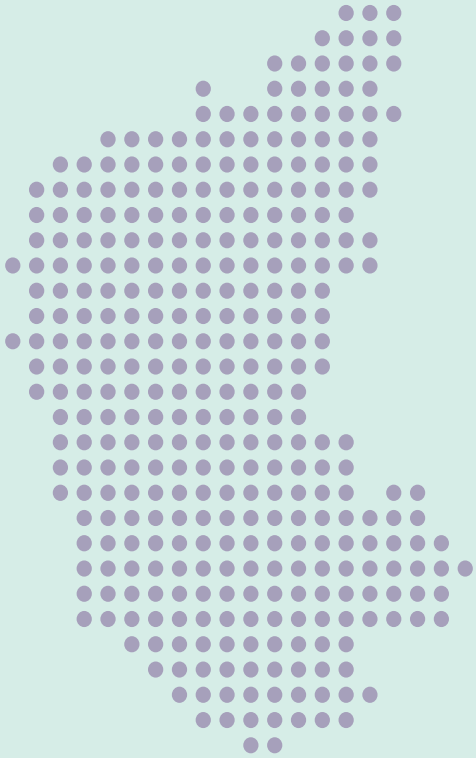
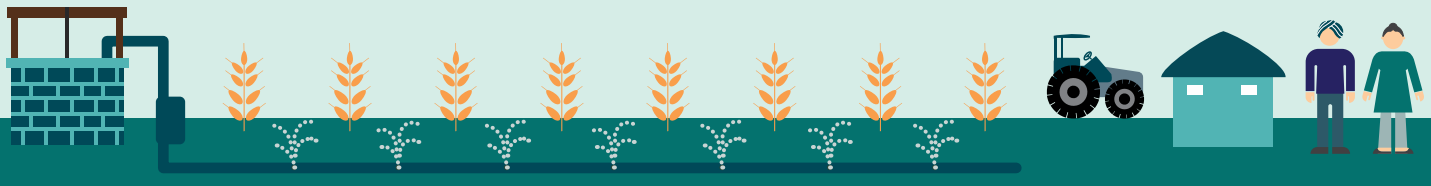
Implementation Roadmap for

Karnataka Micro Irrigation Policy





Global Green Growth Institute

BCCI-K

ISEC

Disclaimer

The Global Green Growth Institute does not make any warranty, either express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or any third party's use or the results of such use of any information, apparatus, product, or process disclosed of the information contained herein or represents that its use would not infringe privately owned rights. The views and opinions of the authors expressed herein do not necessarily state or reflect those of the Global Green Growth Institute.

While every effort has been made to ensure the correctness of data/ information used in this report, neither the authors nor GGGI accept any legal liability for the accuracy or inferences drawn from the material contained therein or for any consequences arising from the use of this material.

The report should be referenced as follows: Global Green Growth Institute (2015) Implementation Roadmap for Karnataka Micro Irrigation Policy, GGGI, Seoul, Republic of Korea

Design: Infonauts, www.infonauts.in

Contents

Acknowledgement

This report is an output of the collaboration between Global Green Growth Institute (GGGI), Bangalore Climate Change Initiative-Karnataka (BCCI-K) and Institute for Social and Economic Change (ISEC, Bengaluru). The report was authored by the technical team of GGGI – Ajith Radhakrishnan, Shilp Verma, Sahil Gulati, ISEC Bengaluru – Dr A. V. Manjunatha, with inputs from Prof. R. S. Deshpande, Prof. M. G. Chandrakanth and Dr. Tushar Shah. Siddarthan Balasubramania (Country Head-GGGI India) and Dr. Prasoon Agarwal (Program Manager-GGGI) provided valuable comments and inputs. The team also acknowledges with thanks, the support and guidance of Dr K Palanisami (IWMI), Dr V Praveen Rao (PJTSU), Dr Neelam Patel (WTC-IARI), Dr VS Prakash (IIIT-B), Dr Avinash Kishore (IFPRI). This report also benefited greatly from inputs and suggestions by various officials from Government of Karnataka, eminent academicians, practitioners, and professionals from relevant industries. This initiative would not have been successful without the constant support and leadership provided by Mr. Krishna Byregowda, Honourable Minister of Agriculture, Government of Karnataka, Mrs. G. Latha Krishna Rao IAS, Additional Chief Secretary and Development Commissioner, Government of Karnataka, and Professor B.K. Chandrashekar, Chairman, BCCI-K.

Executive Summary

The Karnataka vision 2020 and State Action Plan on Climate Change (SAPCC) recognize the need for increasing climate resilience and adaptive capacity of the state as a means of achieving 'sustainability of the state's environment and natural resources' and 'job oriented inclusive economic growth'. To support implementation of the government of Karnataka's progressive policies for climate resilient sustainable growth, a consortium led by Global Green Growth Institute (GGGI) and Bangalore Climate Change Initiative – Karnataka (BCCI-k), comprising of eminent national and international research institutes and think tanks analyzed the green growth opportunities and impacts due to climate vulnerability in key sectors of the state's economy.

In this regard, the "Green Growth Strategy for Karnataka", released by the Honorable Chief Minister of Karnataka, Shri. Siddaramaiah in December 2014, identified micro irrigation as one of the high priority, short-term green growth opportunities for investments and policy action by the state government. In 2015, the government of Karnataka, recognizing the need to adopt an integrated approach to micro-irrigation, set up a Working Group to draft and implement a new micro irrigation policy to ensure equitable and faster adoption of the technology. The WG, chaired by the Development Commissioner and includes eminent members from various departments and GGGI as one of the few external agencies, has asked for this policy analyses to help government understand the current status and real potential of micro irrigation implementation in the state, appropriate financing and institutional mechanisms that optimize government investments and effect equitable, inclusive green growth.

This report also aims to support the government's initiative by providing a roadmap for the successful design and implementation of a micro irrigation policy. The report recognizes that while micro irrigation technologies are often promoted as water saving technologies, farmers adopt them for a variety of reasons – expanding irrigated area, undertaking pre-monsoon sowing, saving labor, energy, fertilizer and other input costs, improving productivity and enhancing net farm incomes.

The potential for Micro Irrigation (MI) in Karnataka is estimated to be in the range of 2.2 to 2.7 mHa of state's Net Irrigated Area. The report caveats the estimate with an assertion that potential is more often a dynamic statistic determined by crop choices, market-price influences and resource availability. As per the latest estimation by Raman (2010)[1] , an area of 4.05 lakh hectares was under micro irrigation at the end of 2009-10 in Karnataka. According to records of Departments of Agriculture and Department of Horticulture, cumulative area of 9.40 lakh ha has been brought under MI ever since it was initiated in 1991-92 in Karnataka. The area covered under MI after launching National Mission on Micro Irrigation (NMMI) i.e. from 2005-06 to 2013-14 was 6.71 lakh hectares. Around 13 districts of the state fall below the state average with respect to per cent of MI area covered as a per cent to Net Irrigated Area. The percentage cover of MI area to NIA of the Eastern Dry Zone (of which some of the most vulnerable districts are a part of), is only around 8 per cent.

On institutional systems, the report recommends setting up an autonomous, single- window, special purpose vehicle akin to the Gujarat Green Revolution Company (GGRC) under the Karnataka Antharaganga Micro Irrigation Corporation (KAMIC) which could act as the nodal agency for all micro irrigation promotion policies and schemes in the state. The KAMIC would imbibe the best features from the subsidy delivery mechanisms followed in well-performing states. A comparison of the subsidy delivery mechanisms in Gujarat, Andhra Pradesh and Karnataka gives a good idea on the features and design elements that Karnataka could adopt to implement a successful micro irrigation promotion program.

On the design of an institutional landscape for micro irrigation promotion, this report suggests that KAMIC

governing board be chaired by the Chief Minister (or a senior minister in the cabinet) to demonstrate political support and ensure generous and seamless access to financial resources. other suggested representatives on the board include members from related ministries and departments – agriculture, horticulture, sericulture, finance, irrigation, energy and renewable energy, rural development – and from industry, academia and financial institutions like NABARD.

KAMIC should operate as a special purpose vehicle, through an independent secretariat in Bangalore and regional / zonal offices across the states, assisted by district-level demonstration sites. The report identifies several opportunities for leveraging co-benefits through coordination and partnerships.

On spurring innovation and market demand, this report suggests that farmers are more likely to respond positively to technologies that promise them tangible outcomes such as enhanced income and therefore recommends a paradigm shift in the positioning of micro irrigation technologies in the minds of farmers: from 'water saving' technologies to 'income enhancing' technologies. It also attempts to suggest measures that will infuse a vibrant, competitive micro irrigation market that reward innovation and quality. We also recommend that low-cost micro irrigation technologies (LCMI) be viewed as 'stepping stones' for eventual adoption of conventional technologies.

By allowing farmers to experiment with a new technology at minimal costs and by encouraging 'farmer-assembled' systems, LCMIs help demystify micro irrigation technologies. Often, farmers with positive LCMI experience 'graduate' to conventional micro irrigation technologies. Thus, it is important to encourage and support informal yet vibrant LCMI markets such as the one thriving in the Kolar region of Karnataka.

On financing (including subsidy regime), micro irrigation in Karnataka, the report strongly suggests a partnership with NABARD, in particular to explore national and international climate financing opportunities including the "Green Climate Fund" (GCF) and National Adaptation Fund. As adoption density in Karnataka increases, the system and servicing costs should fall and these gains should get suitably reflected in unit prices and passed on to the farmers, which is not the case today. The report offers two options for setting unit prices and a third option where the price is allowed to be determined by market forces within a state-determined price band. The third pricing option would be the hallmark of the demand-driven subsidy regime.

A recent review of the performance of the National Mission on Micro Irrigation (NMMI) has noted that there is little, if any, correlation between the level of micro irrigation subsidy and adoption. This report therefore recommends a subsidy structure where the government of Karnataka offers an additional 10-20 per cent subsidy on top of the central subsidy and helps the beneficiaries get access to credit through innovative financing instruments that could be set up by NABARD. It is proposed that subsidies and loans be offered to all willing farmers across the state with differentiation based on land holding and stage of adoption of micro irrigation. It is also proposed that no quotas be fixed per district or per supplier. The subsidy delivery guidelines recommend a time-bound application processing protocol where farmers get final installation done within 50 days of application and suppliers receive final payment within 20 days of final installation.

Based on these parameters and on the premise that the policy will target to cover an additional area of 500,000 ha per annum, the annual subsidy burden for the government of Karnataka is estimated at Rs. 350 crores. In the business-as-usual scenario of 7 per cent annual increase in unit costs, the annual subsidy bill can inflate to more than Rs. 1,250 crores in 20 years. However, if KAMIC is vigilant

and is able to foster healthy competition and develop a farmer centric and farmer driven market, even a three-percent annual reduction in unit costs could bring down the subsidy burden to less than Rs. 200 crores per annum in 20 years.

To ensure successful implementation of the policy and equitable growth, a strong emphasis on **Monitoring and Evaluation** is recommended through a 5-step process. Firstly, KAMIC should track application processing and payment release timelines in addition to key macro-economic variables such as cropping intensity, gross and net irrigated area and shifts towards high value, horticulture crops. Secondly, a techno-socio-economic review should be undertaken by an independent third party to compare on-field implementation with on-record design and to quantify impact on farm output and income. Thirdly, an annual survey of micro irrigation brands should assess farmers' experience with different brands; the results of this survey should be used to 'grade' different manufacturers and suppliers; performance-linked incentives and disincentives can be used to promote healthy competition. Fourth, an annual review of the LCMI market can assist KAMIC in taking proactive steps to support and encourage its growth and spread. Fifth, a biennial, qualitative and introspective review of micro irrigation dis-adoption can help KAMIC bring in useful amendments to its policies and procedures.

Training and capacity building activities are recommended at three levels. Firstly, at the farmer level to create awareness about the range of product and service options available, about regular repair and maintenance procedures, and about procedures for accessing micro irrigation subsidies. Secondly, at the level of field staff, retailers and dealers, capacity building activities on application procedures, after-sales service and advisory, and the importance of adoption clusters. Thirdly, capacity building of officials and industry leaders should focus on adoption and dis-adoption trends and drivers, exchange notes on common problems faced by suppliers, maximizing scale and scope economies, highlighting innovative practices, and discussing cross-sectoral inter-linkages and opportunities for co-leveraging.

It is our sincere hope that the demand-driven, low transaction cost subsidy delivery regime recommended in this report would assist in the transition of Karnataka's agriculture towards a trajectory of sustainable green growth that is both equitable and inclusive.

Footnote **1** Raman,S.2010.State-wise Micro-Irrigation Potential in India-An Assessment. Unpublished paper. Natural Resources Management Institute, Mumbai.

Note References to micro irrigation in the report are in the context of drip irrigation, unless otherwise specified.

1 Background

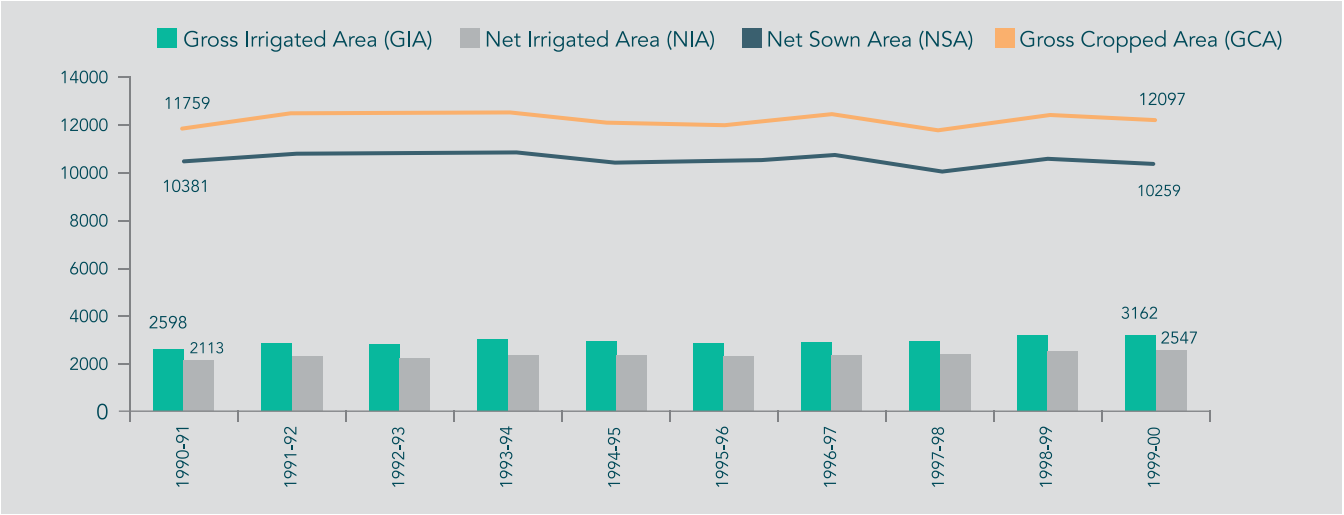
1.1 Agriculture and Water Resources in Karnataka

As per the 2010-11 agricultural census, Karnataka's cultivable area is 12.2 mHa of which nearly 10 mHa was cultivated and 3.4 mHa was irrigated in 2011-12 (GoK 2015). Figure 1 depicts the trends in net sown area (NSA), gross Cropped area (GCA) and net irrigated area (NIA) between 1990-91 and 2009-10. Over the two decades, the net sown area has increased marginally while the net and gross irrigated area has increased substantially.

