PAKISTAN NDC TECHNOLOGY ROADMAP FOR WATER AND WASTE SECTORS

Validation Meeting with Water and Waste Technical Committee | 13th Nov 2024

List of Abbreviations

AJK	Azad Jammu & Kashmir
CDA	Capital Development Authority
CTCN	Climate Technology Centre and Network
EPA	Environmental Protection Agency
GGC	Green Growth Consultants
GGGI	Global Green Growth Institute
GIS	Geographic Information System
IoT	Internet of Things
KP	Khyber Pakhtunkhwa
PDAs	Provincial Development Authorities
PDO	Power Development Organization
PEDO	Pakhtunkhwa Energy Development Organization
MoCC&EC	Ministry of Climate Change and Environmental Coordination
MoWR	Ministry of Water Resources
NDCs	Nationally Determined Contributions
PARC	Pakistan Agriculture Research Council
TRL	Technology Readiness Level
WASA	Water and Sanitation Authority

Contents

Introduction

A technology roadmap for Nationally Determined Contributions (NDCs) implementation is a strategic planning tool that provides a structured approach to identify, prioritize, and sequence the deployment of technologies to address climate change challenges and promote sustainable development. Pakistan's NDCs 2021 prioritizes technology-based interventions as a means towards climate action and calls for technology transfer and interventions for key sectors in Pakistan, including those of water and waste. Pakistan is committed to the incorporation of technology in its climate agenda and for shaping an enabling environment for the effective incorporation of technology in its NDC implementation. This is needed to ensure efficiency, inclusive access, and adequate management of its water and waste sectors. To achieve this, the Ministry of Climate Change and Environmental Coordination (MoCC&EC), through the Climate Technology Centre and Network CTCN's technical assistance, started the development of Pakistan's Technology Roadmap for the waste and water sectors for NDC implementation.

The progress so far is that the roadmap document currently stands at a stage where the first draft is being reviewed for improvement. The Validation Committees Meeting took place online to identify areas of improvement in the roadmap specifically in the action plan for both the sectors. Stakeholders from both water and waste sectors were invited to comment and suggest any enhancements on the various aspects of the action plan and to share any technology specific experience that could modify action categories to better suit local context.

Objectives

The objective of the meeting was to resume the vision of a collaborative, inclusive and data-driven approach needed to finalize the NDC Technology Roadmap. The discussion aimed to explore the various aspects of action plans for each technology form both water and waste sectors, including: Technology Readiness Level and Action Categories, further inviting review on specific actions, their timelines and relevant stakeholders. Furthermore, stakeholders' on-ground experiences with the technologies under discussions were also taken under consideration to improve actions concerned with engaging the private sector, improving end-product market and enhancing gender and social inclusion. The primary objectives of the meeting are listed as below:

➔ Refine and confirm insights gathered:
The development of the technology roadmap has been a process that has engaged the stakeholders at every step. One of the objectives of this meeting was to ensure that all insights that were gathered during such interactions have been incorporated in the document.

➔ Ensure that the Technology Roadmap is realistic and practical:
The meeting was held to ensure that specific to the action plan, the action items listed were realistic and practical in terms of their adoption and their deadlines mentioned. The stakeholders also were scrutinized to ensure appropriate designation of roles and responsibilities.

➔ Ensure that the Technology Roadmap responds to the national and regional objectives:
Since the development of the technology roadmap is aligned with achieving NDC targets, stakeholders were engaged specifically to make sure that the action plan would be leading towards this target. Moreover, the level of harmonization of the roadmap with regional

objectives was also reviewed for a holistic and synchronized approach to implementing technologies adoption.

Methodology

The mode of interaction for the Validation Committee Meeting was hybrid that included a total of 32 members. The list of participants along with the presentation has been given in **ANNEX-I**. The meeting started with opening remarks from GGC and moved forward with introduction given by GGGI that recalled the project and process overview. With the initial 40 technologies that underwent stakeholder assessment, 15 were chosen to be assessed as per the scoring criteria. 5 technologies from each sector were prioritized with an addition of one in the water sector later on.

The presentation then moved on with the description of how the Technology Readiness Level (TRL) Chart was incorporated to determine the entry point of each technology. The scoring criteria for the prioritization of the technologies was revisited after which the heatmap depicting the prioritized technologies for both sectors were presented. It was emphasized how the list for both sectors included existing and emerging technologies with an addition of AI integrated GIS and RS for Water Management in the water sector which despite a low score was added to the list on the recommendation of the Ministry of Water Resources (MoWR). It further gave a brief overview of the various components of the action plan which was to be discussed in detail with the stakeholders. This included the following list:

A. Entry Point

1. Pilot Scale Implementation
2. Operational Scale-Up
3. Technology Sustenance

B. Category of Action

1. Research and modelling
2. Policy
3. Capacity Building
4. Budget
5. Governance
6. Business Continuity
7. Monitoring and Evaluation
8. Gender Equality and Social Inclusion

C. Term of Action

1. Short Term
2. Long Term

After delivering this structure of action plan for a better understanding, it was communicated to the stakeholders to provide their feedback on each technology for both the sectors in the following context:

1. How achievable are the actions given the current resources (finances, personnel, and expertise)?
2. Is there any action missing in drafted plans?
3. Market readiness: Whether it is ready or not to adopt the new technologies?
4. Financing aspect and role of private sector: How can we integrate it? Can we rely on public-private partnership for a smooth adoption of these technologies?
5. Are the proposed timelines realistic given the complexity of the actions?
6. Do you agree with role of stakeholders?

This followed a thorough discussion on each technology where all structural components were analyzed under the lens of practicality in local context as per the knowledge and experience of the stakeholders. The stakeholders were further informed/reminded to provide their feedback on the google form shared with them earlier using the detailed action plan sent through email.

Discussion/Outcomes

WATER SECTOR

The water sector with its 6 prioritized technologies invited recommendations and suggestions on the drafted action plans. In general, it was suggested that policies on pollution reduction should invite action on awareness in the community for which capacity building specifically for farmers was identified. Engagement of the private sector was also emphasized for the sustenance of the technology. Governance was identified as crucial to ensure distribution and harvesting of water resources for which time frames were approved.

Drip Irrigation

Drip irrigation technology was the first technology under discussion and it was suggested by the stakeholders that capacity building programs especially focused on farmers must be incorporated in the action plan along with a pathway to introduce an integrate drip irrigation with water pumping. One prominent action identified was the inclusion of the private sector as service providers for transformation of drip irrigation because maintenance and after sale services for the technology are noted to be poor. A healthy discussion on stakeholder identification called for the inclusion of Agriculture and Irrigation Departments, Ministry of National Food Security and Research as stakeholders in capacity building of farmers. Role of Pakistan Agriculture Research Council and provincial stakeholders was also suggested to be included for all action plans specifically Capacity Building, Environmental Monitoring along with budget where the role of Energy Department was pointed out.

Run of the River Plants

For Run of the River plants the major suggestion was in the stakeholder identification section where it was suggested to include Khyber Pakhtunkhwa (KP) Pakhtunkhwa Energy Development Organization (PEDO) and Azad Jammu & Kashmir (AJK) Power Development Organization (PDO) in action plans. Role of agriculture and irrigation departments was also pointed out. It was suggested to exclude CDA from the list of stakeholders and actions were proposed to develop database for better- and well-informed management.

Micro and Small Hydropower Plants

For this technology one major suggestion was to include Energy Departments for all provinces into the list of identified stakeholders. Policy interventions were suggested for which all stakeholders were advised to be included adding provincial authorities and energy related departments interested in renewable energy.

Rainwater Harvesting

For the development of rainwater harvesting technology, it was again recommended to improve the list of stakeholders taking steps to include provincial development authorities and NGOs working in the water resource management sector. Rooftop rainwater harvesting along with recycling of water from mosques was suggested to be included in the action plan. For the purpose of research and development of technology it was advised to bring in educational institutes where Mehran Institute of Technology was specifically identified. Groundwater recharge monitoring was also suggested where Pakistan Agriculture Research Council (PARC) was noted as a prominent stakeholder. Other suggested stakeholders included the incorporation of Water and Sanitation Authority (WASAs), Housing Authorities along with irrigation departments was noted. The need for a data base was also discussed which was noted as a recommendation to be added into the action plan.

IoT Based Solar Pumps and Storage

Stakeholders' suggestion for this novel and emerging technology was to incorporate actions that would assess individual situation for each province. Representatives from PARC discussed their experience working with solar pumps where they identified their role in monitoring and evaluation and environmental monitoring if IoT is integrated into the technology. The role of EPA was mentioned in budget allocation and governance aspect was emphasized. Skepticism was expressed by a stakeholder on the time frame of capacity building which was addressed by defining that action plans including capacity building programs that were to be sustained until the technology was operation at a large scale for a long term.

AI Integrated GIS and RS for Water Management

The inclusion of this technology was well-received by the stakeholders and it was again suggested to include PARC's role as leading institute on Geographic Information System (GIS) data. Other stakeholders included Capital Development Authorities (CDA), Provincial Development Authorities (PDAs) and Provincial EPAs. A special focus was given to the need for capacity building programs and role of governance in the successful implementation of the technology

WASTE SECTOR

Waste sector was also thoroughly discussed by the stakeholders majorly focusing on the personal experiences that could help improve the action plan or some aspects of it. In general, for some technologies research was a vital action that was suggested especially for technologies being built from pilot scale. Furthermore, it was suggested as a good approach to also include monitoring of leachate being generated from dumped waste that could potentially affect the groundwater quality negatively. Provincial EPAs role in conducting feasibility studies was advised where identification of sub department was recommended for facilitation. Incorporation of solid waste management boards and companies was also noted for all action plans. Integration of private sector to distribute waste management responsibilities and patronage of federal and provincial government to facilitate implementation of technology adoption were major actions identified. Ideas of 3Rs concept, source segregation, zero waste and landfill diversion were revised. In stakeholder identification, local governments, private entities and role of energy department was suggested to be added.

