commercial farmers	3 112	Moderate	Water infrastructures and management, agricultural inputs	Moderate
6.	Industrial/Urban Sub Zone of Malwa (Indore and Bhopal)	Commercial farmers and landless	1 059	Low	Water conservation, groundwater recharge	High
7.	Northern Chambal Ravines Zone - Irrigated mustard predominant	Traditional farmers and landless	2 787	High	Irrigation infrastructures, land reclamation	Low
8.	Gwalior Zone - Pastoral and dry degraded mining area	Traditional farmers	1 203	High	Irrigation infrastructures, lack of watershed management	High
9.	South Chambal Zone - Progressive farming, wheat-soya	Commercial and traditional farmers	2 722	Low	Irrigation infrastructures, extension services	Low
10.	Lower Bundelkhand: low socioeconomic development, low productivity wasteland	Traditional and commercial farmers	2 560	Moderate	Access to water, irrigation infrastructures	High
11.	Upper Bundelkhand: low socioeconomic development, low productivity wasteland	Traditional farmers	2 493	High	Watershed management, tanks renovation, water distribution	High
12.	Western Baghelkhand - Forest, game reserve and energy production	Traditional farmers	4 640	High	Water conservation, extension services	High
13.	Eastern Baghelkhand - Forest, game reserve and energy production	Traditional farmers	2 820	Moderate	Water infrastructures and management, extension services	Moderate
14.	Central Narbada Sub Zone: irrigated Intensive agriculture production (horticulture)	Traditional and commercial farmers	1 273	Moderate	Irrigation infrastructures, extension services	Moderate
15.	Satpura Hills Mahakaushal: tribal forest gatherers and dry land farmers	Traditional and commercial farmers, landless	2 793	High	Water infrastructures and management, credit	Moderate
16.	Mahakaushal Maikal Hill: forest, water rich, subsistence (millet) tribal zone	Traditional farmers	4 137	High	Water infrastructures and management, extension services	Moderate
17.	Upper Narbada: mixed commercial tribal farmers, industrial activities	Commercial farmers	2 651	Moderate	Water infrastructures and management, extension services	Moderate

