			IPM principles to be include in school curriculum	5 – 10	0.5 M			
			Continuous investment in institutional capacity (human resource development and infrastructural and logistic support)	5- 20	20.0M			
	Limited pesticide residue monitoring facility	In line with food safety and to improve market access	Inventory of pesticide commonly used and capacity for determination of pesticide residue Enforce capacity of pesticide residue analysis at food Lab (human and infrastructure)	0-5	4.0 M	MAIFS- Food Lab Ministry of Health AREU Extension	Gov of Mauritius	IOS-No of pesticide residue analysis Risk- Poor linkage between Research , extension and market actors Risk –there is no enforcement / sanction
Institutional and organizational capacity	Lack of cooperation and communication between the involved institutions leading to failure of IPM projects	Need to foster collaboration between all stakeholders involved in agriculture	Strengthen collaboration between institutions (Govt. Research institute, academia , private sectors, extension and farmers) and cooperation at regional level and promote data and information sharing	0-5	0.25 M	MAIFS, Govt of Mauritius , COI, farmers associations	Regional and national	IOS- No. of exchange meetings/ workshop
Social and behavioural	Resistance to change from chemical control to IPM	To demonstrate overall benefits of IPM practices	Encourage Farmers / community participation in IPM	0-5	1.0 M	MAIFS, AREU, SPWF, NGOs,	National	IOS- No. of farmers implement ing IPM Risk – cheaper pestcides
Information and awareness	Inadequate public awareness of IPM and training of farmers	Need to inform public for decision making	Public awareness of potential impacts of pesticide on env. and health and alternatives sound pest and disease control	0-5	0.4 M	MAIFS, AREU . SPWF, NGOs, Farmers associations , Mins of Health &QL, Media	National	IOS- No. of TV spots, Radio talk Risk – Lack of fund
			Economic analysis of IPM program	5 -10	0.35M			
			Continuous training of farmers	5 - 20	1.2 M			

2.3 Action Plan for Micro Irrigation

2.3.1 About the technology

Micro-irrigation is of 2 types: the low-cost micro irrigation such as low-head, low-cost gravity-fed drip (GFD) irrigation kits, micro sprinklers, micro-tube drip system suited for smallholder farmers and highly sophisticated, capital intensive pressurised commercial drip irrigation. It is commonly used for irrigation of high value horticultural crops such as high value vegetables, fruits and ornamentals in open field, greenhouses or orchards. It delivers water precisely and efficiently and is thus useful in addressing the growing competition for scarce water resources and has shown to have positive effects on yield, incomes, and food security. It reduces labour requirement, weed problem and can also be used for fertigation, which is the application of fertiliser through irrigation system. It is applicable to operate with large or small water capacities and over a range of field sizes, topographic and soil conditions and is well suited for automation. This technology requires:

- a water source which can be from small streams, boreholes, tank, reservoir, field pond and rainwater harvesting;
- a water storage facility;
- design/ layout of irrigation system;
- installation of irrigation system which consist of pipes, valves, filters and small drippers or emitters for drip irrigation and a network of pipes with spray heads;
- a pump to lift or pressurised pump to convey and apply irrigation efficiently (except, in case of a

gravity fed system);

- a filtration system in case of poor water quality and
- regular maintenance to ensure that the emitters are not plugged.

Water source can be from borehole, reservoirs, field pond or potable source. Unlike surface or furrow irrigation, it improves water use efficiency by 50-70 % under micro-sprinkler and up to 90 % under drip irrigation. The technology can work in conjunction with rainwater harvesting and protected cultivation where it can be used for fertigation. This technology requires relatively high cost of initial investment. The cost varies depending on the water source and quality, the field size, topography and the type of irrigation system. The benefit cost analysis of micro irrigation over 250 ha over a period of 10 years was estimated to 4.67. This clearly indicated the overall market benefit of this technology in term of reducing risk of crop failure, increasing productivity, saving in water and fertiliser and additional land brought under production was well as non-market social and environmental benefits such as reduction of water wastage, job creation for installation and maintenance of irrigation equipment, minimising risk of nutrient leaching and groundwater contamination as a result of using fertigation and increase cropping intensity. Depending on the value of the crop produced, this technology can have a payback period of 8 -10 years to recover the cost from investment. This technology can be considered as a long-term investment for water saving, to improve or sustain income and output of vulnerable farmers and to promote sustainable agriculture.