Waste Segregation Facility

For Waste Segregation Facility, great emphasis was made to include E-waste in the action plan. Waste modelling approach was encouraged by the stakeholder where it was advised to have the action plan facilitated by already conducted studies and modelling. Several success stories and operational examples were shared by stakeholders deeming waste segregation facility as a viable option. Significant time was given to a discussion on informal sector that is currently a substantial part of the waste sorting aspect of waste management and needs streamlining. For segregation of waste the role of waste management vehicles was noted that deteriorated the value and quality of waste in transportation.

Aerobic Windrow Composting

For Aerobic Windrow Composting low market value of compost leading to technology's lack of sustenance was identified. It was emphasized that compost as a product must be upgraded to be termed as a fertilizer so that it will have market in the chemical fertilizer industry that can take it up for value addition. However, stakeholders also identified the challenges to this perspective due to the contamination of compost and its low calorific value all of which is a good addition to the action plan.

Integrated Biomass Gasification for Syngas and Biochar

Research and development were suggested for this technology where PARC was identified as a stakeholder in capacity building and monitoring and evaluation. Pilot scale project of gasification to CNG were discussed using feedstocks including animal dung, crop based organic matter.

Refuse Derived Fuel

It was suggested to base the action plan on integration of technology with the cement industry which was a tried and tested synergy. The comments on this technology, overall, were few due to the limited experience of stakeholders with refuse-derived fuel.

Engineered Landfill Gas Technology

For this technology several issues with currently operation engineered landfill sites were pointed out. Solid waste management boards and companies were identified as major stakeholders and it was emphasized that owing to the wide practice of waste dumping as a common disposal pathway, the need for an engineered landfill was high and should be explored in the action plan.

Conclusion

In conclusion, the Validation Committee Meeting was fruitful in reviewing the drafted action plan for the NDC Technology Roadmap. Stakeholders actively interacted in the session to identify gaps in the roadmap and make suggestions according to their knowledge and experiences to improve the application of the action plan especially in the local context.

For a brief recap, stakeholders suggested several rearrangement and additions in defining roles and responsibilities in the action plan. They also emphasized on the need to monitor the impact of using one technology and advised the integration with another prioritized technology for a synchronized effect. An example of this was ground water recharge through rainwater harvesting in response to IoT based solar pumping. Similarly for waste technologies, waste modelling was noted as a useful action. Some collective suggestions in both sectors were incorporation of international funding sources specifically ADB, the support of government for technology implementation through policies and capacity building and most importantly creating a market value for end products in waste and facilitating end users in water sector.

Way Forward

All the suggestions made by the stakeholder for each technology for both water and waste sectors will have been noted and incorporated in the action plan. Furthermore, additional feedback will be taken through the google form designed to receive comments from technology experts. The output of this meeting is expected to improve the quality of NDC Technology Roadmap.

ANNEX-I

List of Participants

Sr No	Name	Institute/Designation	Gender	Sector	Province
1	Allah Warayo Rindh	Additional Director General, Agri Dept. Sindh	M	Gov	Sindh
2	Mian Aslam Nadeem	Section Officer (SO) Companies, LG&CD, Punjab	M	Gov	Punjab
3	Maheen Faatima	Director Technical, Punjab Food Authority	F	Gov	Punjab
4	Wali Khilji BEPA	NDC Focal Balochistan, EPA	M	Gov	Balochistan
5	Dr Asghar Ali	Technical Expert, Irrigation Department, Sindh	M	Gov	Sindh
6	Sajid Hussain		M		
7	Uzair Naqvi	Environmental Geologist, (PDO), AJK	M	Gov	AJK
8	Waris Ali DT Sindh EPA	Direct Technical, Sindh EPA	M	Gov	Sindh
9	Dr. Arshad Hussain Memon	Environmental Consultant, Energy Department, Sindh	M	Gov	Sindh
10	Mishal Zahra	Scientific Officer, GB EPA	F	Gov	GB
11	Ahmed Ali Khattak	MP-II, Ministry of Social Pass	M	NGO	Federal
12	Noreen Arif	Energy Dept Punjab	F	Gov	Punjab
13	Bashir Ahmed Khan	Director, Climate Energy and Research, PARC	M	Gov	Federal
14	Mudasser Zeb Khan	Manager Planning Industries, Commerce and Technical Education Department	M	Gov	KPK
15	Saeed Khan	Manager Environment, WSSP	M	Gov	KPK
16	Afsar Khan	Dy. Director, EPA KPK	M	Gov	KPK
17	Abdul Qadeer Kakar	Registrar, Cooperative and Agriculture Department	M	Gov	Balochistan
18	Engr. Ubaidullah	Research Officer, PHED KPK	M	Gov	KPK

19	Dr. Sardar Muhammad Rafique Khan	Deputy Director (CC), EPA-AJK	M	Gov	AJK
20	Engr Mir Abdul Haq	Superintendent Engineer, Metropolitan Corporation, Solid Waste Management	M	Gov	Balochistan
21	Omar Shahid	Assistant Manager, KP	M	Gov	KPK
22	Abdul Khaliq	Deputy Director, Energy	M	Gov	Balochistan
23	Azeem Sajjad	Ministry of Information Technology and Telecommunication	M	Gov	Balochistan
26	Dr. Tahseen Aslam	PCSIR	M	Gov	Federal
27	Eng. Malik Luqman	Planning Officer Tourism Department	M	Gov	KPK
28	Farah Ather		F		
29	Dr. Khalid Farooq	CSO Pak. Bureau of Stat Islamabad	M	Gov	Federal
31	Mr. Amir Habib	Assistant director, ST&IT	M	Gov	KPK
32	Siraj ud din	Assistant Director, Labor Industries and Commerce Department	M	Gov	GB

Presentation

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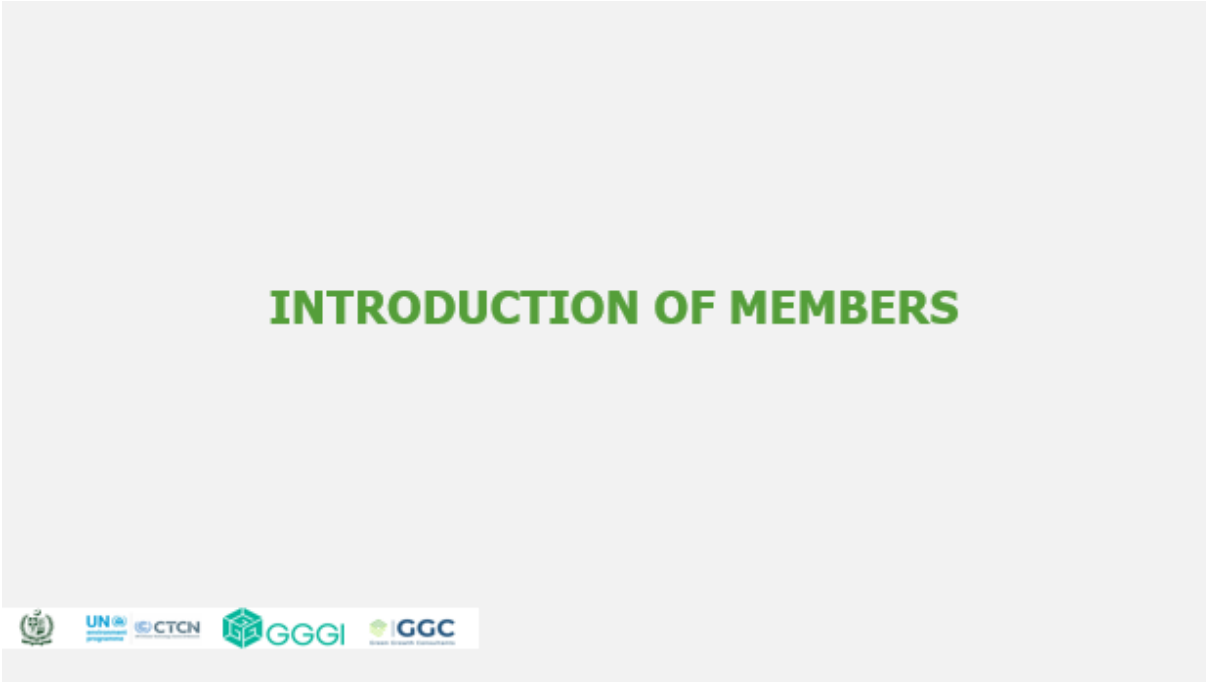