As of 2010, Karnataka has nearly 1.1 million irrigation wells irrigating approximately 51 per cent (1.8 mHa) of net irrigated area. About 4.8 billion cubic meters (BCM) of surface water i.e., 78 per cent of the total volume of water, irrigates 50 per cent of the irrigated area, while 1.4 BCM of groundwater irrigates the remaining 50 per cent irrigated area. In terms of renewable water resource availability, there exists a gap of 0.18 mHa in general (surface and groundwater together) and 0.78 mHa in the case of groundwater. If this trend of continues, the groundwater depletion problem will become more severe; affecting agricultural development. Hence, improved water use efficiency is essential for sustained agrarian growth and prosperity in Karnataka.

Development of irrigated area by source is presented in Figure 2. Around the turn of the millennium, groundwater irrigation overtook canal irrigation in Karnataka and has been growing rapidly ever since. In 1995-96, the area under surface irrigation (canal and tank irrigation combined) was 1.2 mHa; this increased marginally to 1.3 mHa by 2012-13. Groundwater irrigated area, on the other hand, has increased from 0.8 mHa to 1.7 mHa over the same time period.

Figure 1 Net Sown Area (NSA); Gross Cropped Area (GCA); Gross Irrigated Area (GIA); and Net Irrigated Area (NIA) in Karnataka, 1990-1991 to 1999-2000



Cumulative interference among irrigation wells has resulted in the decline in water tables, initial and premature failure of wells and increase in irrigation costs (Chandrakanth et al. 2004, Manjunatha et al. 2011). World Bank (2010) has shown that the water table in Indian hard-rock regions is falling at a rate of 2-6 meters per year. The persistent groundwater overdraft and inadequate recharge efforts have threatened the livelihood of millions of farmers, especially in hard-rock areas of peninsular India. The depletion of groundwater has impacted resource-poor farmers as 32 per cent of the irrigated area is operated by small and marginal farmers, owning 73 per cent of the irrigation wells. Further, groundwater depletion also adds to the large farm power subsidy burden of the state. All these reinforce the need to adopt technologies and practices that can help farmers maximize farm incomes without increasing the pressure on water resources.

1.2 Micro Irrigation Spread, Benefits and Policies

Of the roughly 225 mHa irrigated area in the world, only a little over 11 mHa is micro irrigated as shown in Figure 3. Much of this lies in four main countries: India, Spain, China and the United States of America. Together, these countries represent nearly two-third of the world's micro-irrigated area. These countries, especially USA, also have significant sprinkler irrigated areas and are among the top five countries with respect to the adoption of planned irrigation technologies. Micro-irrigation technologies were initially developed to irrigate high value greenhouse crops and became commercially viable for field crops after the invention of inexpensive, weather-resistant polyethylene plastics post World War II (Wolff 1987; Roberts and Styles 1997; Postel, et al. 2001).

Figure 2 Irrigated area by source in Karnataka, 1995-96 to 2012-13

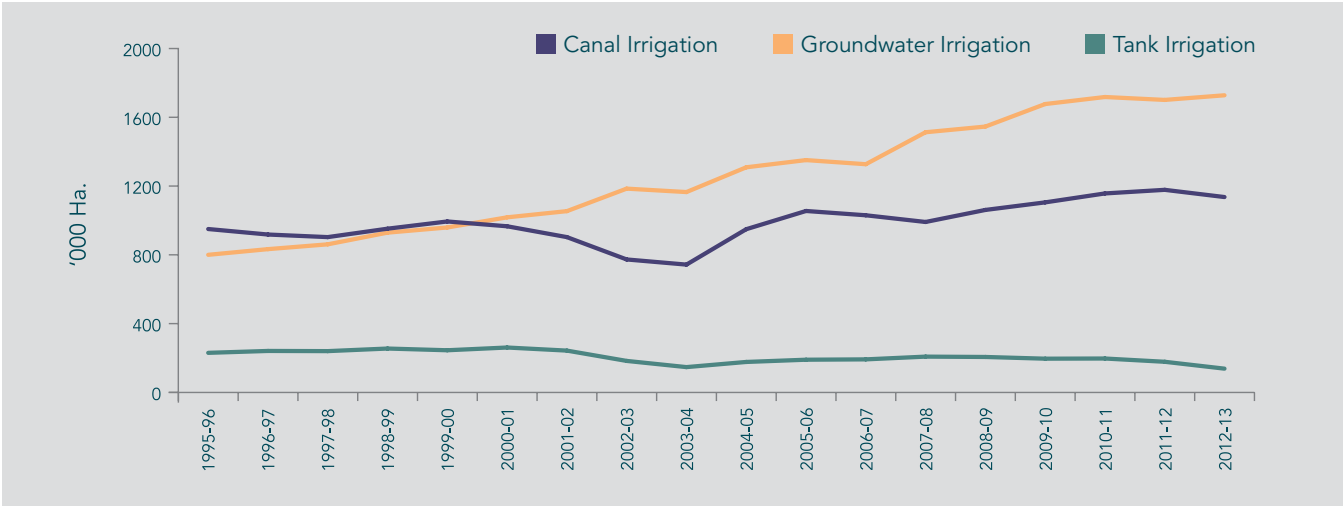
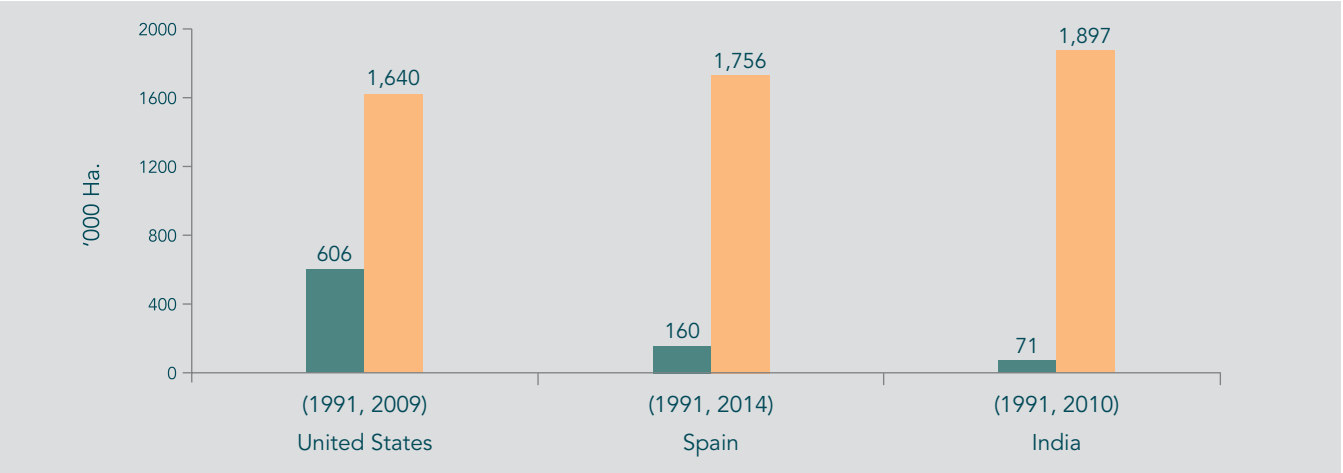


Figure 3 Growth in drip-irrigated area in USA, Spain and India



Source: INCID 1994; ICID 2015

Till 1991, drip irrigated area in India was only about 71,000 Ha (ICID 1994) but in the last two decades, the area under drip has grown to nearly 2 mHa, making India the largest drip irrigator in the world. More recent data from March 2015 suggests that drip irrigated area in India has further expanded to over 3.3 mHa. with Maharashtra, Andhra Pradesh, Gujarat and Karnataka being the leading states (Table 1).

Much of the early literature on the impact of micro-irrigation adoption in India focused on adoption impacts at the farm level. NCPA (1990) documents yield increase of 23 to 88 per cent and reduction in water applied between 36 and 68 per cent in various crops. Researchers and farmers have also reported significant reduction in cultivation costs as a result of micro-irrigation adoption, owing to reduced need for weeding under micro-

Table 1 Expansion of drip irrigated area in select Indian states, 2005 to 2015

STATES	DRIP IRRIGATED AREA (HA.)	
	31.03.2005	28.02.2015
Maharashtra	219,696	881,550
Andhra Pradesh (including Telangana in 2015)	111,407	849,968
Gujarat	16,686	423,771
Karnataka	114,304	393,172
Tamil Nadu	116,665	269,150
Rajasthan	10,025	181,943
Madhya Pradesh	6,483	161,897
All Other States/UTs	29,523	146,696
India	624,789	3,308,147

Source: 2005: Rajya Sabha Unstarred Q No. 20 (17.02.2006); 2015: Lok Sabha Unstarred Q No. 4528, (21.04.2015)

irrigation and savings in fertigation (INCID 1994, Singh and Jain 2003, Shah and Keller 2002). Other benefits attributed to adoption of micro-irrigation technologies include expansion in irrigated area (Shah and Keller 2002, Phansalkar and Verma 2008); improved nutrition (Phansalkar 2003, Shah and Keller 2002); improved land productivity (Verma et al. 2004, Oza et al. 2004), energy and labor saving. A review of benefit-cost ratio under different crops and agro-ecological conditions also points to positive results with the ratio ranging from 1.08 in coconut to 13.35 in grapes (Reddy and Reddy 1995, INCID 1994).

Given the significant positive impacts and favorable benefit-cost ratio, micro-irrigation was expected to take-off in a big way. However, the spread of micro-irrigation technologies in India was sluggish for nearly three decades since they were first introduced in the 1970s. Roughly since 2000, micro irrigation has been expanding at a relatively faster pace and crossed 3.3 mHa in 2010. The ultimate potential of drip irrigation in India has been variably estimated to be 7.93 mHa (Kumar et al. 2008), 18.20 mHa (NCPA 1990), 21.09 mHa (Narayanamoorthy 2008) and 27.00 mHa (Awasthy et al. 2014). Compared to these estimates, the actual area under drip irrigation is quite small. A major reason for slow adoption has been the high capital cost of acquisition. Since the early 1980's, the government of India has been offering subsidies for adoption of micro-irrigation technologies. Between 1982-83 and 1991-92, nearly Rs. 120 million was released to different state governments under centrally-sponsored schemes (Narayanamoorthy and Deshpande 1997, Narayanamoorthy and Deshpande 1998).

The government of India constituted a National Task Force on Micro Irrigation in 2004 with the objective to "emphasize on all aspects of water conservation and to improve the water use efficiency to achieve More Crop Per Drop" (NCPAH nd). In June 2010, the National Mission on Micro Irrigation (NMMI) was launched with an outlay of Rs. 8,032.90 crores to bring an additional 2.85 mHa under micro-irrigation. The mission aims to: [a] increase area under micro-irrigation; [b] enhance water use efficiency; [c] increase crop productivity and farmers' income; [d] establish convergence among government programs; [e] promote, develop and disseminate micro-irrigation technology with modern scientific knowledge; and [f] create employment opportunities, especially for youth (GoI 2010).

This year, the government of Indi has formulated a new scheme, National Mission for Sustainable Agriculture (NMSA), designed by converging, consolidating and subsuming all ongoing as well as newly proposed activities /programs related to sustainable agriculture with a special emphasis on soil and water conservation and water use efficiency, soil health management and rain fed area development. The existing NMMI scheme implemented up to 2013-14 has thus been subsumed in to NMSA from 2014-15.

1.3 Current Status of Micro Irrigation in Karnataka

According to Raman (2010), an area of 0.41 mHa was under micro irrigation in Karnataka at the end of 2009-10. As per the records of Department of Agriculture and Department of Horticulture, a cumulative area of 0.94 mHa has been brought under micro irrigation in Karnataka since 1991-92. The area covered under MI after the launch of NMMI i.e. from 2005-06 to 2013-14 was 0.67 mHa. The implementing departments provided the district-wise and year-wise break-up of area brought under MI by them for the last five to eight years.

Discussions with implementing agencies and manufacturers suggest that MI equipment typically lasts for about eight years, subject to the following conditions: first, the farmers must purchase their equipment from reputed companies and second, the equipment is properly maintained by the farmers. However, it has been noted that quality of equipment in the market is highly variable. The plastic above ground lines of surface irrigation systems have been known to break down (or become brittle) under high temperatures. Thus, a conservative estimate of life of MI equipment would be five years.

We have therefore assumed that the area considered as covered under micro irrigation five years back would return to potential area. Thus, data pertaining to micro irrigated area in Karnataka was collected for five years starting from 2009-10 to 2013-14; we refer to this as the reference period for estimating micro irrigation potential. All implementing departments provided year-wise and district-wise area brought under MI and expenditure incurred during the reference period.

The total area covered during the reference period was 0.45 mHa and the corresponding expenditure incurred

was Rs. 1197.74 crores. This means that as of 2013-14, only 10.9 per cent of the gross irrigated area (GIA) and 13.5 per cent of the net irrigated area (NIA) is currently under micro-irrigation. The highest penetration of micro irrigation technologies, not surprisingly, is in Kolar district where 46.9 per cent of the GIA and 64.6 per cent of the NIA is covered under micro irrigation. Other notable districts with significant coverage include Chitradurga and Bidar; districts with negligible MI coverage include Kodagu, Dakshina Kannada, Udupi and Mandya.

During the reference period, the agriculture department covered around 63 per cent of the total area brought under MI; accounting for 43 per cent of the total expenditure. During the same period, the horticultural department covered 37 per cent of the area and incurred 57 per cent of the expenditure. This variation exists largely because the agriculture department provides sprinkler subsidies (which are relatively cheaper) while the horticulture department mainly provides drip subsidies. The average cost is therefore lower for the agriculture department (approx. Rs. 18,000 per Ha.) vis-à-vis the horticulture department (approx. Rs. 41,000 per Ha.) The overall cost per ha worked out to around Rs. 27,000 per Ha. The analyses and inferences are limited to estimation of micro irrigation potential in irrigated areas of Karnataka at state and district-levels. Estimates of micro irrigation potential with dryland area could be significantly higher.

As per these estimates, 2.1 mHa of net irrigated area can be brought under micro irrigation in Karnataka. Since paddy is mostly grown under flooded conditions, we have estimated this potential without considering paddy area. However, some paddy farmers still adopt micro irrigation for crops grown on the same land parcel in other seasons. Further, recent experiments with drip irrigated paddy cultivation in Tamilnadu (Balasubramaniyan 2013, Times of India 2013, Udasin 2014), Rajasthan (Business Today 2013) and Andhra Pradesh (Business Standard 2010) might render these assumptions obsolete. If so, the potential for micro irrigation in Karnataka will expand to 2.9 mHa. of net irrigated area.