Mapping potential and opportunities for water

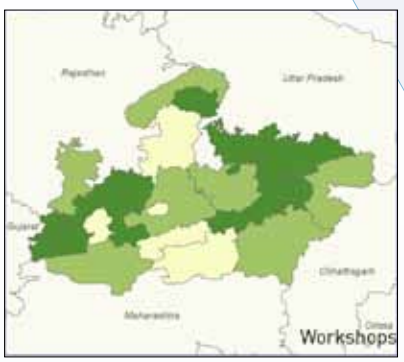
Criteria used

1. Water availability (runoff)



mm/y
- <250
- 250 - 500
- 500 - 750
- 750 - 1 000
- >1 000

2. Perception of water as limiting factor for agricultural production



- LZ_jan2011dsv
- High
- Medium
- Low

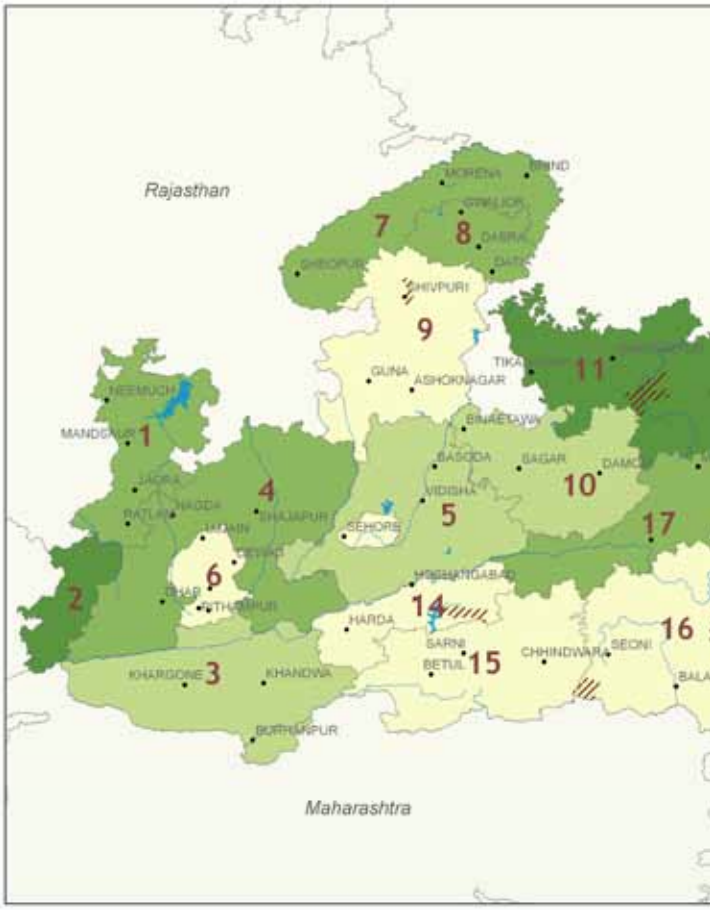
3. Rural population density

P /km²
- < 100
- 100 - 250
- 250 - 500
- > 500

4. Poverty (underweight prevalence among children)

Health Index
- 17.1 - 23.7
- 23.8 - 39.7
- 39.8 - 67.1

Number of potential beneficiaries

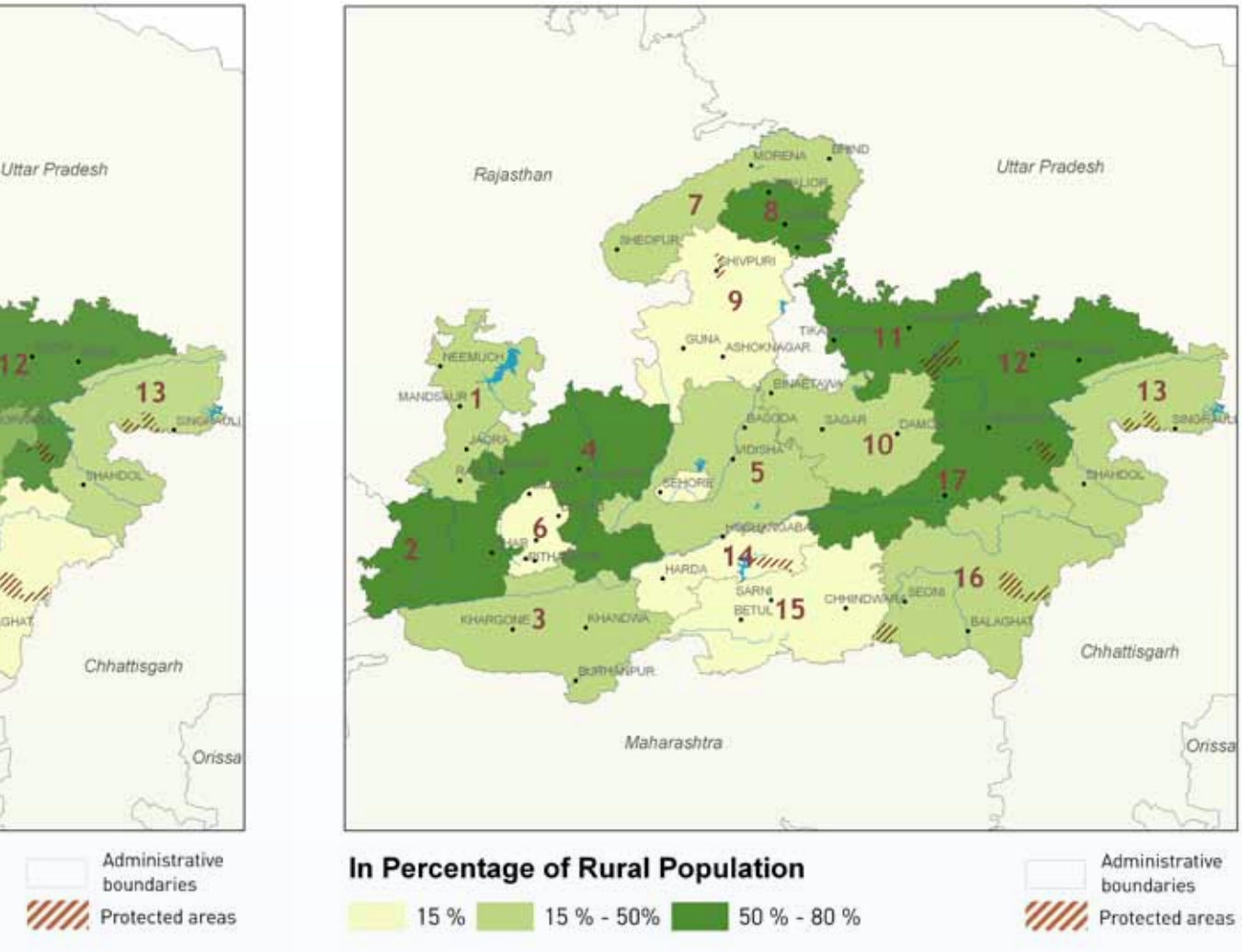


Person / km²
- < 66
- 66 - 78
- 78 - 142
- > 142

The potential for investment in water in support to rural livelihoods is a function of the demand from rural population and the availability of the resource. The maps above show a distribution of rural population who could benefit from water-related interventions. The level of demand is based on the analysis of the livelihood zones described before, combined with poverty level.

The supply is a function of availability of water, calculated on the basis of well established thresholds of water per person (water development being constrained below 500 m^3/pers.). These maps are generic.
The following pages show that the potential varies substantially as a function of the proposed technology.

interventions



Livelihood zone		Water availability: IRWR/cp ($m^3/p/y$)	Rural population			Density (p/km^2)	Potential beneficiaries	
No	Name		Total (,000)	Density (p/km^2)	poverty rate		poverty rate	in % of rural population
1	North Malwa-Chittor zone - Opium-silica production	3,062	2,476	188	22.3	Medium	1,238	50%