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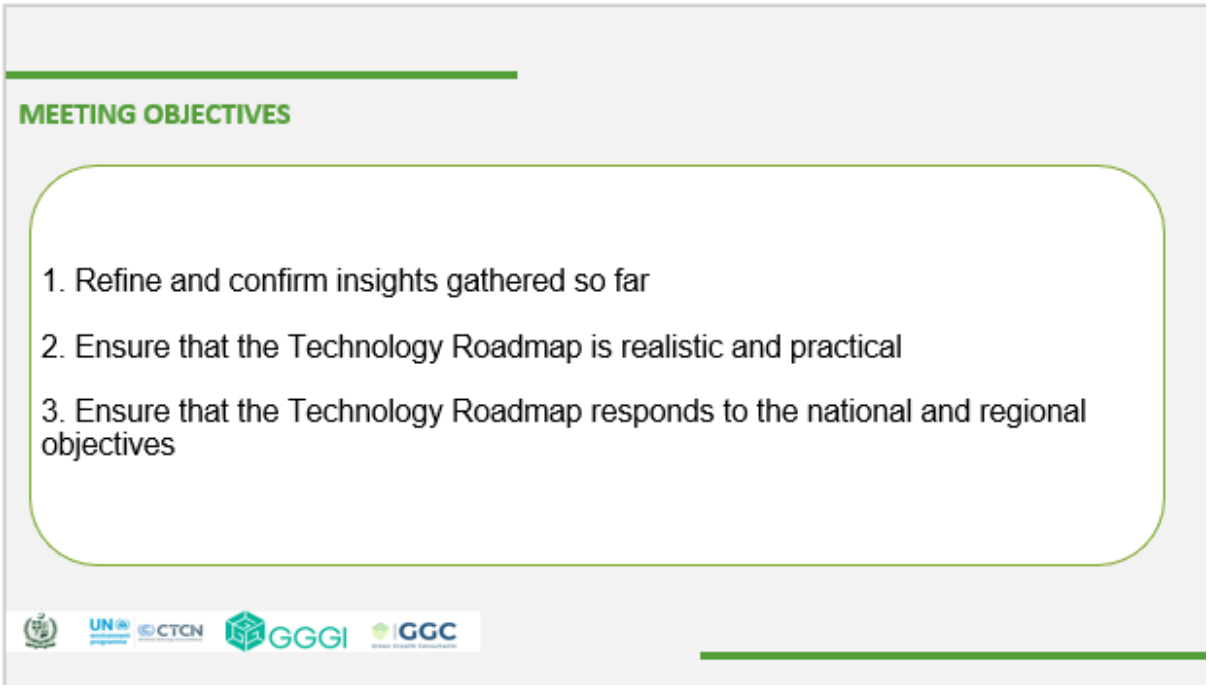

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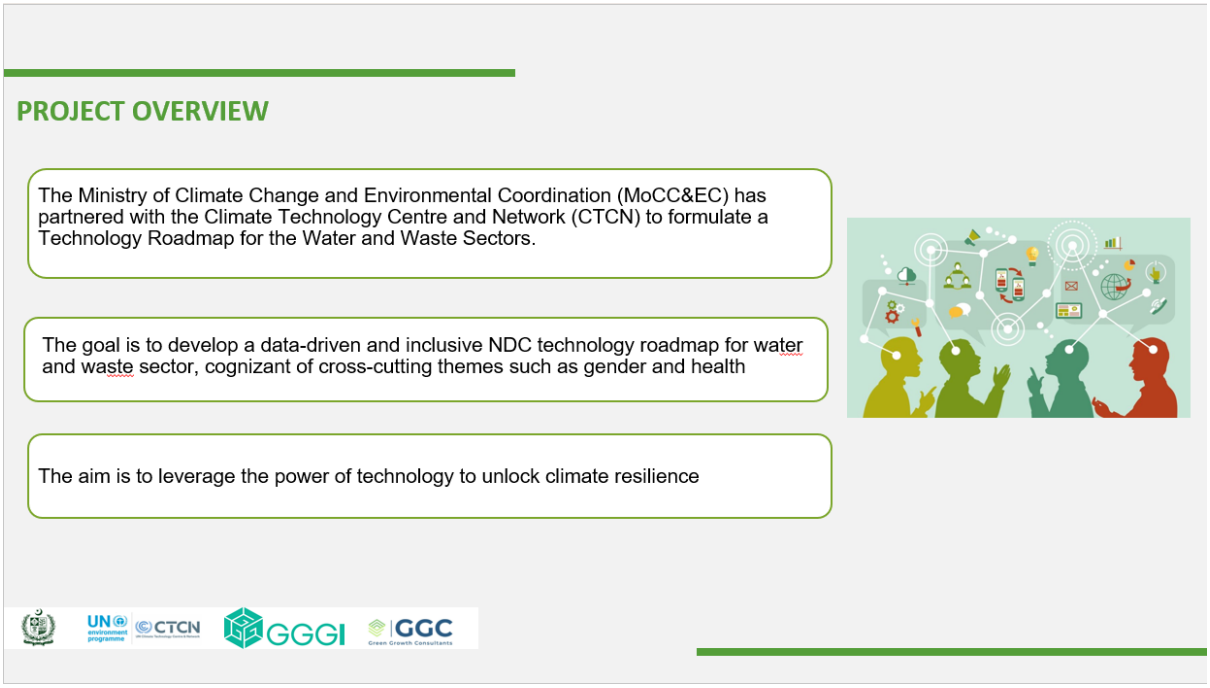

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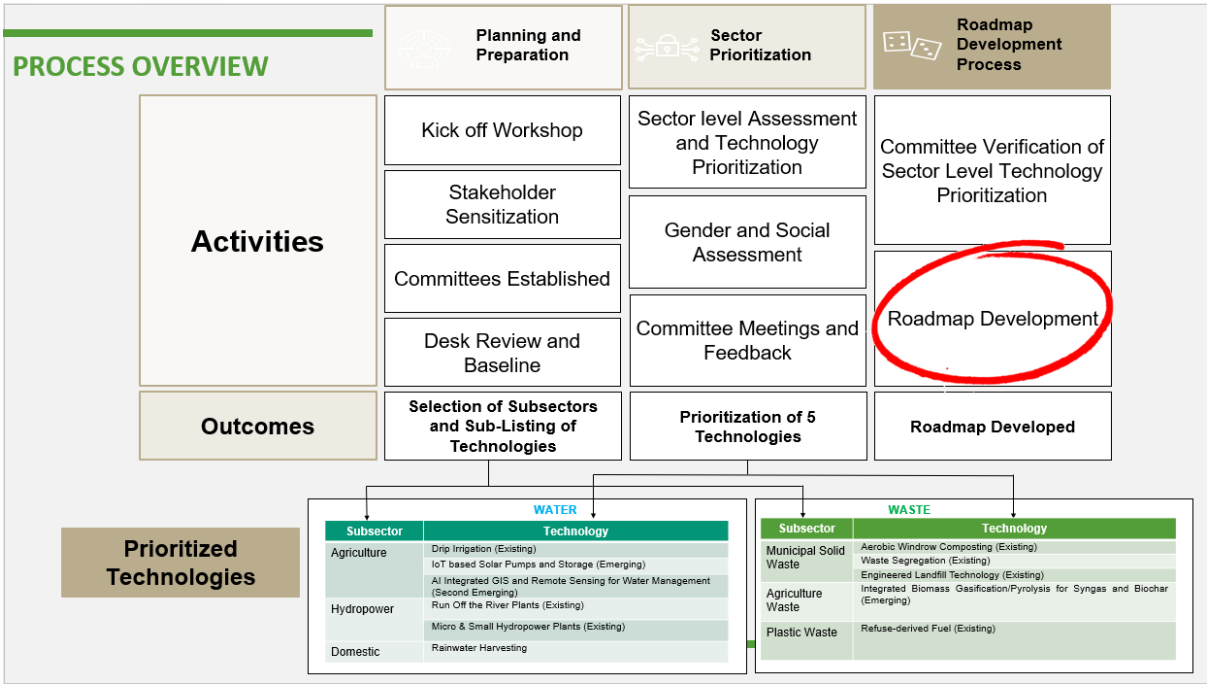

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FORMAT OF ACTION PLAN

Technology Readiness Level Chart

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HEATMAP OF TECHNOLOGIES FOR WATER SECTOR

Legend

Low readiness → High readiness

1 2 3 4 5

AI Integrated GIS and Remote Sensing for Water Management is one technology that has been included in the final roadmap despite a low score. This is in response to the recommendation from the Ministry of Water Resources to align the NDC Technology Roadmap with the National Flood Management Plan with the understanding that an enabling environment will be provided for technology adoption by authorities. Therefore, this technology will be targeted to facilitate flood management that is ranked as one of the most frequent climate disasters in the country.

Category	Parameters	Existing				Emerging	
		Drip Irrigation	Run of the River Plants	Micro and Small Hydropower Plants	Rainwater Harvesting	IOT Solar Based Pumps and Storage	AI Integrated GIS and Remote Sensing for Water Management (Second Emerging) *
Legal and Financial Framework	Guidelines/ Regulations	5	5	5	3	2	2
	Financial Structure	5	3	3	4	3	3
	Private Sector Mobilization	5	4	5	3	3	2
Economic and Technical Feasibility	Resource Efficiency	4	5	4	4	5	2
	Management Efficiency	5	4	3	5	4	2
	Economic Feasibility	4	3	4	4	4	3
	Existing Project	4	4	4	4	1	2
	Skill Capacity	5	3	4	4	3	2
	Capacity Building	5	4	4	4	3	3
Inclusivity and Climate Impact	Emissions Reduction	4	5	4	2	3	2
	Building Resilience	2	4	3	3	2	3
	Quality of Life	4	4	4	4	4	1
	Inclusive Development	4	3	3	3	3	2
	Social Equality	4	3	3	3	3	2
	Gender Considerations	4	3	3	3	3	2
	TOTAL	**64**	**57**	**56**	**53**	**46**	**33**

**Prioritized on the recommendation of Ministry of Water Resources to align NDC Technology Roadmap with National Flood Management Plan*

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HEATMAP OF TECHNOLOGIES FOR WASTE SECTOR