Thus, from a current estimate of less than 1 mHa, Karnataka is a long way from its estimated micro-irrigation potential of 2.1 to 2.9 mHa of net irrigated area. As the area under irrigated high value crops increases and advancements in micro irrigation technologies make it possible to use them with field crops such as paddy, the potential for micro irrigation is only going to expand. The new micro

1.4 Understanding Farmers' Demand For Micro-Irrigation Technologies

irrigation promotion policy has a lot of catching up to do. The high capital cost of micro-irrigation has been cited as the key reason for its slow spread and adoption, especially among small farmers. For a long time, micro-irrigation technologies were viewed as being suitable only for "gentlemen farmers" (Shah and Keller 2002). Of late, though, there have been several efforts by micro-irrigation manufacturers, government programs as well as civil society organizations to reach the benefits of these technologies to poor, smallholder farmers. Several micro-irrigation manufacturers have developed affordable variants of micro-irrigation which are more suited to smaller land parcels; government departments have aggressively promoted micro-irrigation through capital subsidies; and NGOs have used donor money to improve access. However, not all farmers have responded enthusiastically to the technology and the scale of adoption continues to be small.

If we look at the Indian experience, adoption of micro-irrigation technologies seems to have happened in clusters. We find clusters where large numbers of farmers have taken to micro irrigation technologies interspersed by areas with hardly any adoption. Large-scale adoption can be seen, for instance, in Nasik-Jalgaon-Aurangabad region in Maharashtra, Indore-Khargone-Khandwa region of Madhya Pradesh, Coorg and Kolar-Chikkabalapur regions in Karnataka, Junagadh-Rajkot in Gujarat etc. Further, while most government and non-government programs have "marketed" micro-irrigation technologies as "water-saving" technologies, farmers have taken to micro-irrigation for various reasons. We discuss a few here:

Expanding Irrigated Area

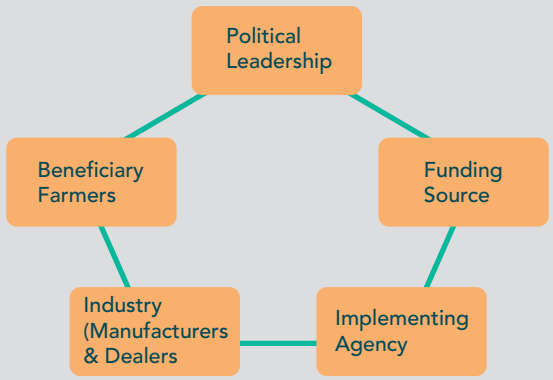
Under conditions of water stress, farmers often are forced into rainfed cultivation or are able to irrigate only a part of their land holding with flood / furrow irrigation. Adoption of micro-irrigation technologies helps farmers take up irrigated cultivation or expand irrigated area. This is perhaps the most dramatic and most visible impact of micro-irrigation

Micro irrigation promotion in Karnataka

Broadly, there are five key stakeholders in the implementation of state-level micro-irrigation promotion

programs: [a] political leadership; [b] funding source; [c] implementing / nodal agency; [d] industry – manufacturers and dealers; and [e] beneficiary farmers. Of these, the role of the implementing / nodal agency is critical. At present,

Figure 4 Key stakeholders in micro-irrigation promotion programs



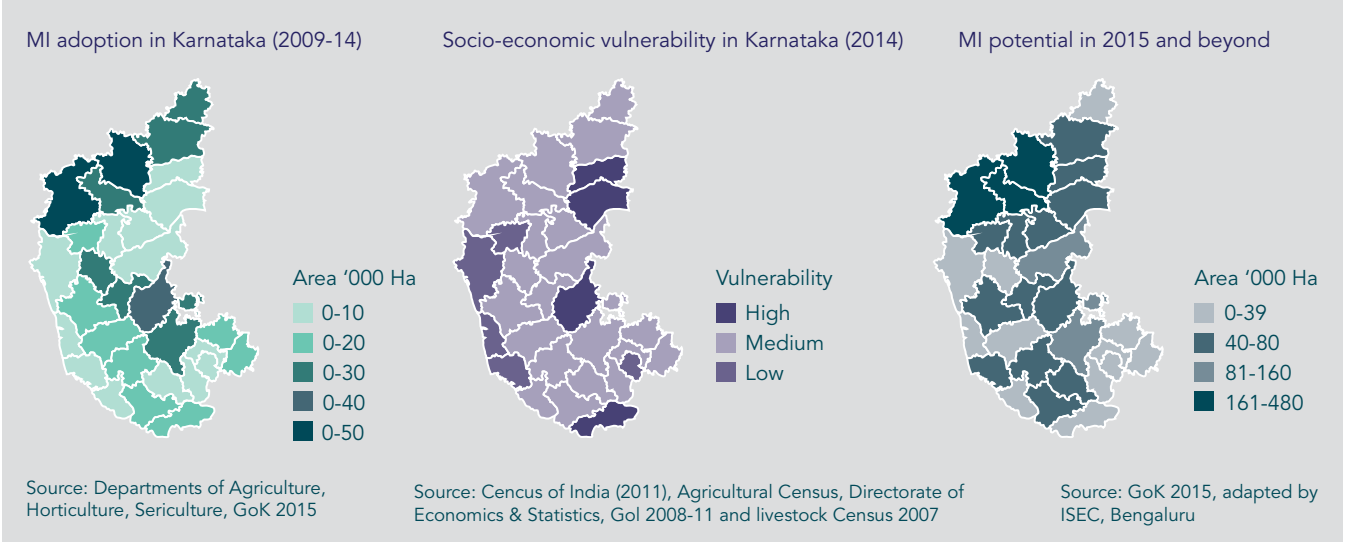
micro-irrigation promotion programs are implemented by several line departments in the Government of Karnataka. The two main departments that implement micro-irrigation subsidy programs are horticulture and agriculture.

The horticulture department primarily caters to the demand for drip irrigation among horticulture farmers while the agriculture department primarily caters to demand for sprinkler irrigation systems used in the cultivation of row crops. Similarly, a few other departments such as sericulture and water resources have their own subsidy programs for micro irrigation, albeit at a smaller scale. In general, there is an 80 per cent subsidy available on drip irrigation for 'General Category' beneficiaries and 90 per cent subsidy for 'SC/ST' beneficiary farmers. In addition, there have been several announcements and media reports regarding support for adoption of micro irrigation technologies in Karnataka.

More recently, in Sep. 2013, speaking at the inauguration of the 'Krishi Mela 2013' at University of Agricultural Sciences, Dharwad, the Karnataka CM Siddaramaiah announced a 90 per cent subsidy on drip (with no discrimination for small and large farmers), citing the harm caused by excessive use of water and chemical fertilizers to the soils in north Karnataka (Murdeshwar 2013). An article from November 2014 mentions the decision to offer 33 to 50 per cent subsidy for drip to sugarcane farmers from the Ministry of Water Resources.

Government statistics provided by the departments of agriculture and horticulture indicate that there are opportunities to expand and upscale the adoption of micro irrigation in socio-economically vulnerable districts of the state. In a comprehensive assessment of agricultural and socio-economic vulnerability of Karnataka, undertaken by IISC, IIT-Delhi and ISEC as a part of the green growth analyses, Raichur, Yadgir and Koppal were identified as highly vulnerable districts. Boosting agricultural livelihoods in these districts can create ripple effects in other sectors of the economy.

Figure 5 Micro irrigation adoption and potential for inclusive development in Karnataka



Source: Departments of Agriculture, Horticulture, Sericulture, GoK 2015

Source: Cencus of India (2011), Agricultural Census, Directorate of Economics & Statistics, GoI 2008-11 and livestock Census 2007

Source: GoK 2015, adapted by ISEC, Bengaluru

2 Institutional Landscape

The government of India's National Mission on Micro Irrigation (NMMI) provides a broad framework for promotion of micro-irrigation technologies all over the country. Each state has followed a different institutional framework for micro irrigation promotion. Maharashtra has been the traditional leader in terms of micro-irrigation area coverage. However, over the past decade or so, Gujarat and Andhra Pradesh have expanded area under micro-irrigation at the fastest pace. This success has largely been attributed to the innovative institutional mechanisms adopted by these states in the form of Gujarat Green Revolution Company (GGRC) and Andhra Pradesh Micro Irrigation Project (APMIP) (Pullabhotla et al. 2012). In this section, we review the institutional models of GGRC and APMIP with that in Karnataka to draw policy lessons for the state.

2.1 GGRC Model

The Gujarat Green Revolution Company Ltd. (GGRC) was incorporated in 2005 as a special purpose vehicle (SPV) for implementing the micro irrigation scheme in the state of Gujarat. GGRC is jointly promoted by Gujarat State Chemicals and Fertilizers Ltd. (GSFC), Gujarat Narmada Valley Fertilizers Co. Ltd. (GNFC) and Gujarat Agro Industries Corporation Ltd. (GAIC). It acts as the "single-window clearance" mechanism for all matters pertaining to micro irrigation in Gujarat. Using the 40% central subsidy under NMMI, GGRC offers 60-85% subsidy and does not enforce any limits on the scale of adoption. The subsidy support is higher for small and marginal farmers and for SC/ST farmers; there is also preferential support for groundwater dark zone blocks (see Table 2). It should be noted here that the subsidy support offered by GGRC to medium and large farmers belonging to 'General' category was 50% or Rs. 60,000 per ha. till recently and has recently been increased to 60%.

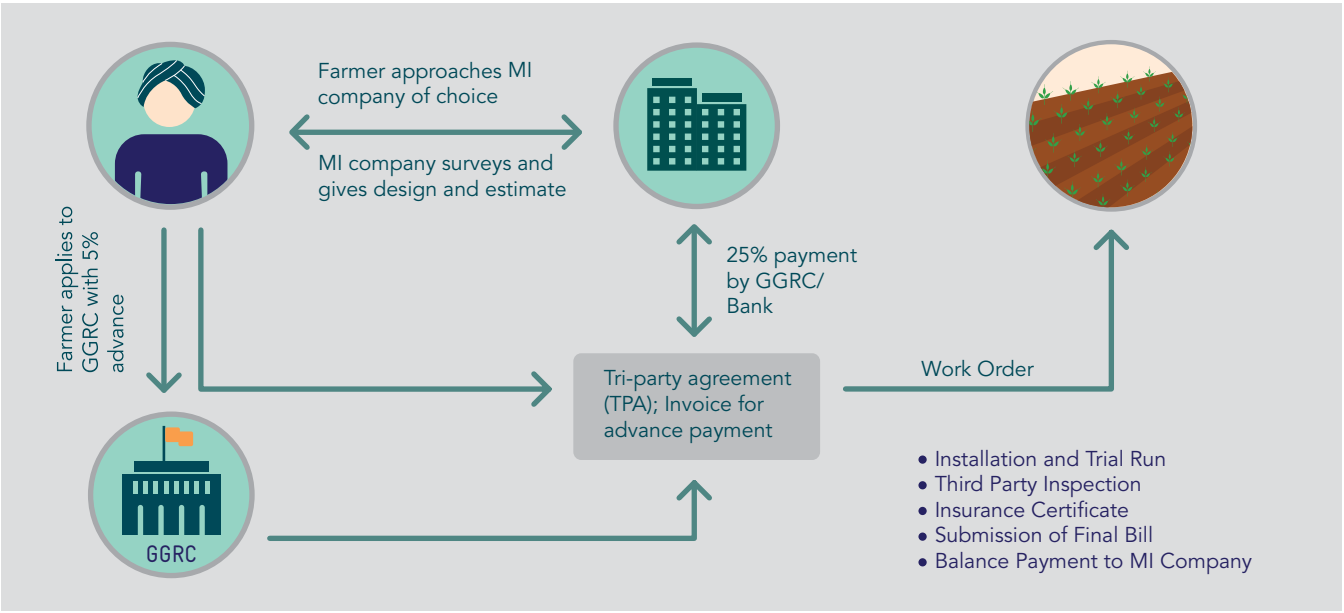
Figure 5 explains the process of micro irrigation subsidy delivery in Gujarat. The farmer approaches a micro irrigation company of his/her choice indicating interest in adoption. The company conducts a technical survey on the farmers' field and provides the farmer with appropriate design and cost estimate. The farmer then applies to GGRC for subsidy along with 5% advance payment. The GGRC, on receipt of application, initiates a tripartite agreement (TPA) between the farmer, GGRC and the micro irrigation company. Once the agreement is signed, GGRC makes 25% advance payment to the company and releases the work order. On completion of installation and trial run, a third-party inspection is undertaken and insurance certificate

Table 2 Subsidy norms for micro-irrigation scheme in Gujarat

FARMER CATEGORY	DARK ZONE TULAKAS	OTHER TULAKAS
General, Small and Marginal farmers (<2 Ha.)	Up to 70% of unit cost or Rs. 70,000 per hectare, whichever is less	Up to 60% of unit cost or Rs. 70,000 per hectare, whichever is less
General, Medium and Large farmers (>2 Ha.)	Up to 60% of unit cost or Rs. 60,000 per hectare, whichever is less	Up to 50% of unit cost or Rs. 60,000 per hectare, whichever is less
SC/ST farmers	Up to 85% of unit cost or Rs. 90,000 per hectare, whichever is less	Up to 75% of unit cost or Rs. 90,000 per hectare, whichever is less

Source: GGRC (2015a)

Figure 6 The GGRC model of micro irrigation subsidy delivery



is issued before submission of final bill to GGRC. At this point, the remaining payment is released (Pullabhotla et al. 2012). The company is required, as per the TPA to provide one-year agronomical services and five-year system maintenance services to the farmer. As of November 2015, 66 micro-irrigation companies have been notified as certified suppliers (GGRC 2015b).