2	Western Malwa Hill Zone - Bhil tribe predominant	2,494	1,379	211	31.2	High	1,103	80%
3	Nimar Plains Zone - Hot dry Cotton Chilli Banana Sugarcane	3,148	3,797	163	67.1	Medium	1,899	50%
4	Malwa Plateau plain zone - Traditional agriculture (spices production)	3,098	5,764	187	23.7	High	4,611	80%
5	Eastern malwa extension zone - quality wheat and pigeonpea production	6,099	3,112	137	34.1	Medium	1,556	50%
6	Industrial/Urban Sub Zone of Malwa (Indore and Bhopal)	4,147	1,059	207	34.7	Low	159	15%
7	Northern Chambal Ravines Zone - Irrigated mustard predominant	2,602	2,787	186	20.8	Medium	1,393	50%
8	Gwalior Zone - Pastoral and dry degraded mining area	2,991	1,203	190	20.9	High	962	80%
9	South Chambal Zone - Progressive farming, wheat-soya	4,670	2,722	132	17.1	Low	408	15%
10	Lower Bundelkhand: low socioeconomic development, low productivity wasteland	5,390	2,560	152	53.5	Medium	1,280	50%
11	Upper Bundelkhand: low socioeconomic development, low productivity wasteland	3,882	2,493	193	23.1	High	1,994	80%
12	Western Baghelkhand - Forest, game reserve and energy production	3,784	4,640	199	28.9	High	3,712	80%
13	Eastern Baghelkhand - Forest, game reserve and energy production	5,713	2,820	145	34.9	Medium	1,410	50%
14	Central Narbada Sub Zone: irrigated Intensive agriculture production (horticulture)	7,032	1,273	136	39.7	Low	191	15%
15	Satpura Hills Mahakaushal: tribal forest gatherers and dry land farmers	6,205	2,793	133	48.4	Low	419	15%
16	Mahakaushal Maikal Hill: forest, water rich, subsistence (millet) tribal zone	7,187	4,137	134	47.4	Medium	2,069	50%
17	Upper Narbada: mixed commercial tribal farmers, industrial activities	5,068	2,651	190	35.7	High	2,121	80%