2.3.2 Target for technology transfer and diffusion

The technology is appropriate for adaptation under present and expected climate scenarios as a mean to save water, increase or sustain farmer's income and enhance food security. Considering the areas with soil moisture deficit and the vulnerability of farmers, this technology is targeted to improve and sustain productivity and income of small scale farmers in the drought prone regions such as the north, west and some of the southern part of the island. It is targeted to cover a total of 250 ha under food crop production over a period of 5 years in highly vulnerable areas with high soil moisture deficit (Table 5) and a reliable access to freshwater. The technology may benefit around 500 small scale foodcrop growers including female farmers suffering from frequent crop failure and yield loss due to water shortage.

Table 5. Soil moisture deficit in different parts of the island and the projected irrigated areas.

Region of the island	Soil moisture deficit M^3/ha/yr	Projected irrigated areas (ha)		
		2020	2025	2030
North	1200	9598	9598	9598
West	1400	5800	6300	6300
East/Centre	800	5700	6300	6300
South	1000	5140	5440	5440
Total		21108	27638	27638

Source: Irrigation Authority and AREU

Identifying the appropriate areas and beneficiaries for this technology will have to consider also the access to water, the prevailing cropping pattern, the level of education and the financial capacity of farmers to invest and support from non-governmental organization.

2.3.3 Barriers and measures to the technology's diffusion

Despite the introduction of the family drip irrigation system (suited for 250 m2) by AREU in 2007 and the introduction of the gravity fed KARI Drip irrigation system(suited for 1250 m2) in 2010 and the multitude of benefits provided by micro irrigation system , its adoption has been restricted to only few farmers who have benefited materials from demonstration projects. This low adoption is mainly attributed to the high initial cost of investment,lack of information on the rate of return on investment and insufficient technical economic benefits of using the technology. The other barriers were summarised into 7 aspects: economic and financial, policy and regulation, technical capability, institutional, market failures, social/ behavioural and information and awareness.

Economic and financial barriers: This involves the cost of equipment (main pipes, lateral, sub-lateral pressurised PVC pipes, water tanks, fittings, pump), cost of transport, design and installation and maintenance. The overall cost varies depending on the field size, the quality of the material and the source of water and is often perceived as a high initial investment for small-scale resource poor farmers whose production depends on rainfall. Thus access to appropriate financial incentives for purchase and installation of micro-irrigation and efficient pricing of water are recognised as the main barriers.

Policy and regulation: the absence of a conducive policy and institutional framework with respect to water management including water rights in the agricultural sector and irrigation water pricing which does not encourage the adoption of this technology.
Technical capability: Access to a reliable water source, high cost of energy, inadequate water quality, land tenure, lack of socio- economic analysis and lack of information of water savings , lack of economies of scale, clogging of emitters, lack of skilled labour for design and installation, high level of skilled required management of MI were identified as the technical barriers.

Institutional: Limited Human and infrastructural capacity for R&D, weak linkages between research, extension, irrigation equipment suppliers, weak inter-institutional collaboration between institutions dealing with water resource management (Water Resources Unit, Central Water Authority, AREU, Irrigation Authority and Wastewater Management Authority) were the barriers to implementation of micro-irrigation technology.

Market failures: the small size of the market, poor access to farmers, absence of a standard and quality control for the equipment, low prices of horticultural produce, shortage of after sale services, insufficient market information, lack of transparency are key barriers identified under local conditions.