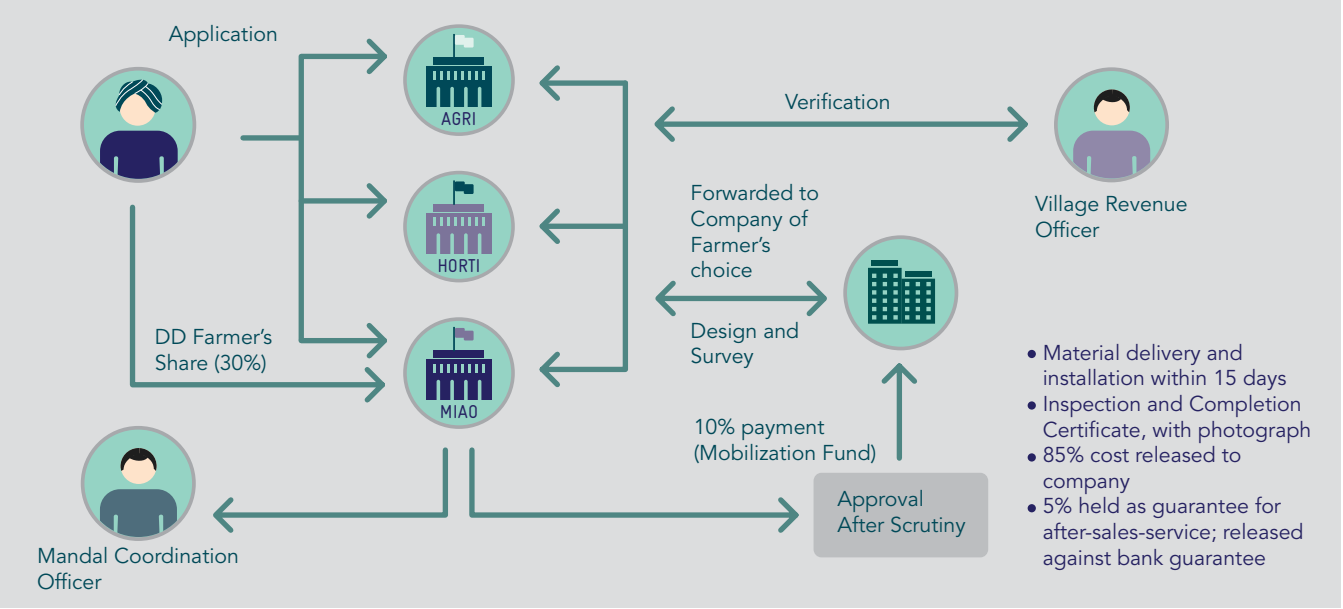
2.2 APMIP Model

The Andhra Pradesh Micro Irrigation Project (APMIP) was launched in November 2003 with the objective of "improving the economic conditions of the farmers by conserving water, bringing additional area into cultivation with the available water resources, enhancing the crop productivity and production, quality, facilitating judicious usage of ground water, saving in power consumption and cost of cultivation" (APMIP 2015a). Although APMIP operates as part of the horticulture department, it acts as the nodal agency for all micro-irrigation subsidy programs in the state. The subsidy offered for medium and large farmers is 50% or Rs. 2,00,000 per family, whichever is less; additional subsidy is offered to SC/ST and small and marginal farmers; no subsidy is offered for land holdings above 5 Ha. Further, each family can only avail the subsidy once for the same parcel of land.

Table 3 Subsidy norms for micro-irrigation scheme in AP

FARMER CATEGORY	ANANTHAPUR & CHITOOR DISTRICTS			ALL OTHER DISTRICTS		
	Subsidy	Area Cap	Amt Cap	Subsidy	Area Cap	Amt Cap
SC/ST, Small and Marginal farmers(< 2 Ha.)	100%	2 Ha.	Rs. 1 Lakh	100%	2 Ha.	Rs. 1 Lakh
General, Small and Marginal farmers(< 2 Ha.)	90%	4 Ha.	Rs. 1 Lakh	70%	2 Ha.	Rs. 1 Lakh
Medium and Large farmers (2 – 5 Ha.)	50%	5 Ha.	Rs. 2 Lakh	50%	5 Ha.	Rs. 2 Lakh

Figure 7 The APMIP model of micro irrigation subsidy delivery



Source: APMIP (2015b)

Figure 7 illustrates the process of subsidy delivery under APMIP. Unlike in the case of Gujarat where all applications are cleared by GGRC, the process of applications and approvals is delegated to APMIP Project Directors or the District Water Management Authority in each district. Farmers submit their application to the local Micro Irrigation Area Officer (MIAO) or the local agriculture/ horticulture officer. The application is sent to the village revenue officer and returns to MIAO after land title verification. Next, the company of farmers' choice is forwarded the application for survey and design preparation. After the survey, the application is sent to the Mandal coordination office (MCO) and the MIAO informs the farmer about how much s/he has to pay. The farmer then submits a demand draft of 30% of his share which is forwarded for scrutiny and sanction at the district office. Upon sanction, 10% of the total cost is released to the company as 'mobilization fund' and the company is expected to complete material delivery and installation within 15 days. After successful installation, MCO conducts an inspection and issues a completion certificate along with photograph after which 85% of the total payment is released to the company. 5% of the total cost is retained as guarantee for providing after-sales service to farmers; this is released if the company provides bank guarantee (Pullabhotla et al. 2012).

2.3 Comparing Institutional Models

Table 4 provides a comparison of the Gujarat and Andhra Pradesh institutional frameworks with the current micro irrigation institutional landscape in Karnataka. There are several aspects of subsidy delivery mechanisms and institutional landscape that Karnataka can adopt based on the experience in Gujarat and Andhra Pradesh.

Table 4 Comparison of institutional framework for micro-irrigation promotion in Gujarat, Andhra Pradesh and Karnataka

PARAMETER	GUJARAT	ANDHRA PRADESH	KARNATAKA	REMARKS
Implementing Agency	GGRC	APMIP	Line Departments: Agriculture, Horticulture, Sericulture etc.	Little or no coordination between line departments in Karnataka; each designing own schemes and policies
Funding Source	Government of Gujarat; Government of India	Government of AP; Government of India [+NABARD assistance]	Government of Karnataka; Government of India	Few, if any, delays in release of subsidy in Gujarat and AP; long delays in Karnataka – Limited financial resources
Subsidy Model	Per unit area, per farmer	Per family	Per unit area	Farmers try to bypass limits imposed by APMIP by fudging land records; similar practice likely popular in Karnataka with the better-off farmers cornering bulk of the subsidy
Extent of subsidy	50-85% with per Rs/Ha cap; no ceiling on area coverage	50-100% with Rs/Ha and per family caps; maximum 5 Ha.	80-90% subsidy with no Rs/Ha cap; district-wise quotas & ceilings; maximum 5 Ha.	GGRC model most amenable to rapid, demand-driven growth
Flow of Funds	Funds deposited with GGRC on annual basis for disbursal	Funds allocated according to district quotas and company-wise targets set centrally	Unclear and ad-hoc funds flow in different line departments	GGRC model seems most suited for 'demand-driven' funds flow; APMIP quotas arbitrarily set; in Karnataka, mismatch between demand and funds availability hampers expansion

PARAMETER	GUJARAT	ANDHRA PRADESH	KARNATAKA	REMARKS
First 'Point of Contact'	Dealers / Manufacturers	MIAO / Line Department	Line Department	GGRC model successfully shifts the burden of micro-irrigation 'marketing' to companies; in APMIP, quota system ensures that companies fight for quota-share rather than market-share
Completion time; Delays in installation and payment	Detailed work-flow charts stipulate maximum time for each step in application processing	Detailed work-flow charts stipulate maximum time for each step in application processing	No clear norms on time taken for each step	Instances of variable performance reported in both Gujarat and AP; in Karnataka, delays in payments have forced companies to discontinue installation
Autonomy	Semi- autonomous corporation (GGRC) with strong financial support	APMIP works under Horticulture department	None yet; KAMIC proposed as new coordinating agency	Decision making on operational issues faster in GGRC; APMIP suffers some administrative delays; long delays in Karnataka
Organizational Structure	Centralized; single-window operations	Decentralized; district offices carry out key functions	Multi-centric and decentralized	APMIP facilitates easier handling of large volume of applications and smoothens monitoring and field inspection; GGRC implements third party monitoring; monitoring almost completely missing in Karnataka
Subsidy: Regulated or Unregulated	Unregulated; no quotas for drips / sprinklers or for MI companies	Yearly quotas fixed; MI companies allotted geographical domains	Limited subsidy available; district-wise fund released on unclear basis	APMIP quota systems cripples competition and distorts the MI market; in Karnataka, sluggishness in subsidy release suppresses demand
Administration and Processing	Streamlined; uniform procedures	Variation between districts; ambiguous chain of command	Varies from district to district; central processing variable / sluggish	Administrative overlaps and non-uniformity of processes creates bottlenecks in AP and Karnataka

PARAMETER	GUJARAT	ANDHRA PRADESH	KARNATAKA	REMARKS
Transparency	Online tracking of application status	Toll-free number for enquiries about application status	Unclear selection of beneficiaries and allocation of subsidies	Process of fixing quotas in APMIP and in Karnataka can be fine-tuned; process of fund releases not transparent in Gujarat
Marketing Strategies	Farmer networks; perceived quality of service	Dealer networks; perceived quality of service	Line depts. don't have capacity for marketing; limited marketing through dealers / manufacturers	Unit costs of MI systems standardized; price differentiation not possible in any state. Kolar, for instance, is an exception; farmers can choose from a range of prices and material quality.
Provision of post-installation services	One-year agronomic services; 5-year system maintenance services	5% payment retained as guarantee for providing after-sales services to farmers	No clear-cut after-sales obligations for micro irrigation suppliers	Emphasis on services in GGRC and APMIP; performance variable in all three states
Quality of Service	Emphasized but variable; despite the threat of de-registration; due to poor farmer awareness	Emphasized but variable; despite the threat of de-registration due to poor farmer awareness	Competitive 'non-subsidy' market in Kolar; Highly variable service elsewhere; adoption sporadic	GGRC monitoring and field inspection out-sourced; often inadequate or not stringent; Karnataka, quality of service is farmers' risk.

Source: Adapted from Pullabhotla et al. (2012)

3 Karnataka's New MI Promotion Policy

Analysis of the current status indicates a strong growth potential for MI in the state; we also noted that while most promotion programs in India have positioned micro irrigation technologies as 'water saving' technologies, farmers also adopt micro irrigation for several other reasons – pertaining to cost reduction or revenue maximization, or both. We also discussed in detail how the institutional landscape for micro irrigation promotion in Karnataka is different from that in Gujarat and Andhra Pradesh – two states that have made impressive progress in expanding area under micro irrigation over the past decade.

With its progressive policies, Karnataka has decided to renew its efforts for micro irrigation promotion through the implementation of a new, improved micro irrigation policy. In this section, we aim to discuss the main tenets of the new policy and how Karnataka could uptake the good practices from Gujarat and Andhra Pradesh to create for itself the "best-of-both-worlds" institutional landscape and micro irrigation subsidy delivery mechanisms.

3.1 Paradigm Shift: 'Water saving' To 'Income Enhancing' Technologies

As a long-term objective, savings in water consumption promises a social good that will benefit not only the farmers but also the non-adopters, domestic water consumers as well as future generations. However, there are two significant kinks in the 'water saving' logic to micro irrigation promotion.

While several studies have noted emphatic reduction in per unit water application as a result of micro irrigation adoption, the jury is out on whether the adoption of micro irrigation technologies really leads to real water savings at the river basin and regional scales. Several field studies in India and elsewhere have reported that adoption of micro irrigation technologies is accompanied by expansion of irrigated area, increase in crop yield, shift to water intensive crops and greater cropping and irrigation intensities. Micro irrigation adoption also allows farmers to cultivate crops that would not have been possible without the technology – pre-monsoon sowing of cotton in Madhya Pradesh and Saurashtra are examples. Even in cases where micro irrigation adopters do not expand their irrigated area and actually draw less water from groundwater aquifers, the so-called "saved" water might be pumped up by their neighbors to expand irrigated area or enhance cropping and irrigation intensity. This means that while 'water use efficiency' improves, overall 'water consumption' might actually increase. This counter-intuitive thesis is also referred to as Jevons' Paradox[1] , named after British economist William Stanley Jevons. Similar results have been reported in California (Walton 2014), Kansas (Pfeiffer and Lin 2013), New Mexico (Ward and Pulido-Velazquez 2008, INTERA 2013), Spain (Gómez and Gutiérrez 2011), and elsewhere. So far, there is no indication that the results would be any different in India. Second, even if we assume that adoption of micro irrigation technologies does "save water", there might be institutional hurdles to adoption. Groundwater is a shared and a classic Common Pool Resource (CPR). Savings made by one user may benefit another user; thus while the benefits are 'social' or 'public', the costs of adoption are 'private'. Farmers, especially poor farmers, are unlikely to invest their scarce private surplus into technologies that only offer public returns. It is therefore advisable to promote private benefits of micro irrigation technologies such as input savings (reduced expenditure on labor, fertilizers and energy) or output enhancing (improved crop yield, better quality of produce).

We therefore propose a paradigm shift in the positioning of micro irrigation technologies in the minds of farmers: from 'water saving' technologies to 'income enhancing' technologies. We believe that farmers are more likely to respond positively to technologies that promise them tangibly higher income rather than an offer of theoretical and diffused water saving.

3.2 Competitive Micro Irrigation Markets

Capital subsidies on micro irrigation have been around for several decades. Today, more than 90% of micro irrigation purchases in India are done with capital subsidy. Malik and Rathore (2011) enumerate some of the harmful impacts of such a pervasive subsidy regime on the micro irrigation market. They argue that rather than fiercely competing with one another to convince farmers (end-users) about their products, the regime has created an environment where manufacturers and suppliers invest bulk of their 'marketing' efforts on cornering a greater share in the subsidy-pie. While the massive subsidies announced by the central and state governments do help expand the reach of these capital intensive technologies, they also stifle the market as annual revenues are driven more by subsidy allocations than by market demand. Such a regime also stifles the entrepreneurial spirit of the market and impedes innovations in product design and costs. Insistence of subsidy programs on product standardization as a pre-condition for becoming a listed supplier also discourages incremental improvements in product design and delivery to better match context specific user requirements.

Despite greater adoption in recent years, most states in India have witnessed rising unit costs of micro irrigation technologies. This trend indicates perverse market structures and the presence of disincentives since the unit cost of producing, selling and servicing a micro-irrigation system should fall as market penetration and adoption intensity increases. One way to reverse these disincentives is to remove, or reduce, entry barriers. Another path to more competitive markets is direct delivery of subsidies to end-users (farmers). This is partly achieved under the subsidy delivery mechanisms adopted in the GGRC model where the 'marketing' function has been rightly restored to suppliers rather than line departments. From 29 companies enlisted in 2011-12, GGRC has expanded the list of certified micro irrigation suppliers to 66 in 2015-16; GGRC also does not impose district-wise or company-wise quotas and allows the farmers abundant flexibility in their choice of suppliers. Both GGRC and APMIP also have stringent provisions for blacklisting companies that are found wanting in terms of product quality and service delivery (Pullabhotla et al. 2012) although these provisions are rarely exercised.

The new micro irrigation policy in Karnataka should embrace these positive features. In addition, the state should create provisions for rewarding innovations in design that help meet user requirements at lower costs; product reliability and longevity; and high quality after-sales service delivery.

3.3 Low-Cost MI Technologies As 'Stepping Stones'

Conventionally, micro irrigation technologies are viewed as capital investments which require high upfront expenditure but offer benefits over the next 5-7 years. Because these technologies are designed to offer service for a longer time period, they require capital subsidy support from the state to encourage adoption, especially among poor farmers. Likewise, because the equipment is expected to last longer, it is expected to be of high quality, meeting several quality standards set by the promoting agencies and, in our case, the Bureau of Indian Standards (BIS). An alternate approach to micro irrigation technology promotion is through low-cost micro irrigation (LCMI) technologies. Typically, LCMIs combine market ingenuity with lower-grade plastics and materials to bring down the costs of micro irrigation technologies by 50-80 per cent. On the flip side, LCMIs often do not last for more than a few cropping seasons and require fresh expenditure for continued use.