Mapping the suitability and demand for specific AWM solutions

The AWM options

The potential for application of the following AWM solutions at national level was assessed on the basis of the case study conducted by the project:

- ***Ex-situ* water harvesting - Rewasagar model**
  Rewasagar are individual on-farm ponds, about 1/10 to 1/20 of land holding size, used to store monsoon rainwater and increase recharge. The solution would entail the rehabilitation / building of ponds and enhancement of their multiple uses. The introduction of "Rewasagar " would provide many benefits including enabling farmers to cultivate previously fallow land, higher crop intensity, new crops, more livestock and fish.
- **Soil and water conservation - Field bunding**
  Field bunding is a farming technique to conserve rainwater in the soil and reduce water erosion that is practiced in steeper areas. The practice implies the construction of on-farm earth terraces/bounds to facilitate water infiltration in the soil. This improves the soil structure and moisture levels, which reduces the need for fertilizers and irrigation. As a result, yields and profits go up. This technique is also important for staple crops and offers protection in low-rainfall years. This technique can be quite labor intensive and need necessary capital and training.

For this AWM option, a biophysical suitability and the potential demand based on livelihood conditions have been mapped.

Biophysical suitability

The map uses a set of criteria to assess the potential geographical extent of each AWM solution. These criteria represent the distribution of the biophysical conditions under which a AWM solution can have the potential highest impact on livelihoods. The maps show two levels of suitability:

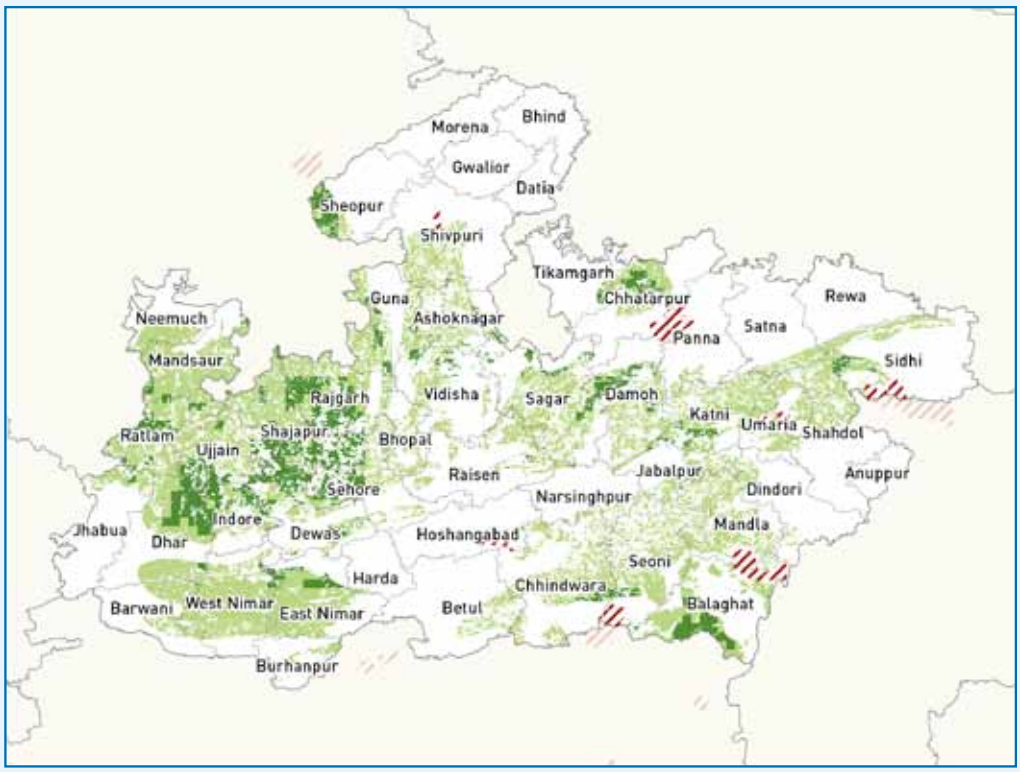
- High suitability: areas which present optimal conditions both in terms of biophysical and infrastructure conditions for adoption of a given AWM solution.
- Moderate suitability: areas where there are possibilities for application of a given AWM solution, but where conditions are less favourable.

