could be adopted by small scale farmers. KARI has established various on-station demonstration sites including at National Agricultural Research Laboratory (NARL) Nairobi, National Dryland Research Centre in Katumani, Regional Research Centre in Mtwapa and Regional Research Centre in Perkerra (Sijali and Okumu, 2002. These centres also stock the kits for sale.

The preliminary target for the transfer and diffusion of drought tolerant sorghum varieties is to introduce the technology to 1 million farmers by the year 2017. The preliminary target for the drip irrigation technology is introduction of 500,000 and 1000 drip irrigation systems to individual farmers and institutions, respectively by the year 2017.

2.1.1 General Barriers and Proposed Measures

General barriers for the transfer and diffusion of drought resistant and drip irrigation technologies and proposed measures to overcome the identified barriers are summarized as follows:

(i) **Economic and Financial Barriers -** These are associated with inadequate financial resources, credit, and loans. These barriers can be overcome by provision of adequate financial resources and reduction of interest rates on credits and loans. If these measures are adopted there will be sufficient financial resources for the transfer and diffusion of the two technologies and therefore more farmers will be able to access credit and loans and take up the technologies. The overall outcome of these measures is enhanced adoption and diffusion of these technologies leading to improved incomes and food security.

(ii) **Human Skills –** Though these technologies exist in Kenya, their uptake is low due to inadequate training and low adaptive capacity by the local communities. This barrier can be overcome by providing adequate and relevant training at all levels. The overall outcome will be more trained personnel, and farmers, resulting in better uptake of these technologies.

(iii) **Information and Awareness –** Inappropriate communication and extension approaches as well as inadequate awareness of the technologies were identified as major barrier. The proposed measures to overcome these barriers include promotion of awareness and effective extension services and creation of sufficient awareness of the existence and use of the technologies. This results in improved response in the adoption and diffusion of the technologies.

The overall outcome applying the measures and associated overcoming of the barriers will be enhanced adoption and diffusion of the technologies by the local communities resulting in enhanced incomes and food security

2.2 Action Plan for Drought Tolerant Sorghum Varieties Technology

2.2.1. About the Technology

Due to global warming and climate change, the country has frequently been faced with drought and hence there is need to lay emphasis on drought tolerant plants and crops especially in areas where rains are not sufficient. Sorghum is grown in areas with as little as 250mm of rainfall. The drought tolerant sorghum varieties such as Serena, Seredo, super sorghum are produced as a result of plant breeding to enhance their resistance or tolerance to stresses that result from climate variability. Drought is a major constraint to rain-fed crop

production. Yield losses vary according to severity and type of drought. Prolonged drought at any stage will result into crop failures.

The Drought Tolerant Sorghum Varieties technology has been developed by KARI and adopted by some farmers in the country. Farmers are already using the drought tolerant varieties in drought prone areas to improve sorghum production under drought conditions. Extension agents and NGOs are promoting drought tolerant sorghum for food security and beer brewing. However, studies on the extent of adoption by farmers in the country are still on-going.

The direct and indirect benefits of drought tolerant sorghum include water use efficiency improved; expands arable land; reduce soil erosion, improvement of soil fertility and improvement in food security. It is estimated that it costs US $ 115 for the adoption of the drought tolerant seeds by a farmer, but this amount does not include the research and development of the drought tolerant sorghum variety by KARI which is estimated to cost about KShs 3 million over a period of about 7 years.

2.2.2 Target for Technology Transfer and Diffusion

The preliminary target for the transfer and diffusion of drought tolerant sorghum varieties is to introduce the technology to 1 million farmers by the year 2017. In order to achieve these targets the stakeholders and players to be involved include policy makers and implementers such as Ministries of Agriculture, Finance and Trade and Industry; research institutions such as KARI; seed multipliers, handlers and distributors such as Kenya Breweries Limited and Kenya Seed Company; wholesalers and retailers; and farmers who grow the crop. The other stakeholders are the millers who make floor for humans and animal feeds and service providers including financial institutions and local NGOs and CBOs