Examples of LCMIs abound, especially among drip irrigation technologies. International Development Enterprises, India (IDE-I) has introduced several low-cost

micro irrigation technologies in different states under its *Krishak Bandhu* brand[2]. Prominent micro irrigation players like *Jain Irrigation* and *Netafim* too have developed some low-cost variants. In Madhya Pradesh, for example, mired by recurring droughts and rapidly depleting groundwater resources, farmers started using old bicycle tubes in place of drip laterals. Eventually, *Pepsee* systems – a sub-$100 per acre variant of drip irrigation – emerged and quickly became popular among farmers in the region (Verma et al. 2004). With laterals made out of low grade plastic straw, pepsee allowed poor farmers to experiment with drip irrigation without committing significant capital. Several of the pepsee adopters eventually graduated to conventional drip irrigation systems but by the time they did, they had already benefitted from the technology and were better able to justify more significant investments. Such technologies, therefore, need to be viewed not as alternatives to conventional micro irrigation systems but as stepping stone technologies (ibid. p. 316) which help in improving access to and demystification of MI technologies.

Similar enthusiasm for low-cost drip irrigation technologies can be seen in and around Kolar town in Karnataka where the business of LCMIs is booming owing to the growing scarcity of water; rapidly declining groundwater tables; poor and erratic farm power supply; farmers' positive experience with LCMIs; and the wide range of quality and prices available in the market. While conventional drip laterals sell for around Rs. 12-14 per meter, the local market in Kolar offers options starting as low as Rs. 2.00 per meter. A recent field visit revealed that the cheapest drip pipes – Tape Drips – are available for Rs. 2.00-2.60 per meter; these are locally manufactured and usually do not last beyond one year. A slightly better variant – *Chennai Drip* – can cost up to Rs. 4.00-5.00 per meter; thicker plastic pipes believed to have originated in Tamilnadu. The *Pepsee* drip and its local variants sold under *Kaveri* and *Euro Drip* brand name cost around Rs. 6.00-8.00 per meter. Not surprisingly, most of these variants do not comply with BIS standards designated for subsidy support and are sold off-the-shelf; farmers purchase laterals, micro tubes and emitters of their choice and assemble their own custom drip kits. According to one local dealer, Kolar represents the most vibrant drip irrigation market in the country.

LCMIs thus play a crucial role in the development of micro irrigation technologies. At very low costs, they allow farmers to experiment with a new technology; they also encourage farmers to assemble their own drip kits, in the process demystifying the technology. More often than not, a farmer who has a positive experience with LCMIs eventually moves on to adopt conventional micro irrigation technologies. So, how can Karnataka's new micro irrigation promotion policy support the LCMI market? While it may be appealing to include LCMIs in the ambit of the capital subsidy regime, doing so would most likely spell doom for the thriving informal LCMI market. The best support the new policy can offer is to make these stepping stone technologies more accessible and to make farmers aware about their potential.

3.4 Institutional Framework To Minimize 'Transaction Costs'

A news report from February 2012 (Hindu 2012) outlines the government of Karnataka's plan for setting up an independent micro irrigation corporation. The 'Karnataka Antharaganga Micro Irrigation Corporation' (KAMIC) is proposed to be constituted as an apex body for "effective implementation, monitoring and evaluation of micro-irrigation systems which get subsidies from the Government". This seems in line with the GGRC model where the GGRC was set up as the nodal agency for all matters related to micro irrigation promotion in Gujarat. The report mentions that the Minister of Agriculture is proposed to be the ex-officio chairman of the corporation; with a 13-member management committee (Figure 7). The corporation will be expected to coordinate with all stakeholders; create awareness among farmers; develop a module for online processing of applications and reporting; register (approved) irrigation system manufacturers; and conduct third party evaluations. There have also been reports that the department of horticulture, government of Karnataka has appointed GGRC as a consultant to develop IT implementation modules for micro irrigation scheme implementation (GGRC 2015c).

We believe that all these are steps in the right direction. An independent and autonomous KAMIC, as proposed, would go a long way in delivering subsidies and rapidly expanding area under micro irrigation in Karnataka. The overall goal of KAMIC should be to minimize transaction costs for beneficiary farmers and micro irrigation suppliers in course of their participation in the micro irrigation promotion scheme. The KAMIC should operate

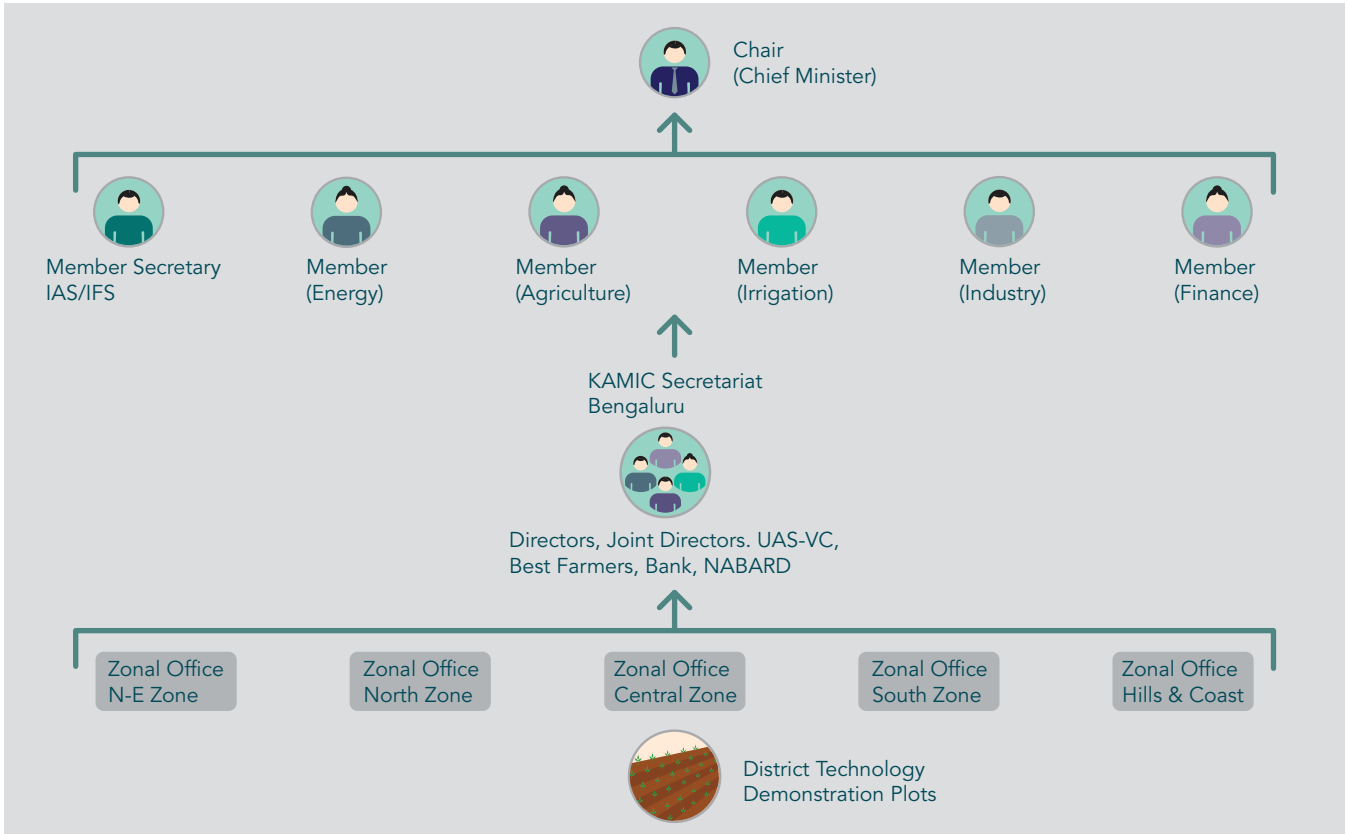
a lean secretariat in Bangalore (with the freedom to hire its own staff; not necessarily manned by staff deputed from horticulture or agriculture departments) with zonal offices in different agro-climatic zones. Depending on demand for micro irrigation technologies from districts, the KAMIC may also set up field labs / demonstration sites in each district.

KAMIC governing board should be chaired preferably by the Chief Minister (or a senior cabinet minister, such as the Finance Minister) to demonstrate political support and ensure generous and seamless access to financial resources. The board may induct representation from other ministries and line departments (horticulture, agriculture, irrigation, sericulture, energy, rural development) and invite representation from among farmers, practitioners from micro irrigation industry, academia and financial institutions such as the National Bank for Agriculture and Rural Development (NABARD) (Figure 7)

As in the case of GGRC, the state government should deposit the annual central and state subsidies and area expansion targets with KAMIC. KAMIC should not only act as the single-window clearing agency for micro irrigation subsidies, over time it should also build into a knowledge institution that undertakes and coordinates monitoring and evaluation work, trainings and capacity building activities. It should also have the authority and flexibility to invest in "market development" for the low cost micro irrigation market.

The district-level demonstration sites may be financed through sponsorships and partnerships with key players in the micro-irrigation industry. However, each demonstration site should be mandated to demonstrate the entire range of micro irrigation technology options. The objective of these demonstration sites should be to expand the micro irrigation market, not for any particular player to corner a share of the existing market.

Figure 8 Proposed institutional framework for MI policy implementation



Footnote
1 *https://en.wikipedia.org/wiki/Jevons_paradox*
2 *http://www.ide-india.org/*

4 Leveraging Co-Benefits

As with any significant deviation in policy, the new micro irrigation policy will influence and will get influenced by the evolving policy environment in related sectors. In this section, we review convergence opportunities with existing schemes and policies that can contribute to and augment micro irrigation promotion. It is expected that the significant cross-sectoral experience proposed to be brought together in the Board of Governance of KAMIC will be able to guide it to benefit from new opportunities that will open up in the future. The board chair should have the powers to invite new members to the board in response to such new opportunities.

4.1 Energy-Water Nexus

The prominence of groundwater in Karnataka's agricultural economy and the need for energy to extract groundwater mean that the fates of the water, agriculture and power sectors are inevitably intertwined. Free or highly subsidized power supply to agriculture has been repeatedly blamed for groundwater overexploitation (Shah et al. 2004, Shah 2009) and the only way state governments have been able to control groundwater extraction has been rationing power supply to agriculture. This has resulted in deterioration in the power supply environment in rural India with daily power supply falling from 16-18 hours to 4-6 hours in some states. Karnataka is no exception and power supply in rural Karnataka is heavily rationed. In 2004-05, Gujarat implemented Jyotigram Yojana which re-wired rural feeders and separated agricultural from non-agricultural feeders. This enabled Gujarat to ensure 24*7 power supply to rural households and industries while effectively rationing power supply to agriculture (Shah and Verma 2008, Shah et al. 2008). Hailed as an overwhelming success, Jyotigram is now being replicated in several states, including in Karnataka under the Niranthara Jyothi scheme (BESCOM 2015).

If feeder separation is implemented as successfully in Karnataka as it was in Gujarat, it is likely to provide a fillip to micro irrigation adoption. One of the reasons attributed for farmers' tendency to over-irrigate is the unpredictability of power supply. When farm power supply is erratic and of poor supply, farmers pump groundwater whenever power is available irrespective of the water requirement of the crop. This is because they are unsure if and when they will be able to irrigate next. Effective rationing of power supply to agriculture, rigorous check on power theft and strict adherence to a pre-announced power supply schedule for farmers will incentivize farmers to adopt micro irrigation technologies.

Another promising development is Karnataka's smart new solar pump policy for farmers – Surya Raitha. Under this, farmers will be offered solar irrigation pumps, connected to the grid and offered an attractive feed-in-tariff for evacuating surplus solar power to the grid. If implemented well, this will incentivize farmers to use power and groundwater efficiently. By creating an opportunity cost for the solar power produced, grid-connected solar irrigation pumps (SIPs) will make it profitable for farmers to shift cropping patterns to high-value, micro-irrigation friendly crops as well as adopt practices and technologies that minimize water and energy use (Shah and Verma 2014, Shah et al. 2014). Encouraging a shift to grid-connected solar pumps – by, for instance, utilizing the Green Climate Fund to finance SIPs – would create strong market incentives for greater micro irrigation adoption.

4.2 Micro Irrigation In Canal Command

Irrigation in canal command areas is predominantly by gravity-flow; water is released and flows through the hierarchy of canals into farmers' fields by gravity. Further, since the canal systems are managed and operated by a government department, farmers have little or no control over water releases. This discourages farmers

from adopting micro irrigation technologies. In 1980's, farmer-level distribution system – mesqas (ditches that deliver water from the canal to farmer fields) – in Egypt were modified to force farmers to lift water instead of receiving it by gravity (Shah 2009). Several states including Rajasthan, Gujarat and Maharashtra are doing something similar. As part of Pressurized Irrigation Network Systems (PINS) project, canal command areas are being reconfigured to facilitate and promote adoption of micro irrigation technologies.

In 2014, the Krishna Bhagya Jal Nigam Ltd. (KBJNL) in Karnataka finalized contracts for a nearly 60,000 acre micro irrigation project in Hungund tauk of Bagalkot district under the 'Ramthal (Marol) II Stage Drip Irrigation Project' (Sastry 2014). KBJNL will work with *Netafim* and *Jain Irrigation* – two leading micro irrigation manufacturers – on a build-operate-maintain-transfer basis at a cost of Rs. 766.83 crores. Recent studies (Singh 2012, Chelumala and Wadhwa 2015) suggest lukewarm to moderate response from farmers to similarly ambitious investments in the Sardar Sarovar command area in Rajasthan where community ponds called diggis store canal water for distribution to famers of a water users association. At the same time, experiments with individual farm ponds in the Indira Gandhi canal have been more successful in stimulating farmer interest (Amarasinghe et al. 2008). Karnataka should carefully review the progress of PINS in states like Rajasthan to draw useful lessons for the Ramthal project.

4.3 Leveraging Value Chains And Development Programs

Opportunities for market-led micro irrigation promotion also exist in the value chains of high-value cash crops such as cotton. In the Maikaal region of Madhya Pradesh, an organic company called *bioRe* has been promoting drip irrigation among cotton farmers (Shah et al. 2005) since early 1990s. Likewise in Gujarat, the Aga Khan Rural Support Programme, India (AKRSP-I) has partnered with the C&A Foundation to promote drip irrigation among cotton farmers in Surendranagar district.

Where farmers are linked directly with niche markets (as in the case of organic cotton farmers in MP) or where companies put a high premium on product quality and standardization (as with Gherkin or Rose farmers in peri-urban Bangalore), micro irrigation can be promoted with support from the value chain. Just as sugar mills and cooperatives help farmers with skills and inputs to produce high quality cane, they can also be used as intermediaries to promote the adoption of micro irrigation technologies.

Karnataka's Krushi Bhagya scheme – launched with the objective of enhancing farm productivity through improved water management, irrigation facilities and agricultural practices – already incorporates drip irrigation along with lined farm ponds and irrigation pumps. Through the *Krishi Rishi* awards, Karnataka felicitates innovative and progressive farmers; making them role models for farmers across the state. The selected *Krishi Rishis* can be excellent ambassadors to propagate the benefits of micro irrigation adoption among potential beneficiary farmers.