Social/ behavioural: Resistance to change, limited know how on the technology, theft and vandalism and perception that water is not a limiting factor and that increased management effort is required for micro irrigation were the reason deterring farmers to invest in micro irrigation.

Information and awareness: lack of awareness on the economic, environmental benefits of the technology, limited access to technical information and training, absence of knowledge on success case studies are the factors limiting its uptake.
Faced with water stress due to climate change and increasing competition for diminishing water resources from other expanding sectors, the agricultural sector which is mainly rainfed with only 30 % its land under irrigation is

likely to be highly vulnerable. Thus to address food security under this condition of water scarcity in agriculture, the water and agricultural policy is to reduce water loss, encourage rainwater harvesting and promote efficient irrigation system to optimise water use and improve productivity. The Irrigation Authority who is responsible to provide irrigation facilities to small planters' community have operated some 18 irrigation projects covering some 4170 ha under different methods of irrigation already has the technical expertise and experience in planning , designing, construction and monitoring of micro-irrigation project. In addition, technical expertise in designing low cost drip irrigation system also exists at AREU to support the farming community.

Considering the above barriers to the uptake of micro-irrigation technology and the existing enabling framework, several measures have been identified to promote the adoption of this technology. These measures include: provision of credit facilities and economic incentives, institutional support for MI dissemination, training of assemblers and extension officers in design of MI, training of farmers in operation and maintenance and MI demonstration, review of water pricing, subsidy on MI products, provision of after sales service , establishment of a quality control on MI equipment, provision of technical and economic information (cost, payback period , pressure requirement, compatibility to cropping system , ease of operation and maintenance uniformity of irrigation) to farmers , provision of inputs (seed, fertiliser) and capacity building of farmers in water management, irrigation scheduling and fertigation.,

2.3.4 Proposed action plans for Micro Irrigation

In view of providing enabling environment to encourage market actors and farmers to invest micro-irrigation technologies to improve efficient water use and improve overall agricultural productivity in the event of diminishing water resources, it is important for the following measures /actions to be taken:

- Provision of financial incentives;
- Improve legislations and regulations;
- Support research and development;
- Increase awareness and technical support; and
- Improve after-sales service.

Table 6. Technology action plan for micro-irrigation technology.

Barrier Category	Barriers	Justification for action	Proposed measures /actions	Time Frame (yrs)	Estimated cost (Rs)	Implementing agencies	Funding sources	Indicators of success (IOS) & Risk
Economic and financial	Absence of financial incentives to encourage farmers to adopt the technology	Need to Improve R&D budget in irrigation and water management and to provide financial incentives to optimise water use	Institutions to provide information on risk of crop failure associated with water stress to policy makers for decision making on need for promoting adaptation Survey of potential zones in water deficit areas and target group Conduct Feasibility study of implementing MI project	0 - 5	0.8 M	Water Resources Unit , Irrigation Authority private sector, AREU, SPWF, MAIFS	National or international funding	IOS- Survey report and cabinet paper Risk - There is no water stress
			Provision of Financial incentives in form of a scheme/grant (40 % of the cost)or soft loan to assist farmers in investing in MI equipment Investment on agricultural research and on farm field demonstration of MI	5 - 10	45.0 M			