Legend

Low readiness → High readiness

1	2	3	4	5

Category	Scoring Parameters	Existing				Emerging
		Aerobic Windrow Composting	Waste Segregation Facility	Refuse-Derived Fuel	Engineered Landfill Technology	Integrated Biomass Gasification for Syngas and Biochar
Legal and Financial Framework	Guidelines/ Regulations	4	5	3	5	3
	Financial Structure	4	2	4	4	1
	Private Sector Mobilization	4	2	4	4	4
Economic and Technical Feasibility	Resource Efficiency	4	5	4	4	4
	Management Efficiency	3	4	3	3	3
	Economic Feasibility	4	3	3	3	3
	Existing Project	4	2	3	2	4
	Skill Capacity	4	3	4	3	2
	Capacity Building	5	4	4	3	3
Inclusivity and Climate Impact	Emissions Reduction	4	5	4	4	3
	Building Resilience	3	4	3	3	3
	Quality of Life	2	4	2	2	3
	Inclusive Development	3	3	3	3	4
	Social Equality	3	3	3	1	4
	Gender Considerations	3	3	2	2	4
	TOTAL	54	52	49	46	48

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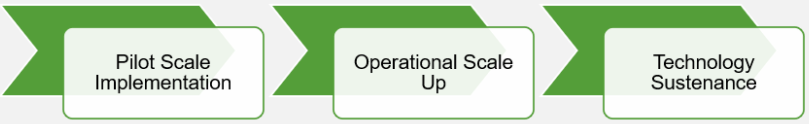
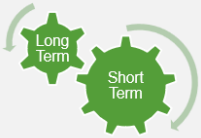
FORMAT OF ACTION PLAN

Entry Point



Category of Action

Term of Action



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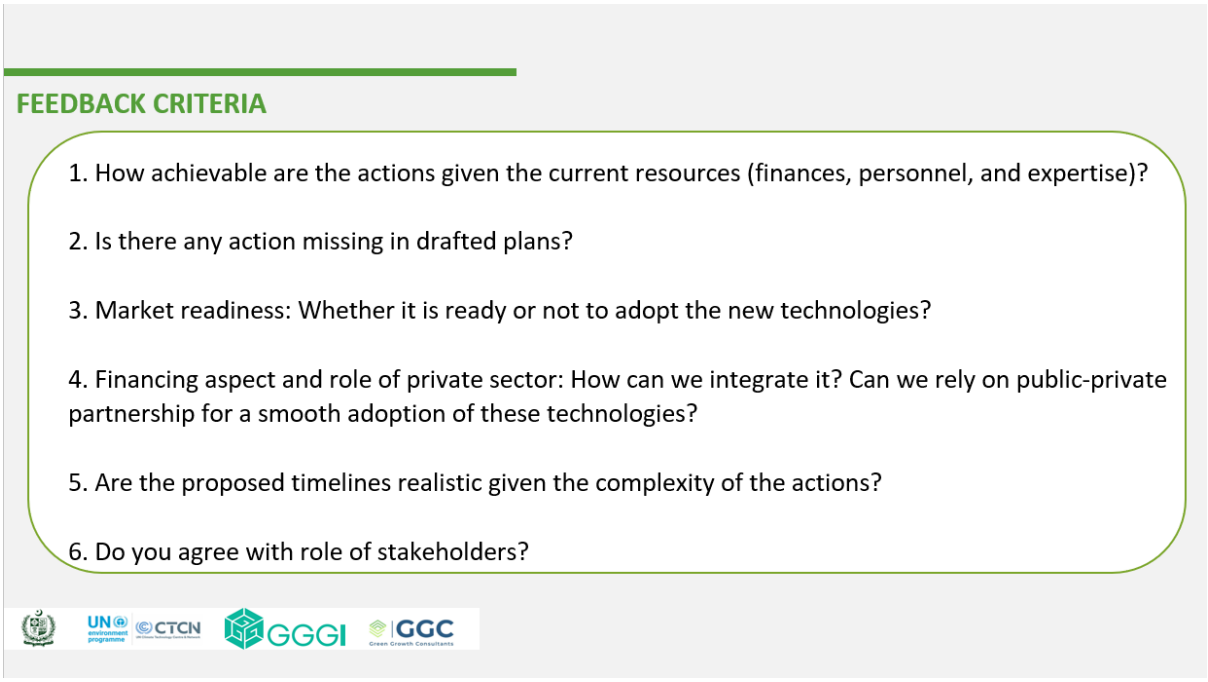

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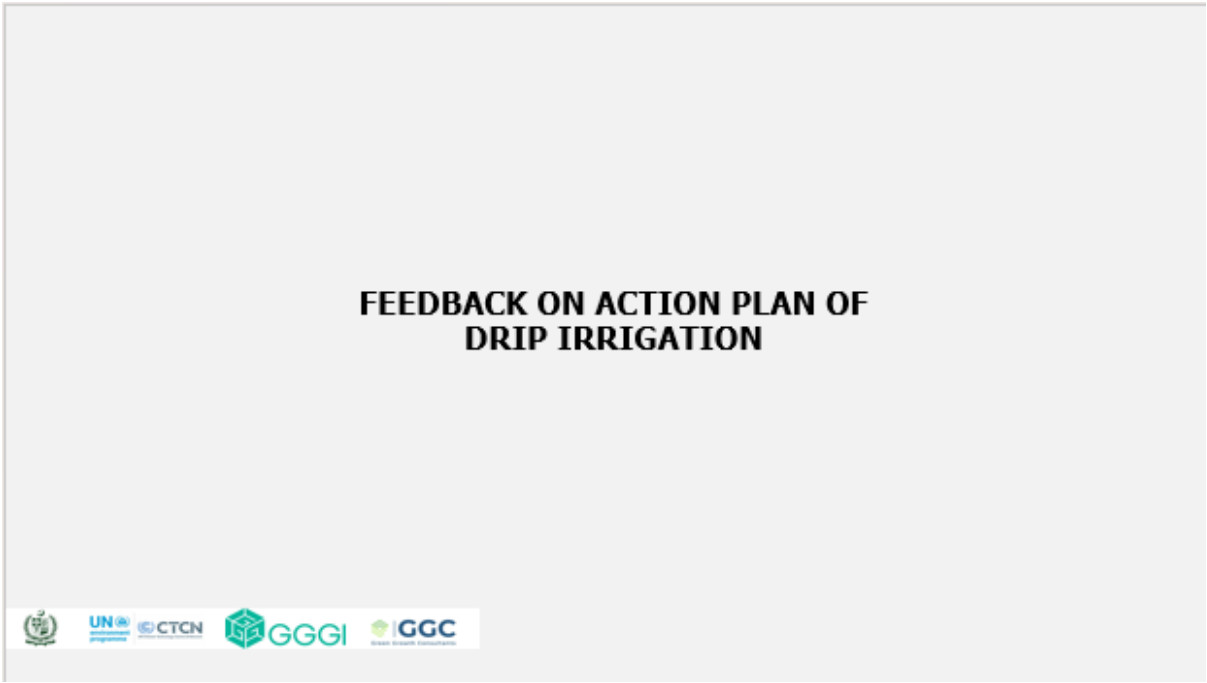

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Action (Time)	Stakeholder
Operational Scale-up	
→POLICY Develop regulations for mobilization of private sector finances GESI (**0-1 y**)	MoCC & EC, EPD, EPAs, Capital Development Authority, SECP, PDAs, MoHR NGOs, Civil Societies, IMO, ILO, UNICEF
→CAPACITY BUILDING Awareness for farmers (**0-3 y**) Awareness for project proponent. Promoting innovation hubs and business incubation centers (**2-10 y**)	PCRWR EPA, PCRWR, Academic Institutes, SMEDA, PITAC
→BUDGET Allocation of budget (**0-6 m**) Climate finance (**1-3 y**)	MoCC&EC, MoF, SBP, PSX, Carbon crediting entities
→GOVERNANCE Optimize efficiency with scheduling (**0-1 y**) Policy implementation for public –private partnership and GESI (**0-3 y**)	Ministry of Water Resources PPPA, MoCC&EC, EPD, EPAs, CDA, PDAs
Technology Sustenance	
→GOVERNANCE Balance disparities in WRM (**0-5 y**)	MoCC&EC
→BUSINESS CONTINUITY Explore untapped areas and financial mechanisms for that (**0-5 y**)	PCRWR, PBR, PPPA
→MONITORING AND EVALUATION Develop and implement monitoring system for water quality parameters and GESI (**1-5 y**) Transparency of monitoring system (**2-10 y**)	EPA, CDA, PDAs; MoHR, NGOs, Civil Societies, IMO, CDA, PDAs, Municipalities
→GESI Technical training session for women and loans for youth (**2-5 y**)	PCRWR PIDC
→ENV. MONITORING Quantify emission reductions (**0-3 y**)	EPA, PCRWR