5 Financing, Pricing and Subsidies

A supply-driven micro irrigation subsidy regime can create distortions and perverse incentives in the market. As Malik and Rathore (2011) have noted, excessive subsidies can suppress innovations in product design and create perverse incentives that keep unit costs inflated. The new micro irrigation policy in Karnataka should aim to circumvent these shortcomings by promoting demand-driven subsidy allocation and a constant effort to promote healthy competition in the micro irrigation market.

However, as adoption of micro irrigation increases, the servicing costs for manufacturers should decline. Maintaining a network of dealers, retailers and service providers is costlier when adopters are few and far between. However, with growing density of adoption, the fixed costs of these services get spread over a larger number of consumers leading to a fall in cost per hectare and cost per farmer.

On setting unit prices, the proposed KAMIC will have three broad options:

Borrow NMSA / GGRC unit pricing norms

The National Mission on Micro Irrigation (NMMI) released central subsidies for micro irrigation based on indicative cost estimates. The NMMI guidelines (GoI 2010) classify states into 'A', 'B' and 'C' categories depending on the total volume of demand, level of awareness, transportation distances, proximity to manufacturing units, density of the marketing network and the overall potential for micro irrigation. Karnataka is classified in 'A' category along with Andhra Pradesh, Gujarat, Madhya Pradesh, Maharashtra and Tamil Nadu. It is therefore estimated that the unit costs would be at least 15% lower in these states than in category 'B' states and 25% lower than category 'C' states (Himalayan region).

The actual prices differ from state to state and depend on the bidding or price determination processes undertaken by state implementing agencies. Both GGRC and APMIP have devised formulae to fix and periodically fix prices for different configurations of micro irrigation installations. The easiest, if not the best, option for KAMIC would be to adopt the prices in any one of the category 'A' states and enforce them in Karnataka.

Establish local prices based on transparent, competitive bidding

It is important to note that the price discovery in both Gujarat and AP does not depend on a demand-based price discovery process; it is based on supply side factors such as the costs of inputs and raw materials (Pullabhotla et al. 2012). These prices are revised periodically but do create some discomfort for both consumers and suppliers. The prices of inputs can be volatile in the short run while price revisions can take time. This implies suppliers have to adhere to standardized prices even in case of short term rise in input prices. On the consumer side, the down side is that once the prices are fixed, they leave little incentive for manufacturers to innovate on product design to reduce costs.

Another option for KAMIC could be to establish local prices based on a transparent process of competitive bidding. This would involve managing a complex process of price setting but will allow KAMIC to nudge suppliers into innovations that reduce unit costs over time.

Do not 'fix' unit prices, allow farmers and suppliers to negotiate, subject to price ceilings

If the KAMIC envisages taking up the role of 'industry regulator', it may exercise a third option. The KAMIC may set up price ceilings to ensure that farmers (and the state exchequer) get a fair deal but allow suppliers to compete with each other in negotiating the best price directly with the beneficiary farmers. In order to do this, KAMIC will have to ensure that prospective micro irrigation adopters

are well aware about the quality of products and services offered by different manufacturers. This can be done by conducting regular surveys of beneficiary farmers about their experience with specific brands and using the results of the survey to rank or grade the performance of different manufacturers. The results of such an exercise should be widely publicized and should be made available to prospective adopters so that they can make informed choices. Such a system would be the hallmark of a truly 'demand-driven' micro irrigation promotion regime.

5.1 Subsidy Calculator

A 2014 comprehensive impact evaluation study of NMMI (Global AgriSystem 2014) noted that "increase in subsidy component beyond a limit has little or no impact on area coverage under MI system". This is based on evidence gathered by the study on the level of capital subsidy and the associated levels of micro irrigation coverage. Therefore, there is no clear linkage between the level of subsidy offered by a state and the level of micro irrigation adoption. The study also concluded that "Presently subsidy is limited to maximum area of 5 hectare per beneficiaries which is an impediment to the growth of area under micro-irrigation. The data on size and distribution of operational land holdings in the country also suggest that medium and large farmers accounted about 15 per cent of total land holdings thus occupying approximately 55.42 per cent of the total area." It therefore argues for extending support for micro irrigation adoption beyond the current 5 Ha. ceiling.

Table 5 shows the subsidy structure proposed under the new micro irrigation policy. We envisage that micro irrigation investments by farmers may be financed from four sources: [a] central subsidy; [b] state subsidy; [c] loans; and [d] farmers' contribution. We differentiate between farmers based on their land holding and whether they are first-time micro irrigation adopters or repeat buyers. We envisage that KAMIC will build a strong partnership with NABARD to access the various climate funds, which will help the farmers avail loans at lower interest rates.

Table 5 Proposed micro irrigation subsidy structure

FARMER CATEGORY	CENTRAL SUBSIDY	STATE SUBSIDY	BANK LOAN COMPONENT	FARMER'S CONTRIBUTION
Small & Marginal Farmers (land:< 2 Ha.)				
First-time adopter	50%	20% + interest on loan	30% + interest-free	-
Repeat buyer	50%	20%	20%	10% upfront
Medium Farmers (land: 2-5 Ha.)				
First-time adopter	40%	20%	30%	10% upfront
Repeat buyer	40%	10%	30%	20% upfront
Large Farmers (land: > 5 Ha.)				
First-time adopter	-	20%	50%	30% upfront
Repeat buyer	-	10%	40%	50% upfront

Small and marginal farmers (landholding < 2 Ha.) will receive 50% central subsidy and another 20% from KAMIC; for first time adopters, KAMIC will also cover the interest burden of 30% loan. Repeat buyers in the small and marginal category will have to contribute 10% of the total cost upfront and will be entitled to a loan of 20% of the cost under the climate finance/grant mobilised with NABARD support. Medium farmers (landholding 2-5 Ha.) will receive 40% central subsidy; first-time adopters will get 20% state subsidy and contribute 10% of the total cost as own contribution; repeat buyers will receive 10% state subsidy and will contribute 20% of total cost as own contribution; all medium farmers will be entitled to 30% loans under climate finance/grants mobilised. Large farmers (landholding > 5 Ha.) at present are not covered under the central subsidy scheme but own more than half the total cultivable area in the country. It is proposed that KAMIC will also bring them under the ambit of micro irrigation subsidies. First time adopters among large farmers will receive 20% state subsidy and have access to 50% loan under climate finance/grants mobilised; repeat buyers will receive 10% state subsidy and will have access to 40% loan under climate finance/grants mobilised.

In exceptional cases, such as severe drought conditions, the government of Karnataka in consultation with the KAMIC may announce special measures for specific regions or districts. One example of this could be offering to partly or fully cover the farmers' interest burden on the loan component to encourage greater micro irrigation adoption. The same special conditions may be offered in groundwater distressed blocks – dark zones – to enhance micro irrigation penetration.

5.2 The Proposed KAMIC Model of Subsidy Delivery

We propose a time bound model for micro irrigation subsidy delivery in Karnataka which will ensure that farmers will have final installation done within 50 days of applying for subsidy and the suppliers will receive 50% advance payment (at the time of approval of design and cost estimates) and the final payment within 20 days of completion of installation (Figure 8).

The 60-day turn-around process will include the following steps:

1. Micro irrigation manufacturers will take up the responsibility of developing and expanding the market by marketing their products directly to end-users (farmers). No company will be allocated a fixed quota / share of the market or the annual subsidy by KAMIC. Each company will have to win orders by convincing farmers about the superiority of their products and services vis-à-vis their competitors.

2. On being approached by an interested farmer, the chosen supplier will conduct the field survey, prepare implementation design as per the requirements of the farmer and issue a cost estimate to the farmer (Day 0 – Day 10).

3. KAMIC will implement a simple application procedure in which farmers can apply at the zonal offices or district field labs. With the help of GGRC (or other service providers), KAMIC will implement an online Enterprise Resource Planning (ERP) system that will allow speedy processing of farmer applications, including bank loan applications (Day 10 – Day 30).

4. On completion of processing, the farmer, KAMIC, chosen supplier and bank (where applicable) will come together to finalize implementation timeline, payment terms and loan-repayment schedule. KAMIC will then issue the work order to the supplier along with 50% advance payment (Day 35).

5. On receipt of approved work order and 50% advance payment, the chosen supplier will ensure that the field implementation is completed within 10 days (Day 45).

6. Once the supplier reports work completion and raises bill for final payment, KAMIC will have 15 days to commission and complete third party survey, issue work completion certificate and release final payment (Day 60).

Accomplishing an operating cycle of 60 days for each application will have some pre-conditions:

1. The micro irrigation suppliers will have to ensure that the initial field survey will be completed and cost estimates handed over to the farmer within 10 days of the farmer approaching the company;

2 KAMIC will have to create systems for parallel processing of farmers' applications and via a partnership with

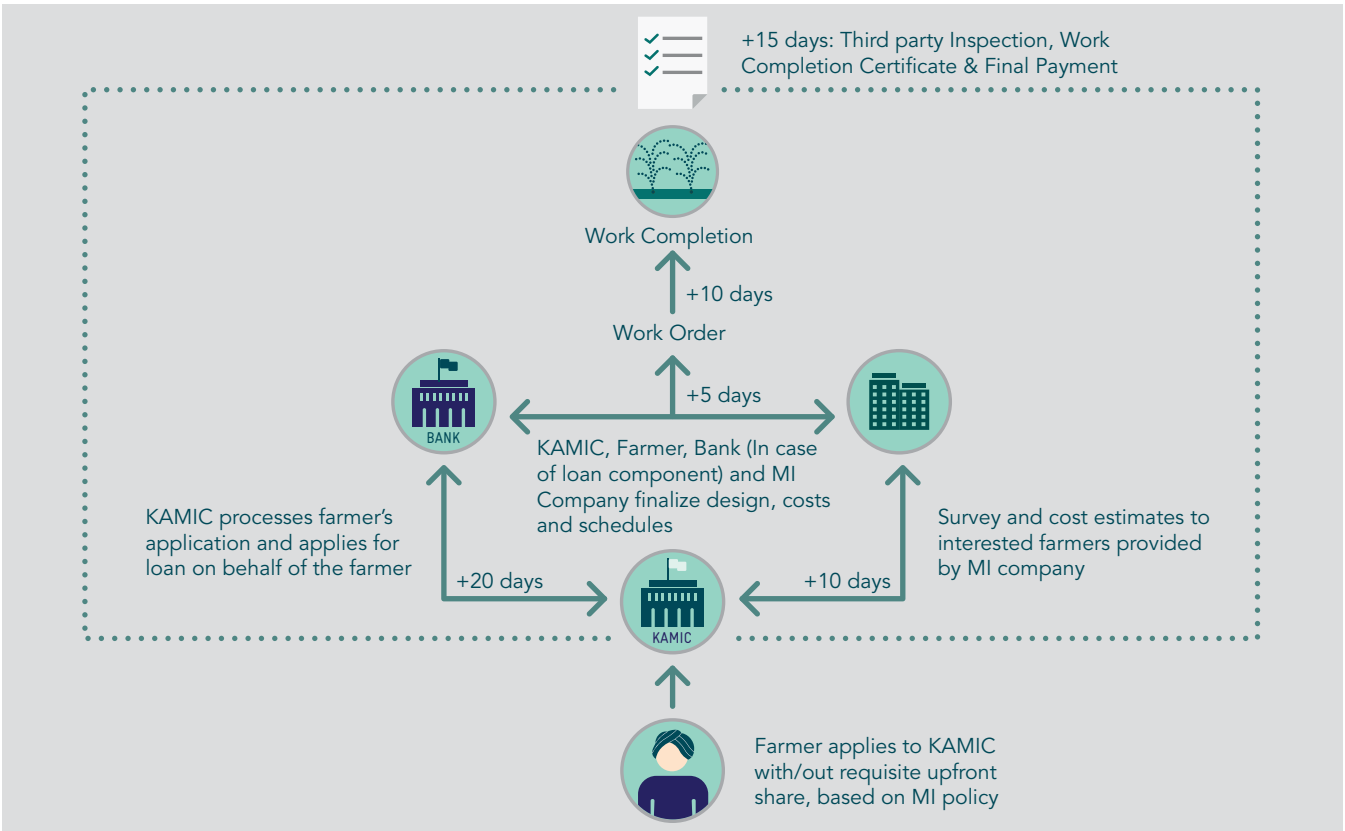
NABARD and the national/international climate funds, pre-approved loan processing on behalf of farmers. KAMIC will have 20 days to complete both these tasks;

3. The micro irrigation suppliers will have to maintain sufficient inventory of material and manpower to initiate and complete installation within 10 days of receiving the approved work order and advance payment;

4. KAMIC will have to coordinate third party inspection and release of work completion certificate along with final payment to supplier within 15 days. For this, KAMIC would need to maintain a pool of third party institutions / qualified consultants in each district who will be in a position to conduct inspections on short notice.

The maximum time period earmarked for each step in the process can be reviewed periodically. For instance, if experience shows that processing of loan applications or third party inspections require more time, the timelines can be amended. However, once key stakeholders agree to a reasonable time schedule, all applications must be processed within the allotted time. Delays in implementation and or release of payments will have a cascading effect and will seriously impinge accomplishment of micro irrigation expansion targets.

Figure 9 The (proposed) KAMIC model of subsidy delivery



6 Implementation Protocols

6.1 Setting Annual Targets

We have seen that Karnataka has a long way to go to achieve its micro irrigation potential of 2.1 to 2.9 mHa of irrigated area. At present, the area under micro irrigation is less than 0.5 mHa. Much of the current coverage of micro irrigation is with semi-medium, medium and large farmers who have availed subsidies through the horticulture and agriculture departments of the government of Karnataka. Karnataka has opportunities to implement an inclusive micro irrigation program by considering dryland areas that are agriculturally and socioeconomically vulnerable, including districts of Raichur, Yadgir and Koppal (Figure 5). In Table5, we have proposed a subsidy structure for different categories of farmers under the new micro irrigation promotion policy. We have also argued for a competitive micro irrigation market with a 'demand-driven' subsidy regime. One of the bottlenecks in administering a demand driven subsidy regime is that it is difficult to set annual targets and tight subsidy budgets since actual subsidy disbursement will depend on demand from farmers.

Table 6 shows the land holding pattern in Karnataka. The average land holding in Karnataka is 1.55 Ha; however, this is not evenly distributed across the state's farmers. Nearly half the farmers belong to the marginal farmer category with an average land holding of 0.48 Ha.; another 27 per cent of the farmers belong to the small farmer category and own between 1 and 2 Ha. land with an average holding of 1.41 Ha. Together, more than 3/4th of the farmers in Karnataka are small and marginal and own a little over 40 per cent of the cultivable land. The semi-medium farmers comprise 16 per cent of the population and own nearly 28 per cent of the land while the medium and large farmers number less than 8 per cent but own nearly 32 per cent of the cultivable land.