Livelihood-based Demand

Local consultations and individual expert knowledge allowed expressing the potential demand for a technology among the population living in the different livelihood zone and provided more in-depth information on the potential adopters. These are for instance: farmer typology, vulnerability to shocks, dependence on water resources, and average landholding size. The resulting map shows distribution of these factors in the different livelihood zones which, in turn, identify areas where livelihoods conditions are more favourable for a given AWM solutions.

Solution 1: Rewasagar water harvesting model

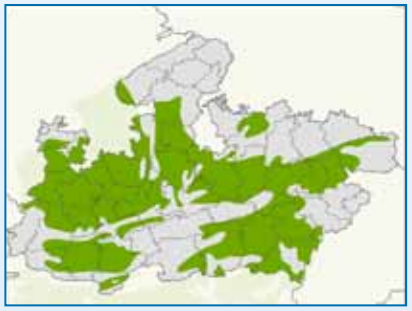
Biophysical suitability



Highly suitable
Moderately suitable
Protected areas

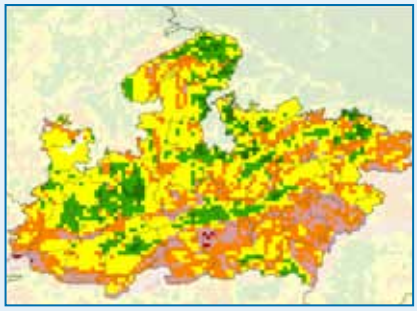
Biophysical criteria and conditions

Topography (Slope)



Soil properties
Vertisols
Other

Soils



Slope classes
Undefined
1 - 2%
2 - 5%
5 - 8%
8 - 16%
16 - 30%
30 - 45%
> 45%

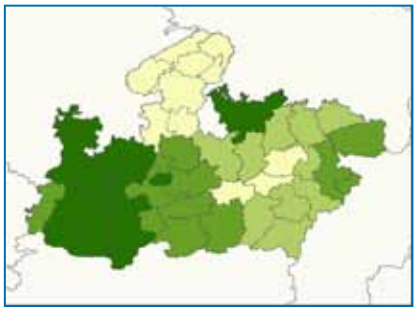
Biophysical criteria and conditions	
Soils	**Topography**
Requirement: presence of vertisols	**High**: < 5% slope; **Moderate**: >5% slope

Physical suitability for ex-situ water harvesting and, in particular, Rewasagar model, has been assessed on the basis of soils (vertisols) and steepness (slope < 5 % is assumed to be more suitable). Vertisols, due to their clay content and compactness, are assumed to be more suitable for water harvesting.

Livelihood-based demand

The livelihood-based demand is assessed through the analysis of the livelihood context of the zone. In particular, the context is assumed to be more favorable in zones with relatively higher prevalence of:

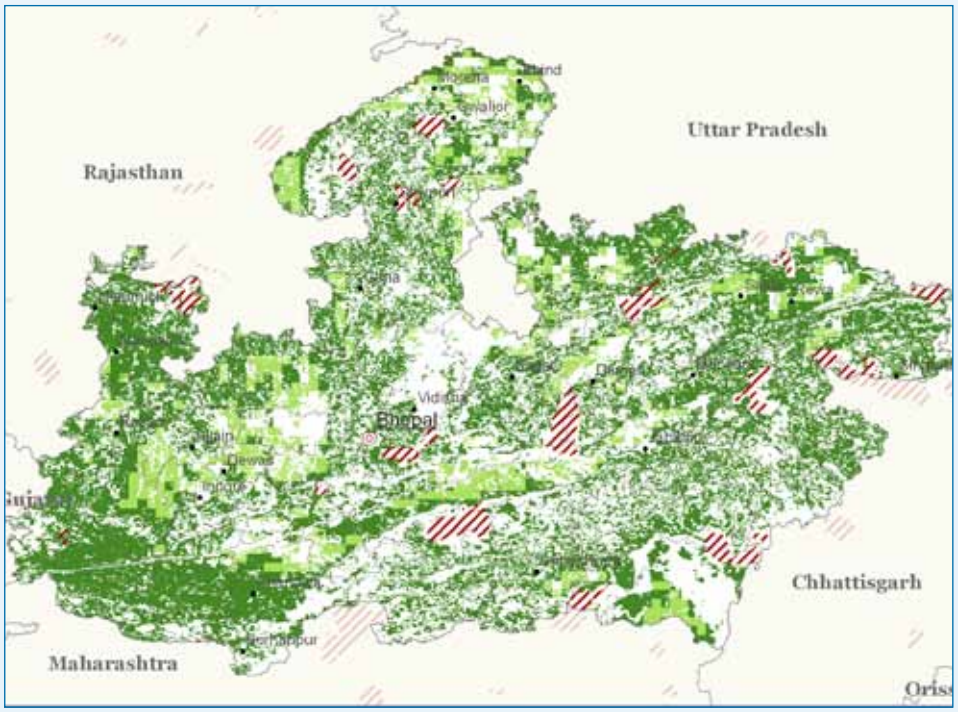
- **Areas with average landholding size of at least one ha**
  this technology would imply having sufficient land to construct the pond. Landless farmers are then excluded. Therefore, this typology of farmers is considered to be more in demand of this technology
- **Areas where groundwater resources are partially or totally depleted**
  Farmers residing in these areas are considered to be more in demand of this technology as they cannot make use of groundwater.
- **Areas where are more vulnerable to droughts**
  This typology of farmers is considered to be more in demand of this technology as water harvesting is an effective measure to cope with recurrent droughts.



High
Medium-high
Medium-low

Solution 2: Soil and Water conservation (field bunding)

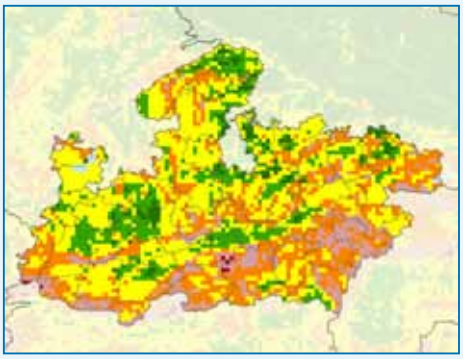
Biophysical suitability



Highly suitable
Moderately suitable
Protected areas

Biophysical criteria and conditions

Topography (Slope)

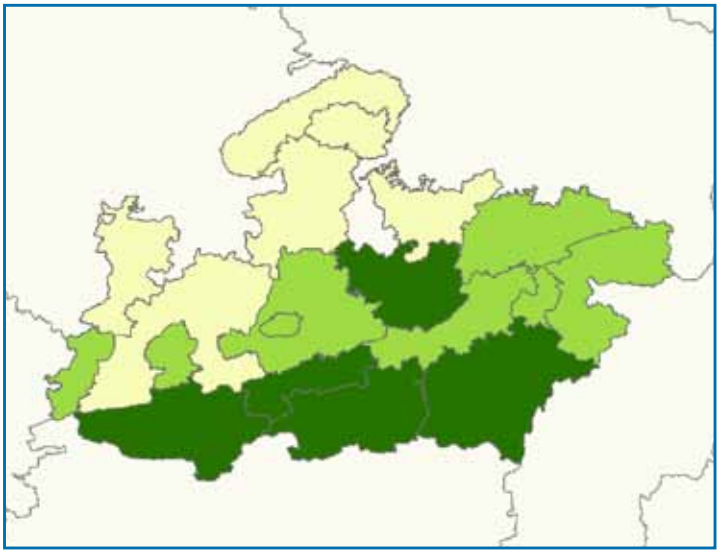


Slope (reclassified GTOPO30)