			Investment of water infrastructure (reservoir, pipes, canals) to improve access to water to support irrigation projects in water deficit areas Provision of economic incentive to invest in water efficient irrigation system Provision of special incentives and technical support to first MI adopters (act as model and drive others)	10- 20	110.0M			
Policy and regulation	Inadequate policy to promote efficiency water use in agriculture	Promoting efficient use of water resources is In line with Food security policy and sustainable development	Policy framework to enhance access to and productive use of water in agricultural sector Review of water rights ,pricing of water and electricity Encourage investment in support services for design , installation and advice on trouble shooting	0-5	0.5 M	State law Office, MAIFS, MOESD, Sugar Estates	National and Private sectors	IOS- Policy put in place and enforced
			Promote market oriented approach to disseminate MI Technology Policy to enhance private sector investment in irrigated agricultural development	5- 10	2.0 M			
Policy and regulation	Inadequate policy to promote efficiency water use in agriculture	Promoting efficient use of water resources is In line with Food security policy and sustainable development	Policy framework to enhance access to and productive use of water in agricultural sector Review of water rights ,pricing of water and electricity Encourage investment in support services for design , installation and advice on trouble shooting	0-5	0.5 M	State law Office, MAIFS, MOESD, Sugar Estates	National and Private sectors	IOS- Policy put in place and enforced
			Promote market oriented approach to disseminate MI Technology Policy to enhance private sector investment in irrigated agricultural development	5- 10	2.0 M			
Institutional and organisational Institutional	Limited resources and weak linkage between R&D and MI equipment suppliers	Capacity building and improve linkages	Policy to encourage inter-institutional collaboration and data and information sharing	0 -5	0.4 M	MIAFS, Research Institution , Private sectors, Irrigation Authority(IA), AREU, MSIRI, SFWF, farmers associations	National , regional and international	IOS- MOU between institution , Role of each institution clearly defined
Market mechanism	Limited market and lack of competition Poor standard of MI equipment	Identify ways to reduce cost and make technology affordable	Conduct cost benefit analysis and feasibility study for MI technology on different farm size and crop types Establish of a Quality Control to monitor quality of MI equipment put on sale on local market		5.0 M			IOS- Report of study,Quality standard and quality control established Risk – increase in freight cost and cost of rrigation equipment
Research and Development capacity	Lack of research network and collaboration	Build a network of relevant stakeholders	Build a research network though public and private partnership Enhance skills of researchers through training / workshop and visits	0-10	4.0 M	MIAFS, Irrigation Authority ,AREU, MSIRI, UoM	National and regional	OIS- No of research and technical publication on irrigation and water management No of farmers receiving assistance in MI

	Inadequate research to support appropriateness of Irrigation technologies for small scale farmers	To improve R& D capacity / linkage between research and extension alleviate poverty , improve farmers income and welfare and improve productivity	Research to enhance yield in irrigated areas through improve agronomic practices Assessment of small scale irrigation performance in terms of water use efficiency under different crop water requirement / under different soil types, Training of extension irrigation specialist Technical assistance to farmers on cultural practices to improve productivity under irrigation Capacity building of entrepreneurs involved in design , installation and maintenance of irrigation system	0 – 5	10.0 M	MAIFS, Irrigation Authority , AREU , MSIRI, NGos, Sugar Estates , Water Users Association		
			Survey of potential areas for development of water resources based on hydrological information Benefit-cost analysis for alternative MI technologies taking into account affordability, accessibility, maintenance and sustainability Identification of appropriate water use agricultural model and strategies to assist farmers					
Information and awareness	Inadequate capacity building in MI Absence of technical know-how on MI	Build capacity of researcher, extension, farmers and entrepreneurs involved in design and installation / after sale service	Identify training needs of beneficiaries in areas related to MI technologies, water management , operation and maintenance and input supply Human resource development through training of research, extension, farmers and active players involved in MI Workshop / seminar/ exhibition to promote MI at regional and national level Demonstration of MI on recognised farms of Research Institute/ progressive farmers of horticultural crops (0.5 ha each) Promote sustainable business for designing and producing and marketing MI technologies	0 – 5	6.8 M	MAIFS, AREU, IA, SFWF, NGOs	Government and private	IOS- No. of training / workshop , exhibition No. of field demonstration, video,, factsheet Risk –unavailability of sufficient funding
			Development of guidelines for micro irrigation system design and management Factsheet on micro irrigation , video show and radio talks with successful case studies on benefit of MI	5- 10	2.2 M			