Table 6 Land holding pattern in Karnataka

AVG. LAND HOLDING (HA)	FARMER CATEGORY	SHARE IN POPULATION	SHARE IN LAND HOLDING
0.48	Marginal Farmers (< 1 Ha)	49.14%	15.22%
1.41	Small Farmers (1-2 Ha)	27.30%	24.83%
2.68	Semi-Medium Farmers (2-4 Ha)	16.17%	27.90%
5.69	Medium Farmers (4-10 Ha)	6.52%	23.88%
14.71	Large Farmers (>10 Ha)	0.86%	8.17%

Source: GoK (2011)

If we assume that the new policy will target to cover 20 per cent of the potential micro irrigation area each year, it adds up to roughly 0.5 mHa. The per hectare costs vary substantially across departments and districts. This is because sprinkler systems costs much less (roughly

Rs. 20,000 per Ha.) while drip irrigation costs more (roughly Rs. 95,000 per Ha). During the reference period 2005-06 to 2013-14, 1197.74 crores were spent to bring nearly 0.45 mHa under drip irrigation; this implies an average cost of nearly Rs. 27,000 per Ha. Since this only includes the subsidy component, assuming an average subsidy of 70 per cent, the total cost per hectare comes to Rs. 38,500. It would also be safe to assume that, at least in the initial years, bulk of the demand for micro irrigation would continue to come from semi-medium, medium and large farmers. We assume that roughly 20 per cent of the demand will come from small and marginal farmers; 40 per cent from farmers with 2 – 5 Ha and the remaining 40 per cent from medium and large farmers having more than 5 Ha. land. We use these numbers to make projections about annual targets and subsidy budgets.

At an average cost of Rs. 38,500 per Ha., bringing an additional 0.50 mHa under micro irrigation would require a total investment of Rs. 1,925 crores. Of this, the subsidy offered by the government of Karnataka would be roughly 15-20 per cent (see Table 5) depending on the relative share of small and large farmers. This would mean an annual subsidy burden of Rs. 350 crores for the government of Karnataka.

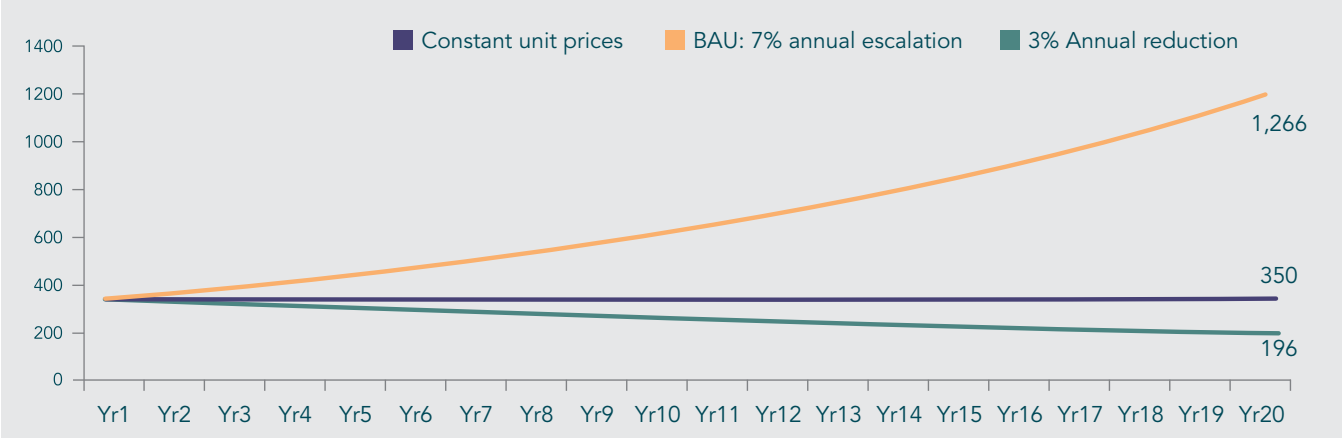
Over the past 5 years, unit costs of micro irrigation have been rising at roughly 7 per cent per annum. If we project these escalations over a 20 year period, the annual subsidy bill will keep rising and exceed Rs. 1,250 crores in 20 years. However, if KAMIC is able to reward innovation and nurture healthy competition among micro irrigation players, the annual subsidy bill can gradually reduce to nearly Rs. 200 crores (Figure 10).

The analyses and inferences are limited to estimation of micro irrigation potential in irrigated areas of Karnataka at state and district-levels. Estimates of micro irrigation potential with dryland area could be significantly higher.

6.2 Quality Assurance, Monitoring and Evaluation

Ensuring that farmers get top quality products and services from micro irrigation manufacturers and suppliers is a key responsibility of KAMIC. This role goes beyond setting norms and standards for micro irrigation components and requires continuous follow-up. It is also important that the micro irrigation industry feels compelled to provide quality products and services; and this would happen if their future business prospects are clearly linked to past performance.

Figure 10 The (proposed) KAMIC model of subsidy delivery



In order to track the performance of the new micro irrigation promotion policy, it is proposed that KAMIC anchors the following activities:

Tracking key macro-economic variables

The Karnataka horticulture department has proposed a partnership with GGRC to develop an IT implementation module for micro irrigation promotion. KAMIC can leverage this partnership to learn from GGRC and adopt their MIS best practices. This partnership can help KAMIC to track application processing and payment release timelines. Besides micro irrigation area coverage and expenditure, KAMIC should also track changes in cropping intensities, gross and net irrigated area, and aggregate production of key crops growth with micro irrigation technologies. Emerging trends in cropping pattern shifts towards high value and horticulture crops are also important as they will define the potential for micro irrigation adoption in the state.

Annual third-party review

An annual survey of beneficiary farmers is critical to understand the impact and drivers of micro irrigation adoption. The survey should be conducted by an independent third-party and should cover a sample of 5-10% of beneficiaries having more than 2 seasons of experience with micro irrigation technologies. The survey would have two broad components: [a] a techno-economic review to compare on-field implementation with on-record designs; and [b] a socio-economic impact assessment to quantify impact on irrigated area, water use efficiency, crop choices, yield and net farm income. The results of the annual survey should be published and widely disseminated.

Annual survey of MI brands

A separate study should be undertaken to measure the performance on different manufacturers and suppliers in the field. This study should focus predominantly on farmers' experience and perceptions about performance and reliability of products and after-sales services. The results of this survey can be used by KAMIC to grade suppliers; performance-linked incentives and disincentives can be offered to nurture competition. For instance, KAMIC may initiate a series of annual awards for micro irrigation brands based on results from this survey. Likewise, poor performance over consecutive years may attract a penalty or black-listing of brands.

Annual review of LCMI market

As discussed earlier, LCMIs are stepping stones towards conventional micro irrigation adoption and can play a crucial role in the development of micro irrigation markets. For this reason, it is important to regularly track the changes in this informal market. The proposed KAMIC should not only be a keen observer of changes in the LCMI market, it should also take proactive steps to support and encourage the spread of such informal markets in different parts of Karnataka.

Biennial review of MI disadoption

In order to understand future demand for micro irrigation technologies, it is very important to understand why some farmers discontinue the use of micro irrigation technologies even after acquiring some experience with them. From the KAMIC database of beneficiaries, this study should select first-time adopters who did not apply for repeat purchases and survey a sample of these. This would largely be a qualitative exploration but the results from this survey can help KAMIC bring useful amendments to its policies and procedures.

In order to accomplish all of the above activities, KAMIC will have to maintain a roaster of experts, academic institutions and researchers who can undertake M&E activities each year in different parts of the state. It is recommended that the KAMIC secretariat house at least one full-time M&E manager and a small team of capable research associates.

6.3 Training and Capacity Building

As in the case of monitoring and evaluation, the KAMIC secretariat should take the lead in coordinating training and capacity building for improved promotion of micro irrigation in Karnataka. Three levels of trainings and capacity building activities are envisaged:

Farmer Awareness and Trainings Programs

The key objective of these activities would be to inform prospective beneficiaries about the range of product and service options available to them. These activities would best be held in collaboration with the local district demonstration sites and village panchayats.

Farmers should also be made aware about regular repair and maintenance procedures as well as procedures for accessing micro irrigation subsidies.

Trainings for Field Staff, Retailers and Dealers

More than the farmers themselves, it is often the retailers, dealers and field staff who need to be well aware about subsidy application procedures because farmers usually rely on them. It is therefore important to train them regularly and keep them updated about any changes in policies, schemes or procedures. The field staff and dealers should also be trained to provide after-sales service and advisory services. As discussed earlier, micro irrigation adoption often takes place in clusters. Positive experience of a few early adopters can go a long way in word-of-mouth propagation and quick spread of adoption; the converse is equally applicable. The field staff and dealers need to be aware of this on two counts: [a] any positive experience should be widely shared and potential beneficiary farmers should be encouraged to interact with the successful adopters; and [b] any negative experience should be swiftly followed up to understand its drivers.

Capacity Building for Officials and Manufacturers

It is not enough to train farmers and field staff; officials in the proposed KAMIC secretariat as well as from the micro irrigation industry also need training and capacity building support. The objective of these activities should be to discuss adoption and dis-adoption trends and drivers, exchange notes on common problems faced by suppliers, maximizing scale and scope economies, highlighting innovative practices, and discussing cross-sectoral interlinkages and opportunities for co-leveraging.

7 Conclusion

Adoption of micro irrigation technologies, much like any other new technology, follows different stages of introduction, acceptance and adoption. When micro irrigation is initially introduced among farmers, only a few early adopters take to it. These early adopters are mostly those farmers who view these as coping mechanisms for an immediate hardship such as limited water availability in their well, limited hours of farm power supply or reduced availability of labor. Such adoption usually occurs in small clusters and adopters are only concerned about meeting their immediate need, rather than the overall impact of micro irrigation on their farming system.

With initial positive experience, farmers expand micro irrigated area and start observing several additional benefits of adoption. Adopters start viewing micro irrigation as a favorable business proposition and accept the technology as part of their farming system. With several years of experience, micro irrigation reaches full-scale adoption status, such as we find in the Nashik-Jalgaon-Aurangabad region in Maharashtra. The role of a good micro irrigation promotion program or policy is to guide farmers through these stages and to create a favorable environment for a competitive market to develop.

The informal and vibrant low cost micro irrigation market in Karnataka's Kolar region can probably be characterized between the first two stages of adoption: Kolar farmers initially resorted to drip irrigation in response to falling groundwater table and poor (and erratic) farm power supply. However, with experience, more and more farmers now view it as a favorable business proposition, which explains the booming local industry.

The objective of the new micro irrigation promotion policy is to facilitate the transition of farmers through these innovation life cycle stages towards full adoption. The KAMIC-model we have proposed in this report draws on the experience of the leading micro irrigation states in India and tries to combine their best features. We believe that more that the quantum of capital subsidy, it is the vibrancy and competitiveness of the micro irrigation market that will drive large-scale micro irrigation adoption. A demand-driven, low transaction cost subsidy delivery mechanism that rewards innovations and focuses on maximizing farm incomes would be the best bet for transitioning Karnataka's agriculture towards a high and sustainable growth trajectory

8 References

Agarwal, M.C. and Goel, A.C. 1981. Yield, quality and water use efficiency for vegetable crops under drip and surface methods. Proceedings of First National Seminar on Drip Irrigation, Tamil Nadu Agriculture University, Coimbatore, pp. 39-49.

Amarasinghe, U.A., Bhaduri, A., Singh O.P., Ojha, A. and Anand, B.K. 2008. Cost and benefits of intermediate water storage structures: Case study of diggies in Rajasthan. Proceedings of the CGIAR Challenge Program on Water and Food and 2nd International Forum on Water and Food. Vol. 3, pp. 79-82. Addis Ababa, Ethiopia.

APMIP. 2015a. Welcome to APMIP project. Website of the Andhra Pradesh Micro Irrigation Project (APMIP). Available online:*http://horticulturedept.ap.gov.in/Horticulture(S(t0nuimr53zu5vs13p05tx4fy))/Aboutus.aspx* [last accessed: 24-Dec-2015]

APMIP. 2015b. APMIP implementation guidelines. Website of the Andhra Pradesh Horticulture Department. Available online:*http://horticulturedept.ap.gov.in/Horticulture/(S(kimbk4ns0hduc3hhz31w3lsv))/UserInterface/Portal/Documents/MIP/34-09.07.15-AAP-15-16-implementational%20guidelines.PDF* [last accessed: 24-Dec-2015]

Awasthy, P., Patel, B., Sahu, P., Patanwar, M. and Parmeshwar, S.K. 2014. Potentials of micro irrigation in India: An overview. International Journal of Agricultural and Food Science, 4(4), pp. 116-118. Available online: *http://urpjournals.com/tocjnls/7_14v4i4_3.pdf* [last accessed: 24-Dec-2015]

Balasubramaniyan, A.D. 2013. Where paddy requires only drops of water. The Hindu web edition, 24-May. Available online: *http://www.thehindu.com/news/national/tamil-nadu/where-paddy-requires-only-drops-of-water/article4743549.ece* [last accessed: 24-Dec-2015]

BESCOM 2015. About Niranthara Jyothi scheme. Website of the Bengaluru Electricity Supply Company Limited (BESCOM). Available online: *http://bescom.org/en/about-the-project-nj/* [last accessed: 24-Dec-2015]

Business Standard 2010. Rice output can rise to 130 mn tns by 2020 via drip irrigation. Laxmi Devi / PTI, Coimbatore, Business Standard web edition, 02-Jul. Available online: *http://www.business-standard.com/article/markets/rice-output-can-rise-to-130-mn-tns-by-2020-via-drip-irrigation-110070200209_1.html* [last accessed: 24-Dec-2015]

Business Standard. 2015. Karnataka plans to bring sugarcane area under drip irrigation. Business standard web edition, 15-Jan. Available online: *http://www.business-standard.com/article/economy-policy/karnataka-plans-to-bring-sugarcane-area-under-drip-irrigation-115011501017_1.html* [last accessed: 24-Dec-2015]

Business Today. 2013. Drip irrigation: One drop at a time. Business Today web edition, 06-Jan. Available online: *http://www.businesstoday.in/magazine/cover-story/drip-irrigation-of-paddy-improves-yields-saves-water/story/190843.html* [last accessed: 24-Dec-2015]

Chandrakanth, M.G., Bisrat, A. and Bhat, M.G. 2004. Combating negative externalities of drought: A study of groundwater recharge through watershed. Economic and Political Weekly 39(11): 1164-1170.

Chelumala, P. and Wadhwa, D. 2015. Assessment of PINS and micro-irrigation on Narmada canal in Rajasthan. Development Internship Segment (DIS) report. Anand: IWMI-Tata Water Policy Program.