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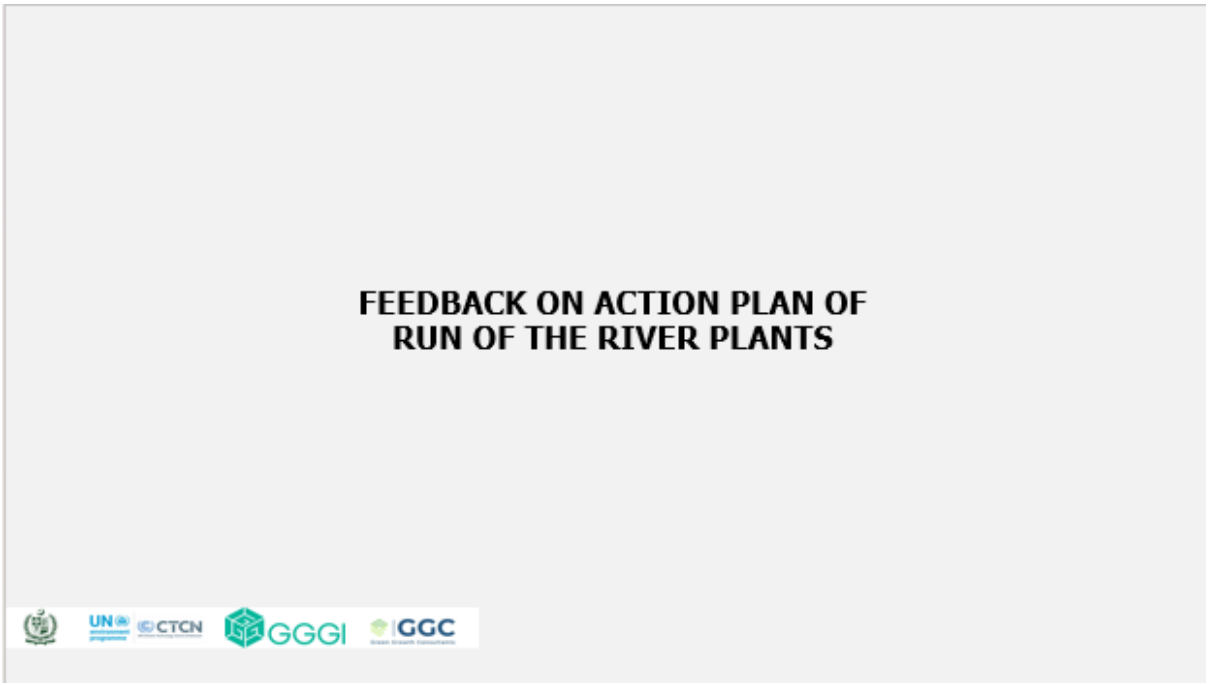

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Action (Time)	Stakeholder
Technology Sustenance	
→POLICY Develop regulations for mobilization of private sector, finances, GESI (**0-1 y**)	MoCC&EC, EPD, EPAs, Capital Development Authority, SECP, Provincial Development Authorities, MoHR, NGOs, Civil Societies, IMO, ILO, UNICEF
→CAPACITY BUILDING Awareness for project proponent. Promoting innovation hubs and business incubation centers (**2-10 y**)	PCRWR EPA, PCRWR, Academic Institutes, SMEDA, PITAC
→BUDGET Allocation of budget (**0-6 m**) Climate finance (**1-3 y**)	MoCC&EC, MoF, SBP, PSX, Carbon crediting entities
→GOVERNANCE Policy implementation for public –private partnership and GESI (**0-3 y**) Balance disparities in WRM (**0-5 y**)	MoWR PPPA, MoCC&EC, EPD, EPAs, CDA, PDAs
→BUSINESS CONTINUITY Facilitate wider adoption (**0-1 y**) Explore untapped areas and financial mechanisms for that (**0-5 y**)	PCRWR, PBR, PPPA
→MONITORING AND EVALUATION Develop and implement monitoring system for water quality parameters and; GESI (**1-5 y**) Transparency of monitoring system (**2-10 y**)	EPA, CDA, PDAs; MoHR, NGOs, Civil Societies, IMO, CDA, PDAs, Municipalities
→GESI Develop cottage industry for time saved because of technology (**3-5 y**) Technical training session for women and loans for youth (**0-3 y**)	PCRWR PIDC
→ENV. MONITORING Quantify emission reductions (**0-3 y**)	EPA, PCRWR

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Action (Time)	Stakeholder
Technology Sustenance	
→POLICY Develop regulations for mobilization of private sector: finances: GESI (**0-1 y**)	MoCC & EC, EPD, EPAs, Capital Development Authority, SECP, Provincial Development Authorities, MoHR, NGOs, Civil Societies, IMO, ILO, UNICEF
→CAPACITY BUILDING Awareness for project proponent. Promoting innovation hubs and business incubation centers (**2-10 y**)	PCRWR EPA, PCRWR, Academic Institutes, SMEDA, PITAC
→BUDGET Allocation of budget (**0-6 m**) Climate finance (**1-3 y**)	MoCC&EC, MoF, SBP, PSX, Carbon crediting entities
→GOVERNANCE Policy implementation for public –private partnership and GESI (**0-3 y**) Balance disparities in WRM (**0-5 y**)	MoWR PPPA, MoCC&EC, EPD, EPAs, CDA, PDAs
→BUSINESS CONTINUITY Facilitate wider adoption (**0-1 y**) Explore untapped areas and financial mechanisms for that (**0-5 y**)	PCRWR, PBR, PPPA
→MONITORING AND EVALUATION Develop and implement monitoring system for water quality parameters and; GESI (**1-5 y**) Transparency of monitoring system (**2-10 y**)	EPA, CDA, PDAs; MoHR, NGOs, Civil Societies, IMO, CDA, PDAs, Municipalities
→GESI Develop cottage industry for time saved because of technology (**3-5 y**) Technical training session for women and loans for youth (**0-3 y**) Engage local services in the construction phase (**3-5 y**)	PCRWR PIDC
→ENV. MONITORING Quantify emission reductions (**0-3 y**)	EPA, PCRWR

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Action (Time)	Stakeholder
Technology Sustenance	
→POLICY Expand scope of current policy. Develop regulations for mobilization of private sector, finances and GESI (**0-1 y**)	MoCC & EC, EPD, EPAs, Capital Development Authority, SECP, Provincial Development Authorities, MoHR, NGOs, Civil Societies, IMO, ILO, UNICEF
→RESEARCH Initiate research on barriers to wider adoption (**2-4 y**)	HEC, PCRWR, Academic Institutes
→CAPACITY BUILDING Existing sites for capacity building (**2-4 y**) Awareness for project proponent. Promoting innovation hubs and business incubation centers (**2-10 y**)	PCRWR EPA, PCRWR, Academic Institutes, SMEDA, PITAC
→BUDGET Allocation of budget (**0-6 m**) Climate finance (**1-3 y**)	MoCC&EC, MoF, SBP, PSX, Carbon crediting entities
→GOVERNANCE Policy implementation for public –private partnership and GESI (**0-3 y**) Develop mechanisms to facilitate technology infrastructure (**0-2 y**) Create and update data base for weather patterns (**0-1y**) Facilitate harmonization among departments (**2-10 y**)	PPPA, MoCC&EC, EPD, EPAs, CDA, PBR, PCRWR, Pakistan Meteorological Department, MoF, SECP, WAPDA, PDF, PPIB
→BUSINESS CONTINUITY Incorporate traditional practices (**0-5 y**) Engage local business in construction phase (**0-2 y**)	PCRWR, CDA, PDAs, Local construction companies, SMEDA, PIDC
→MONITORING AND EVALUATION Develop and implement monitoring system for water quality parameters and GESI (**1-5 y**)	EPA, CDA, PDAs; MoHR, NGOs, Civil Societies, IMO, CDA, PDAs, Municipalities
→GESI Target communities affected by desertification (**0-2 y**) Facilitate women to indulge in entrepreneurship (**2-4 y**) Develop cottage industry for time saved because of technology (**3-5 y**)	MoCC&EC, CDA, PDAs, PIDC
→ENV. MONITORING Smart Water Meters (**2-5 y**) Quantify emission reductions (**0-3 y**)	EPA, PCRWR

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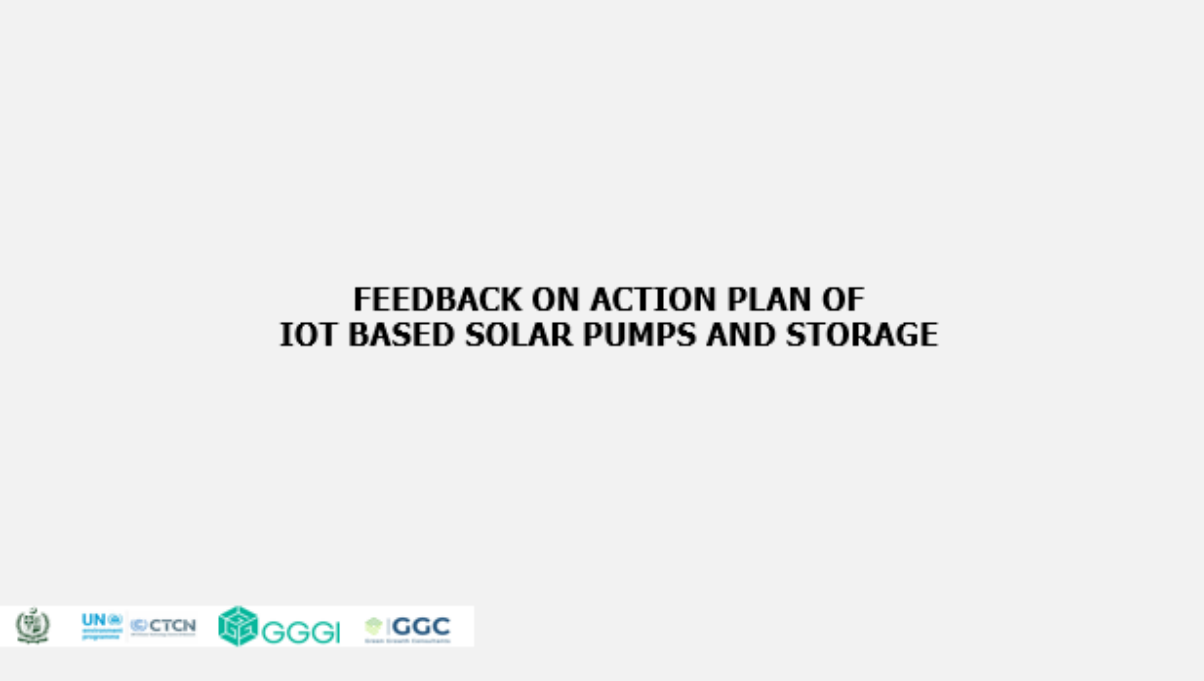