- Undefined
- 1 - 2%
- 2 - 5%
- 5 - 8%
- 8 - 16%
- 16 - 30%
- 30 - 45%
- > 45%
- Inland water

Physical suitability for soil and water conservation (field bunding) has been assessed on the basis of slope: moderately suitable with slope > 2% , and highly suitable with slope > 5%.

Livelihood-based demand



High
Medium-high
Medium-low

The livelihood-based demand is assessed through the analysis of the livelihood context of the zone. In particular, the context is assumed to be more favorable in zones with relatively higher prevalence of:

- **Areas with average landholding size of at least one ha**
  this technology would imply having sufficient land to construct the pond. Landless farmers are then excluded. Therefore, this typology of farmers is considered to be more in demand of this technology
- **Areas where farmers are more vulnerable to droughts**
  This typology of farmers is considered to be more in demand of this technology as field bunding is an effective measure to cope with recurrent droughts.
- **Areas with limited accessibility to water and high poverty rates**
  Poor farmers are often those one with limited capacity to access water, where they cannot afford to invest in expensive infrastructures to lift and distribute water.
  This technology is the considered suitable for this typology of farmers as it is low-cost.

Estimate the potential benefits of investing in AWM

Potential beneficiaries, application areas and investments costs

Potential beneficiaries (rural households)
– 50% of adoption rate

Livelihood zones	Rewasagar				Field bunding			
	(,000 households)		(% total househ.)		(,000 households)		(% total househ.)	
	min	max	min	max	min	max	min	max
1	17	146	1%	6%	130	153	5%	6%
2	2	15	0%	1%	69	74	5%	5%
3	10	165	0%	4%	183	216	5%	6%
4	118	300	2%	5%	217	324	4%	6%
5	13	54	0%	2%	55	79	2%	3%
6	21	44	2%	4%	27	50	3%	5%
7	12	19	0%	1%	40	92	1%	3%
8					21	37	2%	3%
9	7	56	0%	2%	59	89	2%	3%
10	19	80	1%	3%	73	97	3%	4%
11	8	24	0%	1%	76	116	3%	5%
12		42	0%	1%	150	209	3%	5%
13	4	56	0%	2%	121	142	4%	5%
14		1		0%	37	70	3%	5%
15	3	47	0%	2%	96	111	3%	4%
16	30	174	1%	4%	180	223	4%	5%
17	7	71	0%	3%	77	111	3%	4%
Total	**269**	**1293**	**0.55%**	**2.6%**	**1612**	**2192**	**3.2%**	**4.4%**

Potential application area (ha)
– 50% of adoption rate

Livelihood zones	Rewasagar				Field Bunding			
	(,000 ha)		(% total agric. land)		(,000 ha)		(% total agric. Land)	
	min	max	min	max	min	max	min	max
1	25	218	3%	22%	288	339	29%	34%
2	3	22	1%	5%	153	165	36%	39%
3	15	248	1%	16%	407	479	27%	32%
4	177	450	8%	22%	483	720	23%	34%
5	20	80	2%	9%	122	175	14%	20%
6	31	66	9%	18%	60	111	17%	31%
7	18	28	2%	3%	88	203	10%	23%
8					47	82	12%	21%
9	10	84	1%	8%	130	197	12%	18%
10	28	120	4%	16%	163	214	21%	28%
11	12	36	1%	4%	170	257	18%	27%
12		63	0%	5%	333	464	24%	34%
13	5	84	0%	8%	269	314	24%	28%
14		2			82	155	17%	32%
15	4	71			214	247	24%	28%
16	44	261	4%	22%	399	495	33%	41%
17	11	106			171	247	23%	33%
Total	**404**	**1939**	**2.4%**	**11.3%**	**3579**	**4866**	**21.1%**	**28.6%**