Deccan Herald. 2010. Karnataka to extend drip irrigation scheme to entire state. 22-Jul. Available online: *http://www.deccanherald.com/content/83133/karnataka-extend-drip-irrigation-scheme.html* [last accessed: 24-Dec-2015]

GGRC 2015c. Impressive growth story. Website of the Gujarat Green Revolution Company Limited (GGRC). Available online: *http://ggrc.co.in/webui/Content.aspx?PageId=5* [last accessed: 24-Dec-2015]

GGRC. 2015a. Subsidy norms of micro irrigation scheme. Website of the Gujarat Green Revolution Company Limited (GGRC). Available online:*http://ggrc.co.in/webui/Content.aspx?PageId=33* [last accessed: 24-Dec-2015]

GGRC. 2015b. List of MIS suppliers notified as per acceptance of appointment letter as on 16.11.2015 – Gujarat. Website of the Gujarat Green Revolution Company Limited (GGRC). Available online: *http://ggrc.co.in/documents/SupplierAddress_18_11_2015.pdf* [last accessed: 24-Dec-2015]

Global AgriSystem. 2014. National Mission on Micro Irrigation (NMMI): Impact evaluation study. Submitted to government of India, ministry of agriculture, department of agriculture and cooperation. June 2014, Global AgriSystems. Available online: *http://nhm.nic.in/Archive/Impact_Evaluation_Study_June-2014.pdf* [last accessed: 24-Dec-2015]

GoI. 2010. National Mission on Micro Irrigation; Operational guidelines. Available online: *http://www.nccd.gov.in/PDF/Guidelines-NMMI.pdf* [last accessed: 24-Dec-2015]

GoK. 2011. Agricultural Census 2010-11 Report on Operational Holdings in Karnataka, Directorate of Economics & Statistics, Bangalore. Available online: *http://raitamitra.kar.nic.in/landholdings.html* [last accessed: 24-Dec-2015]

GoK. 2015. Website of the Karnataka State Department of Agriculture (KSDA). *http://raitamitra.kar.nic.in/ENG/index.asp* [last accessed: 24-Dec-2015]

Gómez, C.M. and Gutiérrez, C. 2011. Enhancing Irrigation Efficiency but Increasing Water Use: The Jevons' Paradox. Paper presented at the EAAE 2011 Congress, "Change and Uncertainty: Challenges for Agriculture, Food and Natural Resources", 30-Aug to 02-Sep, Zurich, Switzerland. Available online: *http://ageconsearch.umn.edu/bitstream/114622/2/Gomez_Carlos_544.pdf* [last accessed: 24-Dec 2015]

Hindu. 2012. Apex body to monitor micro-irrigation systems. The Hindu, 10-Feb. Available online: *http://www.thehindu.com/todays-paper/tp-national/tp-karnataka/apex-body-to-monitor-microirrigation-systems/article2877603.ece* [last accessed: 24-Dec-2015]

Hindustan Times. 2003. Karnataka extends drip irrigation subsidy to all farmers. Hindustan Times, 10-Jun. Available online: *http://www.hindustantimes.com/archives/karnataka-extends-drip-irrigation-subsidy-to-all-farmers/article1-7112.aspx* [last accessed: 24-Dec-2015]

ICID. 2015. Annual Report, 2014-15. New Delhi: International Commission on Irrigation and Drainage (ICID). Available online: *http://www.icid.org/ar_2014.pdf* [last accessed: 24-Dec-2015]

INCID. 1994. Drip irrigation in India. Indian National Committee on Irrigation and Drainage (INCID), New Delhi.

INTERA. 2013. Remote-sending-based comparison of water consumption by drip-irrigated versus flood-irrigated fields: Deming, New Mexico. Report prepared for New Mexico Interstate Stream Commission by INTERA Incorporated.

Kumar, M.D., Sharma, B.R. and Singh, O.P. 2008. Water saving and yield enhancing micro-irrigation technologies: How far can they contribute to water productivity in Indian agriculture? In Amarasinghe, U.A., Shah, T. and Malik, R.P.S. (Eds). India's water future: Scenarios and issues. Strategic analyses of the National River Linking Project (NRLP) of India, Series 1. 417p, Colombo: International Water Management Institute.

Malik, R.P.S. and Rathore, M.S. 2011. Accelerating adoption of drip irrigation in Madhya Pradesh. Colombo: International Water Management Institute (IWMI). (AgWater Solutions Project Case Study Report).

Manjunatha, A.V., Speelman, S., Chandrakanth, M.G. and Van Huylenbroeck, G. 2011. Impact of groundwater markets in India on water use efficiency: A data envelopment analysis approach. Journal of Environmental Management 92(11): 2924-2929.

Muralidhara, H.R., Gundurao, D.S., Sarpashkar, A.M. and Ramaiah, R. 1994. Is drip irrigation viable for mulberry cultivation – An economic analysis. Mysore Journal of Agriculture Science, Vol. 28. pp. 256-266.

Murdeshwar, V. 2013. 90 per cent subsidy for drip irrigation: CM. Times of India, 23-Sep. Available online: *http://www.newindianexpress.com/states/karnataka/90-percent-subsidy-for-drip-irrigation-CM/2013/09/23/article1798818.ece* [last accessed: 24-Dec-2015]

Narayanamoorthy, A. 1999. Drip irrigation for sustainable agriculture. Productivity, Vol. 39, No. 4, Jan-Mar, pp. 672-678.

Narayanamoorthy, A. 2008. Drip and sprinkler irrigation in India: Benefits, potential and future directions. In Amarasinghe, U.A., Shah, T. and Malik, R.P.S. (Eds). India's water future: Scenarios and issues. Strategic analyses of the National River Linking Project (NRLP) of India, Series 1. 417p, Colombo: International Water Management Institute.

Narayanamoorthy, A. and Deshpande, R.S. 1997. Efficient water management through drip irrigation: Some evidences from Western India. In ICID, The Tenth Afro-Asian Regional Conference Proceedings: Water and land resources development and management for sustainable use, Denpasar, Bali, Indonesia, 19-24 July.

Narayanamoorthy, A. and Deshpande, R.S. 1998. Economics of drip irrigation: A comparative study of Maharashtra and Tamil Nadu.

Mimeograph Series No. 47, Agro-Economic Research Centre, Gokhale Institute of Politics and Economics, Pune, Maharashtra.

Navhind Times. 2014. Subsidy for drip irrigation for sugarcane in Karnataka. Navhind Times, 12-Nov. Available online: *http://www.navhindtimes.in/subsidy-drip-irrigation-sugarcane-karnataka/* [last accessed: 24-Dec-2015]

NCPA. 1990. Status, potential and approach for adoption of drip and sprinkler irrigation systems. Pune: National Committee on the Use of Plastics in Agriculture (NCPA).

NCPAH. nd. National mission on micro irrigation. Website of the National Committee on plasticulture applications in horticulture. Available online: *http://www.ncpahindia.com/mi* [last accessed: 24-Dec-2015]

Oza, A., Jessani, K. and Dungrani, S. 2004. AKRSP(I)'s experiences in promoting micro-irrigation devices in Saurashtra, Gujarat. Paper presented at Water and Welfare: Critical Issues in India's Water Future, 17 – 19 February, Institute of Rural Management, Anand. IWMI-Tata Water Policy Program.

Paul, J.C. and Sharma, S.D. 1999. Micro-irrigation for water scarce areas of Orissa. Kurukshetra, Jun, pp. 27-30.

Pfeiffer, L. and Lin, C.-Y.C. 2013. Does efficient irrigation technology lead to reduced groundwater extraction? Empirical evidence. Journal of Environmental Economics and Management, 67 (2), pp. 189-208.

Phansalkar, S.J. 2002. Appropriate drip irrigation technologies promoted by IDEI: A socio-economic assessment. IDE Research Report 018. New Delhi: International Development Enterprises (IDE), India.

Phansalkar, S.J. 2003. Evolving technology through collaboration and partnership: Case of IDE's work with tomato packaging in Himachal Pradesh, India. In A. Hall, B. Yoganand, R. V. Sulaiman and N. G. Clark (Eds.) Post Harvest Innovations in Innovation. Kent: N. R. International.

Phansalkar, S.J. and Verma, S. 2008. Silver bullets for the poor: Off the business mark? International Development Enterprises (IDE), India.

Postel, S., Polak, P., Gonzales, F. and Keller, J. 2001. Drip irrigation for small farmers: A new initiative to alleviate hunger and poverty. Water International, 26(1), pp. 3-13.

Pullabhotla, H.K., Kumar, C. and Verma, S. 2012. Micro-irrigation subsidies in Gujarat and Andhra Pradesh: Implications for market dynamics and growth. Water Policy Research Highlight #43, Anand: IWMI-Tata Water Policy Program.

Raina, R. 2004. Technological and institutional innovations: A case study of pomegranate production and marketing. IDE Research Report 021. New Delhi: International Development Enterprises (IDE), India.

Raman, S. 2010. State-wise micro-irrigation potential in India: An assessment. Unpublished paper. Natural Resources Management Institute, Mumbai.

Reddy, K.S. and Reddy G.P. 1995. Micro irrigation for water scarce areas. Yojana, Vol 39, No. 8, Jun. pp. 39-42.

Roberts, J. C. and Styles, S. W. (1997). Drip irrigation technology: A resource management tool for farmers. Irrigation Journal. 47 (7), pp: 14-16.

Sastry, A.K. 2014. Contracts for Ramthal drip irrigation project awarded. The Hindu web edition, 01-Jan. Available online: *http://www.thehindu.com/todays-paper/tp-national/tp-karnataka/contracts-for-ramthal-drip-irrigation-project-awarded/article5524889.ece* [last accessed: 24-Dec-2015]

Shah, T. 2009. Taming the anarchy: Groundwater governance in South Asia. Washington D.C.: Resources for the Future Press.

Shah, T. and Keller, J. 2002. Micro-Irrigation and the Poor: A Marketing Challenge in Smallholder Irrigation Development. In Private Irrigation in Sub-Saharan Africa: Regional Seminar on Private Sector Participation and Irrigation Expansion in Sub-Saharan Africa, edited by H. Sally and C.L. Abernethy. Colombo: International Water Management Institute, 165–84.

Shah, T. and Verma, S. 2008. Co-management of Electricity and Groundwater: An Assessment of Gujarat's Jyotirgram Scheme. Economic and Political Weekly, 43 (7), pp. 59-66.

Shah, T. and Verma, S. 2014. Addressing Water Management. In Debroy, B. and Tellis, A.J. (Eds). Getting India back on track: An action agenda for post-election reforms. pp. 185-205, Washington: Carnegie Endowment for International Peace.

Shah, T., Bhatt, S., Shah, R.K. and Talati, J. 2008. Groundwater governance through electricity supply management: Assessing an innovative intervention in Gujarat, western India. Agricultural Water Management, 95 (11), pp. 1233-1242.

Shah, T., Mehta, M., Sankar, G. and Mondal, S. 2012. Organizational reform in Gujarat's electricity utility: Lessons for revitalizing a bureaucratic service delivery agency. Water Policy Research Highlight #06, Anand: IWMI-Tata Water Policy Program.

Shah, T., Scott, C.A., Kishore, A. and Sharma, A. 2004. Energy-irrigation nexus in South Asia: Improving groundwater conservation and power sector viability. 2nd revised edition, IWMI Research Report #70, 28p, Colombo: International Water Management Institute (IWMI).

Shah, T., Verma, S. and Durga, N. 2014. Karnataka's Smart, New Solar Pump Policy for Irrigation. Economic and Political Weekly, Vol. XLIX, No. 48, pp. 10-14.

Shah, T., Verma, S., Bhamoriya, V., Ghosh, S. and Sakthivadivel, R. 2005. Social impact of technical innovations: Study of organic cotton and low cost drip irrigation in the agrarian economy of West Nimar region. Colombo: International Water Management Institute. Available online: *http://www.fibl.org/fileadmin/documents/en/development-cooperation/production-systems/social-impact-report.pdf* [last accessed: 24-Dec-2015]

Shashidhara, K.K., Bheemappa, A., Hirevenkanagoudar, L.V. and Shashidhar, K.C. 2007. Benefits and constraints in adoption of drip irrigation among the plantation crop growers. Karnataka Journal of Agricultural Sciences 20 (1), pp. 82-84.

Singh, D. 2012. Rajasthan's experiment with efficient distribution of Narmada water. Draft unpublished report. Anand: IWMI-Tata Water Policy Program.

Singh, N. and Jain, N. 2003. Technology adoption: Comprehending the un-induced demystification of micro (drip) irrigation technology. Management Traineeship Report, Anand: IWMI-Tata Water Policy Program.

Sivanappan, R.K. 1977. Sprinkler and drip irrigation. Indian Farming, 27(2), pp. 23-24.

Sivanappan, R.K. and Padmakumari, O. 1980. Drip irrigation. Tamil Nadu Agriculture University, Booklet, pp. 70.

Sivanappan, R.K., Padmakumari, O. and Kumar, V. 1987. Drip irrigation. Keerthi Publishing House (P) Ltd., Coimbatore.

SugarOnline. 2011. INDIA: Karnataka mills encouraged to use drip irrigation. SugarOnline.com, 15-Jul. Available online: *http://www.sugaronline.com/website_contents/view/1176354* [last accessed: 24-Dec-2015]

Times of India. 2013. Tamil Nadu Agricultural University experiments with drip irrigation in paddy cultivation. Times of India online edition, 17-Oct. Available online: *http://timesofindia.indiatimes.com/city/coimbatore/Tamil-Nadu-Agricultural-University-experiments-with-drip-irrigation-in-paddy-cultivation/articleshow/24273311.cms* [last accessed: 24-Dec-2015]

Udasin 2014. Netafim: Drip irrigation can increase rice yields, reduce greenhouse gas emissions. The Jerusalem Post online edition, 24-Aug. Available online: *http://www.jpost.com/Israel-News/New-Tech/Netafim-Drip-irrigation-can-increase-rice-yields-reduce-greenhouse-gas-emissions-372141* [last accessed: 24-Dec-2015]

Verma, S. 2004. Promoting micro-irrigation in India: A review of evidence and recent developments. Paper presented at Water and Welfare: Critical Issues in India's Water Future, 17 - 19 February, Institute of Rural Management, Anand. IWMI-Tata Water Policy Program.

Verma, S., Tsephal, S. and Jose, T. (2004). Pepsee systems: Grassroots innovation under groundwater stress. Water Policy. 6 pp: 303-318.

Walton 2014. Spending to conserve water on California farms will not increase supply. Website of 'Circle of Blue', 28-Feb. Available online: *http://www.circleofblue.org/waternews/2014/world/conserve-water-california-not-increase-supply/* [last accessed: 24-Dec-2015]

Ward, F. and Pulido-Velazquez, M. 2008. Water conservation in irrigation can increase water use. Proceedings of the National Academy of Sciences of the United States of America (PNAS), 105 (47), pp. 18215-18220. Available online: *http://www.pnas.org/content/105/47/18215.full.pdf* [last accessed: 24-Dec-2015]

Wolff, P. 1987. On the development status of micro-irrigation. Report No. 19 of the Department of Irrigation, Drainage and Soil Conservation, Faculty of International Agriculture, University of Kassel, Witzenhausen, Germany.

World Bank. 2010. Deep wells and prudence: Towards pragmatic action for addressing groundwater overexploitation in India. Washington: World Bank. Available online: *http://siteresources.worldbank.org/INDIAEXTN/Resources/295583-1268190137195/DeepWellsGroundWaterMarch2010.pdf* [last accessed: 24-Dec-2015]

Global Green Growth Institute
19F Jeongdong Bldg. 21-15
Jeongdong-gil Jung-gu
Seoul 100-784
Republic of Korea

T: +82 2 2096 9991
F: +82 2 2096 9990