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Action (Time)	Stakeholder
Pilot Scale Implementation	
→POLICY Develop regulations for IoT integrating with groundwater (**0-1 y**)	MoCC&EC, EPA, PPIB, AEDB, PCRET
Operational Scale-up	
→POLICY Develop regulations for mobilization of private sector, finances, GESI (**0-1 y**)	MoCC&EC, EPA, PPIB, AEDB, (PCRET)MoHR NGOs, Civil Societies, IMO, ILO, UNICEF
→CAPACITY BUILDING Awareness for farmers (**1-3 y**) Awareness for project proponent. Promoting innovation hubs and business incubation centers (**2-10 y**)	PCRWR, EPA, PSF, PCST, NARC, PCRWR, Academic Institutes, SMEDA, PITAC
→BUDGET Allocation of budget (**0-6 m**) Facilitate upfront cost burden for farmers (**0-1 y**) Climate finance (national and international) (**1-3 y**)	MoCC&EC, MoWR, MoF, SBP, PSX, Carbon crediting entities
→GOVERNANCE Optimize efficiency with scheduling (**0-1 y**) Policy implementation for public –private partnership and GESI (**0-3 y**) Integrate Smart Control (**0-6 y**)	MoWR, PPPA, MoCC&EC, EPD, EPAs, CDA, PDAs Research Institutes, WAPDA, Private Technology companies
Technology Sustenance	
→GOVERNANCE Facilitate harmonization among departments (**2-10 y**)	MoCC & EC, MoF, MoWR, Research Institutions, PBR, CDA, SECP, WAPDA, PDF, PPIB, PCRWR, PCRET, Private Sector
→RESEARCH Expand the scope of research to address local context (**1-5 y**)	HEC, PSF, PCST, NARC
→MONITORING AND EVALUATION Develop and implement monitoring system for water quality parameters and GESI (**1-5 y**) Transparency of monitoring system (**2-10 y**)	EPA, CDA, PDAs; MoHR, NGOs, Civil Societies, IMO, CDA, PDAs, Municipalities,
→ENV. MONITORING Quantify emission reductions (**0-3 y**)	Federal and provincial water departments, PMD, EPA, PCRWR

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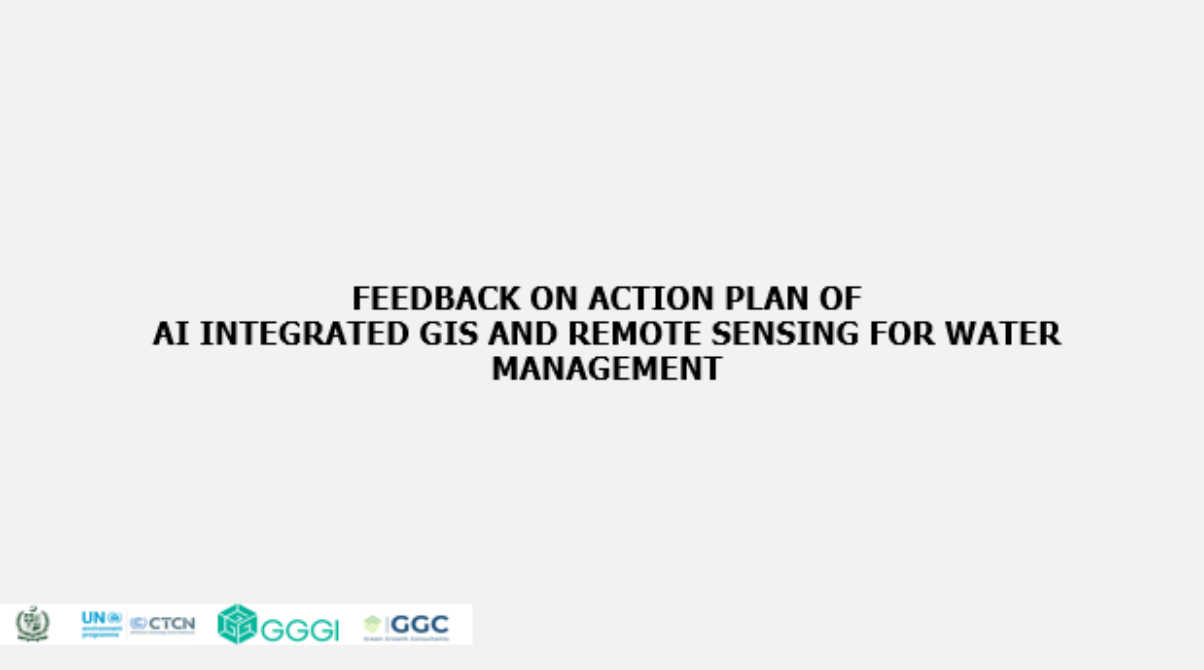

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Action (Time)	Stakeholder
Pilot Scale Implementation	
→POLICY Develop regulations for AI integrated GIS (**0-1 y**)	MoCC&EC, MoIT
Operational Scale-up	
→POLICY Develop regulations for mobilization of private sector, finances, GESI (**0-1 y**)	MoCC & EC, MoWR, SECPEPD, EPAs, CDA, PDAs, SBP, BoP, World Bank, ADB, SMEDA, MoHR, NGOs, Civil Societies, ILO, UNICEF
→CAPACITY BUILDING Awareness for project proponent. Promoting innovation hubs and business incubation centers (**2-10 y**)	EPA, PCRWR, Academic Institutes, SMEDA, PITAC
→BUDGET Allocation of budget (**0-6 m**) Climate finance (national and international) (**1-3 y**)	MoWR, MoCC&EC, MoIT, MoF, SBP, PSX, Multilateral Financial Institutions
→GOVERNANCE Optimize efficiency with scheduling (**0-1 y**) Policy implementation for public –private partnership and GESI (**0-3 y**) Integrate Smart Control (**0-6 y**)	PPPA, MoCC&EC, EPD, EPAs, CDA, PDAs
Technology Sustenance	
→GOVERNANCE Facilitate harmonization among departments (**2-10 y**)	MoCC & EC, MoF, MoWR, MoIT, Research Institutions, PBR, CDA, SECP, WAPDA, PDF, PPIB, PCRWR, PCRET, Private Sector
→MONITORING AND EVALUATION Develop and implement monitoring system for water quality parameters and GESI (**1-5 y**)	EPA, CDA, PDAs; MoHR, NGOs, Civil Societies, IMO, CDA, PDAs, Municipalities,

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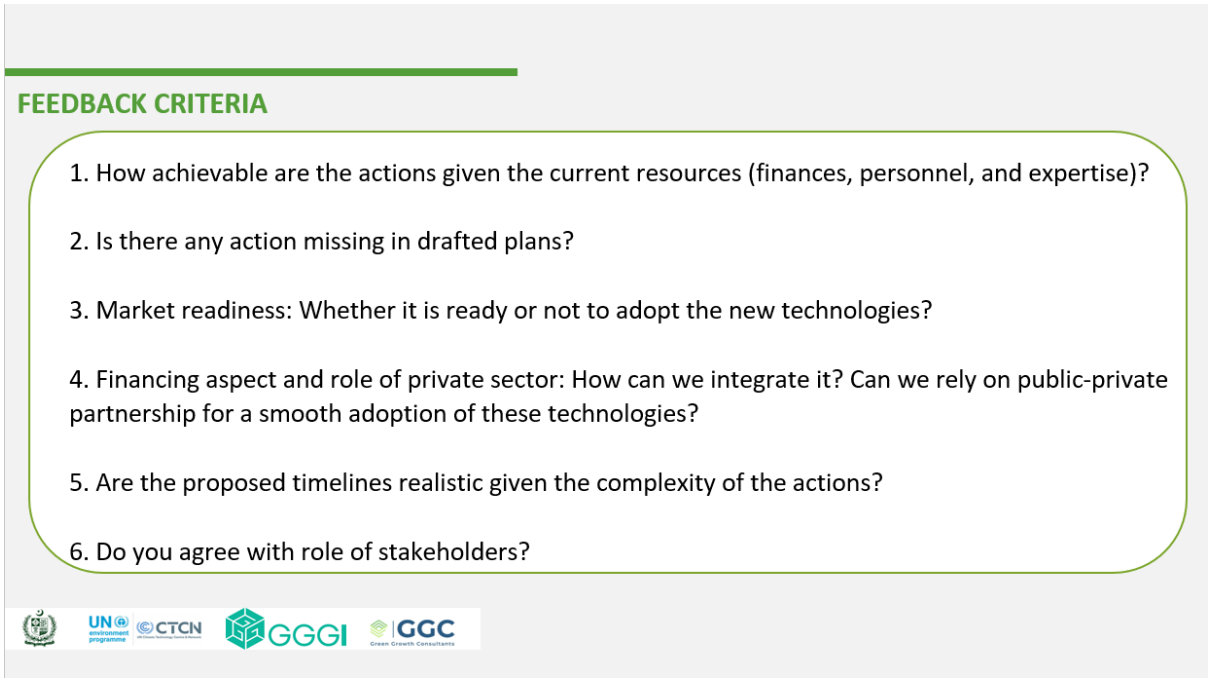