Note: the above potentials are considered independently for each AWM option. There is therefore a possibility of double counting, i.e. the same rural household benefitting several AWM options. The total investment potential, areas and beneficiaries for the four options is likely to be less than the sum of the options taken separately

Assumptions

The maps are used to assess the potential number of beneficiaries and the extent of land which could benefit from any of the AWM solutions. These calculations represent a 'gross' potential and do not take into account demand-side aspects of agricultural production. Therefore a possible adoption rate is not applied. The calculations are performed as follows:

1. The figures reflect the assumption that 50% of farmers, among those who could potentially benefit from the AWM option, are able or willing to adopt it.
2. the total number of rural people falling into the areas of high or low suitability is calculated on the basis of a rural population density map. These results are then aggregated by livelihood zone
3. the livelihood-based demand criteria allow for the establishment of "correction" factors that represents the part of the rural population which is likely to benefit from a given AMW solution. The factors reflect the importance of a given solution for the population living in the livelihood zone.
4. A unit area of land per household that can benefit from a given AWM solution is established on the basis of information obtained from the case studies and literature, i.e. 1.5 ha for Rewasagar water harvesting and 2.22 ha (state average) for field bunding. The number of potential beneficiaries, expressed in number of households, is then used to calculate the extent of land that could benefit from the solution. From national statistics , the country average household size is 4.5 persons.
5. The result is assessed against current extent of cropland in the suitable area, and in terms of its impact on the water balance, and adjusted downwards if needed.
6. The "correction" factors derived from livelihood-based demand (eg. farmers typology, poverty, land holding size etc.) are applied as de-multiplying factors.

Estimate the potential benefits of investing in AWM

Investments costs

Livelihood zones	Investment cost (Million USD)			
	Rewasagar		Field bunding	
	Min	Max	Min	Max
1	102	952	86	102
2	7	97	46	50
3	64	1 186	122	144
4	845	2 096	145	216
5	186	987	37	52
6	170	455	18	33
7	74	109	26	61
8	-	-	14	25
9	70	758	39	59
10	206	1 059	49	64
11	122	324	51	77
12	2	363	100	139
13	41	617	81	94
14	0	16	25	47
15	40	755	64	74
16	260	2 077	120	148
17	**64**	**887**	**51**	**74**
Total	**2 254**	**12 738**	**1 074**	**1 460**

Note: the above potentials are considered independently for each AWM option. There is therefore a possibility of double counting, i.e. the same rural household benefitting several AWM options. The total investment potential, areas and beneficiaries for the four options is likely to be less than the sum of the options taken separately

Calculating investment costs

The following assumptions have been made to assess investment cost for each AWM option.

1. The investment cost for rural electrification have not been calculated.
2. Rewasagar water harvesting ponds:
   - based on expert knowledge the land allocated for water harvesting is calculated as 1/15 of the number of potential benefitted households multiplied by the state average landholding size (2.22 ha/household).
   - For each ha allocated for water harvesting there are 30 000 m3 of water stored.
   - An upper limit would apply to potential application area, should the total volume of stored water exceed 30% of total annual runoff, at state level .
3. Field bunding:
   - No assumptions were made.

Investment costs at state level		
AWM options	Unit cost	Investment costs (min-max)
		Million US$
Rewasagar	0.75 US$/per m^3 of water stored	2 254 - 12 738
Field bunding	300 US$/ha	1074 - 1 460

For more information consult the project website **http://awm-solutions.iwmi.org** or the FAO Water website **www.fao.org/nr/water/projects_agwatermanagement.html** and contact Guido Santini **(Tel: +39 0657054400; E-mail: guido.santini@fao.org)** or Livia Peiser **(Tel: +39 0657056421; E-mail: livia.peiser@fao.org)** or our local partner: Centre for Advanced Research & Development (CARD), Bhopal, Madhya Pradesh **(E-mail: card_vivek@yahoo.com)**.