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Action (Time)	Stakeholder
Operational Scale-up	
→WASTE MODELLING Gather and analyze data through models (**0-1 y**) Conduct economic feasibility and EIA using LCA approach (**0.5-1 y**)	EPA, PCSIR
→POLICY Develop and implement regulations for construction of IRRCs with technology integration, mobilization of private sector, finances and GESI (**0-1 y**)	MoCC & EC, EPD, EPAs, CDA, SECP, PDAs, MoHR NGOs, Civil Societies, IMO, ILO, UNICEF
→CAPACITY BUILDING Procurement of designated vehicles, tracking systems (**0-1 y**) Development of model facility (**0.5-1 y**) Awareness for project proponent. Promoting innovation hubs and business incubation centers (**2-10 y**)	Private sector entities, CDA, PDAs, PCSIR, Academic Institutions, SMEDA, PITAC
→BUDGET Allocation of budget (**0-6 m**) Climate finance (**1-3 y**)	MoCC&EC, MoF, SBP, PSX, Carbon crediting entities like repurpose Global and Plastiks
→GOVERNANCE Defining roles, ensuring compliance, ensure women at managerial positions, informal sector and youth led businesses (**0-3 y**) Integration of IT in terms of a digital platform (**2-10 y**)	MoWR, PPPA, MoCC&EC, EPD, EPAs, CDA, PDAs, PPPA, IOM, MoIT, P@sha
Technology Sustenance	
→BUSINESS CONTINUITY Improve market value of recovered and processed resource (**2-5 y**)	CDA, PDAs
→MONITORING AND EVALUATION Develop and implement monitoring system for sanitation parameters and GESI (**1-5 y**) Leverage IT in terms of digital platform for monitoring (**1-3 y**) Transparency of monitoring system (**2-10 y**)	EPA, CDA, PDAs; MoHR, NGOs, Civil Societies, IMO, CDA, PDAs, Municipalities
→GESI Responsive complaint system and regular inspections/audits (**1-5 y**)	MoHR, NGOs, Civil Societies, IMO, CDA, PDAs
→ENV. MONITORING Quantify emission reductions (**0-3 y**)	EPA, PCSIR

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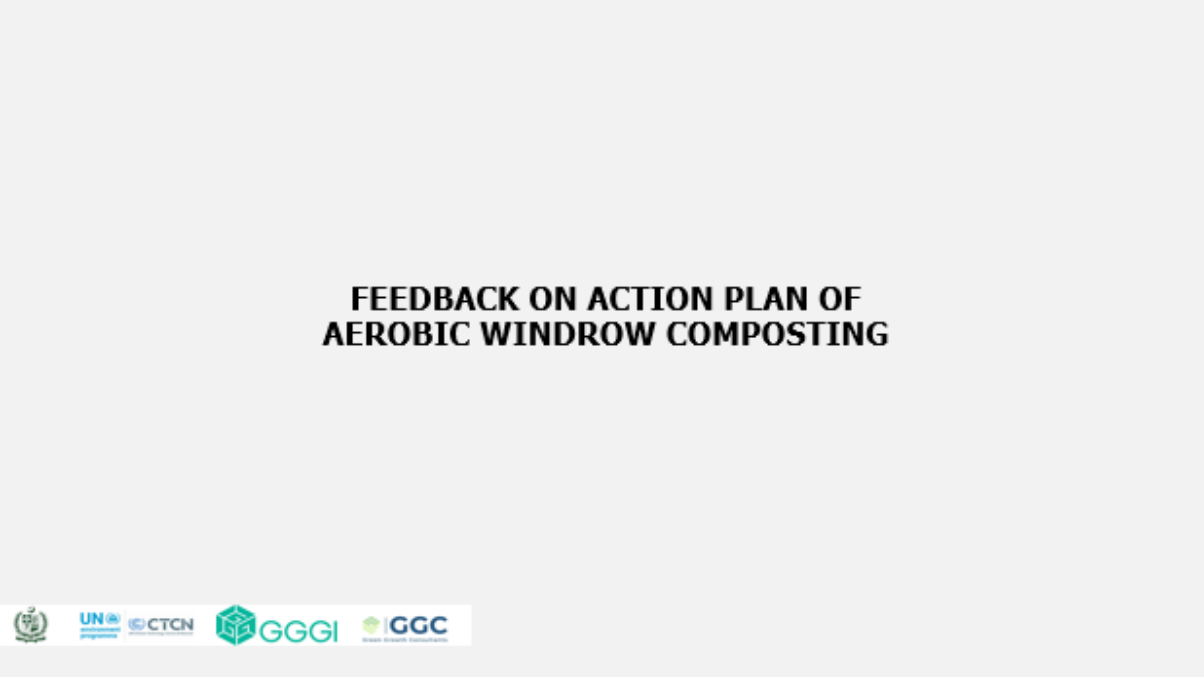

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Action (Time)	Stakeholder
Operational Scale-up	
→WASTE MODELLING Gather and analyze data through models (**0-1 y**) Conduct economic feasibility and EIA using LCA approach (**0.5-1 y**)	EPA, PCSIR
→POLICY Develop and implement regulations for construction of IRRCs with technology integrated and improve market value of compost, mobilization of private sector, finances and GESI (**0-1 y**) Mandate source segregation system (**3-6 y**)	MoCC & EC, EPD, EPAs, CDA, SECP, PDAs, SBP, BoP, World Bank, ADB, FMFB, Khushhali Microfinance Bank, and U Microfinance Bank, SMEDA, MoHR, NGOs, Civil Societies, IMO, ILO, UNICEF
→CAPACITY BUILDING Development of model facility (**0.5-1 y**) Awareness for communities. Promoting innovation hubs and business incubation centers (**2-10 y**)	Private sector entities, CDA, PDAs, PCSIR, Academic Institutions, SMEDA, PITAC
→BUDGET Allocation of budget (**0-6 m**) Climate finance (**1-3 y**)	MoCC&EC, MoF, SBP, PSX, Carbon crediting entities like rePurpose Global and Plastiks
→GOVERNANCE Defining roles, ensuring compliance, ensure women at managerial positions, informal sector and youth led businesses (**0-3 y**) Integration of IT in terms of a digital platform (**2-10 y**)	MoWR, PPPA, MoCC&EC, EPD, EPAs, CDA, PDAs, PPPA, IOM, MoIT, P@sha, PSEB, Software development companies, PHA, Agriculture Department and Ext.
Technology Sustenance	
→BUSINESS CONTINUITY Improve market value of recovered and processed resource (**2-5 y**)	Agriculture Department and Extensions Municipalities, private entities, research institutes
→MONITORING AND EVALUATION Develop and implement monitoring system for sanitation parameters and GESI (**1-5 y**) Leverage IT in terms of digital platform for monitoring (**1-3 y**) Transparency of monitoring system (**2-10 y**)	EPA, CDA, PDAs; MoHR, NGOs, Civil Societies, IMO, CDA, PDAs, Municipalities
→GESI Responsive complaint system and regular inspections/audits (**1-5 y**)	MoHR, NGOs, Civil Societies, IMO, CDA, PDAs
→ENV. MONITORING Quantify emission reductions (**0-3 y**)	EPA, PCSIR

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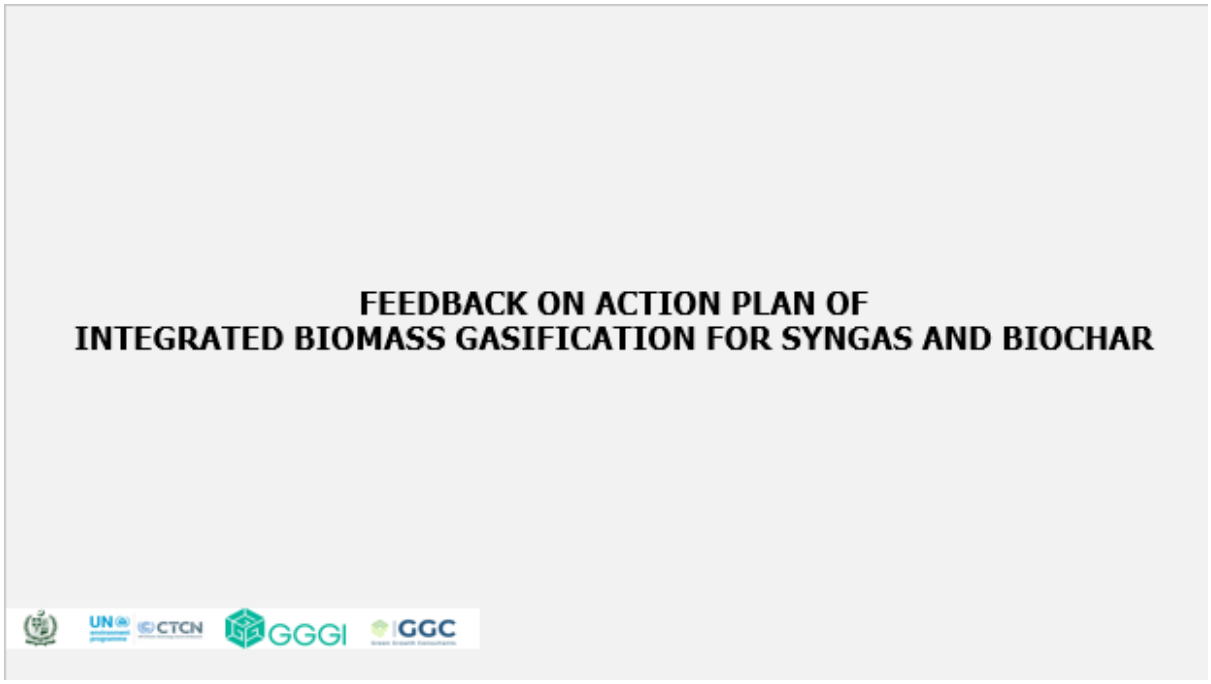

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Action (Time)	Stakeholder
Operational Scale-up	
→**POLICY** Refine policy and develop clear guidelines and monitoring systems (**0-1 y**)	CDA, PDAs, PPIC, NISF
→**WASTE MODELLING** Gather and analyze data through models (**0-1 y**) Conduct economic feasibility and EIA using LCA approach (**0.5-1 y**)	EPA, PCSIR
→**POLICY** Policy for IRRCs with integration of IBG technology, mobilization of private sector, finances and GESI (**0-1 y**) Mandate source segregation system (**3-6 y**)	MoCC & EC, EPD, EPAs, CDA, SECP, PDAs, SBP, BoP, World Bank, ADB, FMFB, Khushhali Microfinance Bank, and U Microfinance Bank, SMEDA, MoHR, NGOs, Civil Societies, IMO, ILO, UNICEF
→**CAPACITY BUILDING** Development of model facility (**0.5-1 y**) Evaluation against set targets for stakeholder engagement and sorting efficiency (**0.5 y**) Awareness for communities. Promoting innovation hubs and business incubation centers (**2-10 y**)	Private sector entities, CDA, PDAs, PCSIR, Academic Institutions, SMEDA, PITAC
→**BUDGET** Allocation of budget (**0-6 m**) Climate finance (**1-3 y**)	MoCC&EC, MoF, SBP, PSX, Carbon crediting entities like repurpose Global and Plastiks
→**GOVERNANCE** Defining roles, ensuring compliance, ensure women at managerial positions, informal sector and youth led businesses (**0-3 y**) Ensure complete value chain for by-products (**2-5 y**) Integration of IT in terms of a digital platform (**2-10 y**)	MoWR, PPPA, MoCC&EC, EPD, EPAs, CDA, PDAs, PPPA, IOM, MoIT, P@sha, PSEB, Software development companies, PHA, Agriculture Department and Extensions Municipalities
Technology Sustenance	
→**BUSINESS CONTINUITY** Improve market value of recovered and processed resource (**2-5 y**) Combination of practices for optimization (**3-10 y**)	Agriculture Department and Extensions Municipalities, private entities, research institutes
→**MONITORING AND EVALUATION** Develop and implement monitoring system for sanitation parameters and GESI (**1-5 y**) Leverage IT in terms of digital platform for monitoring (**1-3 y**) Transparency of monitoring system (**2-10 y**)	EPA, CDA, PDAs; MoHR, NGOs, Civil Societies, IMO, CDA, PDAs, Municipalities
→**GESI** Responsive complaint system and regular inspections/audits (**1-5 y**)	MoHR, NGOs, Civil Societies, IMO, CDA, PDAs
→**ENV. MONITORING** Quantify emission reductions (**0-3 y**)	EPA, PCSIR

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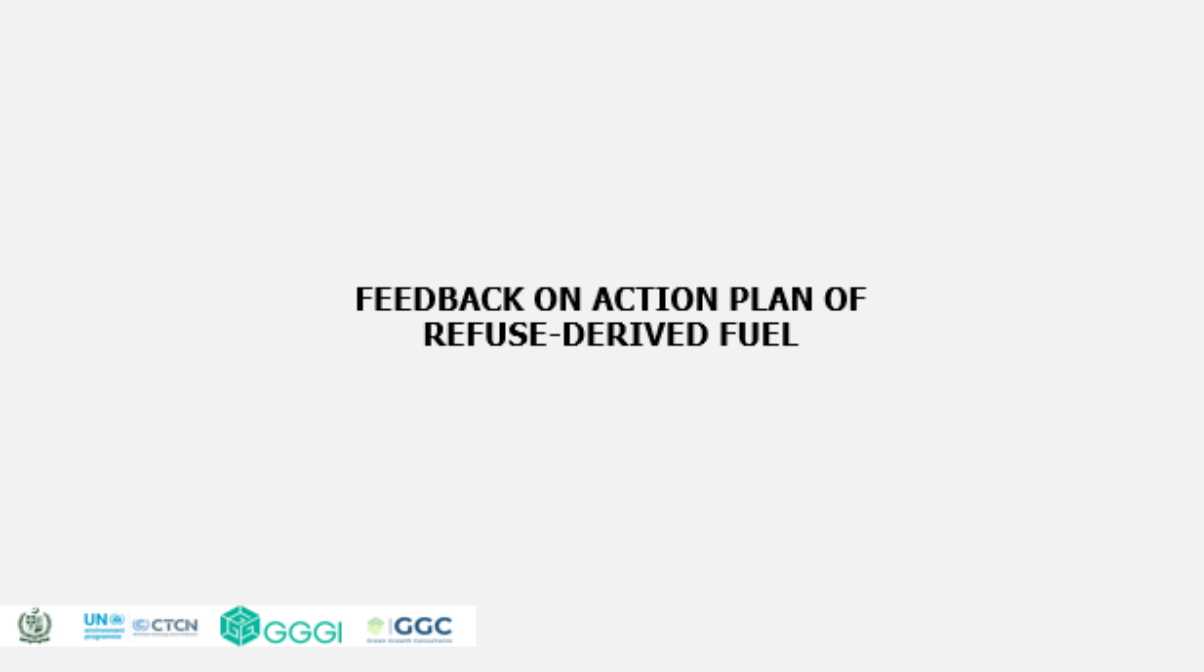

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Action (Time)	Stakeholder
Operational Scale-up	
→WASTE MODELLING Gather and analyze data through models (**0-1 y**) Conduct economic feasibility and EIA using LCA approach (**0.5-1 y**)	EPA, PCSIR
→POLICY Nationwide policy for RDF, mobilization of private sector, finances and GESI (**0-1 y**)	MoCC & EC, EPD, EPAs, CDA, SECP, PDAs, SBP, BoP, World Bank, ADB, First MicroFinance Bank (FMFB), Khushhali Microfinance Bank, and U Microfinance Bank, SMEDA, MoHR NGOs, Civil Societies, IMO, ILO, UNICEF
→CAPACITY BUILDING Development of model facility (**0.5-1 y**) Awareness for communities. Promoting innovation hubs and business incubation centers (**2-10 y**)	Private sector entities, CDA, PDAs, PCSIR, Academic Institutions, SMEDA
→BUDGET Allocation of budget (**0-6 m**) Climate finance (**1-3 y**)	MoCC&EC, MoF, SBP, PSX, Carbon crediting entities like rePurpose Global and Plastiks
→GOVERNANCE Defining roles, ensuring compliance, ensure women at managerial positions, informal sector and youth led businesses (**0-3 y**)	MoWR, PPPA, MoCC&EC, EPD, EPAs, CDA, PDAs, PPPA, IOM, Municipalities
Technology Sustenance	
→BUSINESS CONTINUITY Improve market value of recovered and processed resource (**2-5 y**) Develop an ecosystem of industrial partners (**1-3 y**) Combination of practices for optimization (**3-10 y**)	PITAC, PIDC, SMEDA, Private entities, Academic/Research Institutes
→MONITORING AND EVALUATION Develop and implement monitoring system for sanitation parameters and GESI (**1-5 y**) Leverage IT in terms of digital platform for monitoring (**1-3 y**) Transparency of monitoring system through IT digital platforms (**2-10 y**)	EPA, CDA, PDAs; MoHR, NGOs, Civil Societies, IMO, CDA, PDAs, Municipalities
→GESI Responsive complaint system and regular inspections/audits (**1-5 y**)	MoHR, NGOs, Civil Societies, IMO, CDA, PDAs
→ENV. MONITORING Quantify emission reductions (**0-3 y**) Quality of RDF (**1-5 y**)	EPA, PCSIR

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Action (Time)	Stakeholder
Pilot Scale Implementation	
→POLICY Refine policy framework for technology and end-products (**0-1 y**)	CDA, PDAs, PPIB, NISF, ISWA, International experts
→RESEARCH Research on existing issues (**0-2 y**)	MoCC&EC, PCSIR
→WASTE MODELLING Gather and analyze data through models (**0-1 y**) Conduct economic feasibility and EIA using LCA approach (**0.5-1 y**)	EPA, PCSIR
Operational Scale-up	
→POLICY Develop and implement regulations to ensure economic viability. Mobilization of private sector, finances and GESI (**0-1 y**)	MoCC & EC, EPD, EPAs, CDA, SECP, PDAs, SBP, BoP, World Bank, ADB, FMFB, Khushhali Microfinance Bank, and U Microfinance Bank, SMEDA, MoHR, NGOs, Civil Societies, IMO, ILO, UNICEF
→CAPACITY BUILDING Evaluation against set targets for stakeholder engagement and sorting efficiency (**2-10 y**) Promoting innovation hubs and business incubation centers (**2-10 y**)	Private sector entities, CDA, PDAs, PCSIR, Academic Institutions, SMEDA, PITAC
→BUDGET Allocation of budget (**0-6 m**) Climate finance (**1-3 y**)	MoCC&EC, MoF, SBP, PSX, Carbon crediting entities like repurpose Global and Plastiks
→GOVERNANCE GIS, RS and Ecoinformatics (**0-2 y**) Define roles, implement PPP, compliance with standards (**0-3 y**)	MoWR, PPPA, MoCC&EC, EPD, EPAs, CDA, PDAs, PPPA, IOM, MoIT, P@sha, PSEB, Software development companies, PHA, Agriculture Department and Ext.
Technology Sustenance	
→BUSINESS CONTINUITY Improve market value of recovered and processed resource (**2-5 y**) Combination of practices for optimization (**3-10 y**)	Agriculture Department and Extensions Municipalities, private entities, research institutes
→MONITORING AND EVALUATION Develop and implement monitoring system for sanitation parameters and GESI (**1-5 y**) Leverage IT in terms of digital platform for monitoring (**1-3 y**) Transparency of monitoring system (**2-10 y**)	EPA, CDA, PDAs; MoHR, NGOs, Civil Societies, IMO, CDA, PDAs, Municipalities
→GESI Responsive complaint system and regular inspections/audits (**1-5 y**)	MoHR, NGOs, Civil Societies, IMO, CDA, PDAs
→ENV. MONITORING Quantify emission reductions (**0-10 y**)	EPA, PCSIR

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