2.2.3 Barriers to Technology's Diffusion

The barriers to the transfer and adoption of drought tolerant sorghum varieties technology include inadequate financial resources which is associated with lack of available capital to buy seeds and agricultural credit including low affordability amongst rural farmers. The other identified barriers are:

a) Market failure associated with inaccessibility of seeds to farmers caused by lack of functional seed market, unreliable suppliers, uncertainty on demand and late release of seeds
b) Inadequate policy, legal and regulatory framework due to inadequate government commitment associated leading to lack of patenting of research findings.
c) Technical barriers including inefficient seed production, distribution and delivery associated with delayed release of varieties and complexity of the technology
d) Lack of human capital associated with inadequate training on seed multiplication and lack of early involvement of farmers in variety selection
e) Inadequate information and awareness associated with inappropriate communication and extension approaches
f) Inadequate institutional and organization capacity to carryout agricultural research
g) Network failures due to lack of collaboration between national agricultural research institutions, extension officers and other stakeholders.

The barriers were then screened in order to identify the most important barriers to the adoption and diffusion of the technology. The most important economic and financial

barrier was identified as inadequate financial resources. Decomposition of the barrier showed that inadequate financial resources is due to lack of available capital to buy seeds, lack of agricultural credit and loans and low affordability amongst rural farmers. These hinder the adoption of the drought tolerant sorghum technology.

The main identified non-financial barrier to adoption and diffusion of drought tolerant sorghum technology is market failures. Analysis of the barrier showed the elements of the barrier to be associated with unreliable supplies due to absence of stockists; lack of functional markets in Arid and Semi-Arid areas; uncertainty on the demand for seeds; low seed demand; and poor infrastructure.

2.2.4 Proposed Measures and Enabling Framework

After identification, categorization and description of the barriers, the measures for addressing the barriers were formulated. They include economic and financial measures, which makes it easier for farmers to access affordable agricultural credit and loans. The non-financial measures are establishment of reliable supplies of inputs, functional seed market and efficient seed production and mounting adequate training and education on seed multiplication. They also include making available human labour and draught animals; improving communication and extension techniques; involvement of farmers in varietal selection; and integration between formal and informal seed systems improving agricultural research and timely release of varieties.

The proposed enabling framework includes establishment of necessary policy to enable financial institutions to provide affordable capital and putting in place relevant policies on land ownership, customer rights, quality control, business permits, business ethics, and taxation.

2.2.5 Proposed Action Plan for Drought Tolerant Sorghum Variety Technology

The proposed Action Plan for drought tolerant sorghum variety technology include adaptation interventions and provide for the enabling framework required to effectively respond to impacts of climate change. These in sequential order include:

(i) Provide adequate training - Provision of adequate training will improve farmers' skills in adoption and diffusion of drought tolerant sorghum variety technology. It will also enable effective communitarian between farmers, extension staff and researchers.

(ii) Formulate and enact appropriate legislations regulations and policies - This will facilitate in a conducive environment for research, development and diffusion of the technology. It will also improve extension services and facilitate harmonization of strategies and policies of all key players for enhancement of the technology at all levels.

(iii) Intensify coordination - Intensification of coordination will improve collaboration, integrate formal and informal markets, and provide adequate technological information. This will lead to collaboration of all key players and harmonization of their policies for use and diffusion of the technology.

(iv) Intensify research efforts - This will result in increased release of drought tolerant sorghum varieties in time, enhance research capacity, and provide adequate technological information. This will lead to release of improved

varieties of drought tolerant sorghum for various ecological regions on time and therefore enhance the use and diffusion of the technology.

(v) Provision of agricultural credit and loans for farmers - Provision of agricultural credit and loans to farmers will increase accessibility of financial resources and facilitate purchase of inputs. It will also facilitate training of farmers on agricultural credit management systems. These actions will lead to accessible and affordable credit including efficient use of such funds for the use and diffusion of drought tolerant sorghum variety technology.

(vi) Establishment of functional agricultural produce market outlets and agribusiness for farmers - Enhance use and diffusion of the technology will lead to increased demand for seeds and production of drought tolerant sorghum which requires access to markets. The establishment of functional agricultural market outlets and agri-business for farmers will improve marketing and value addition strategies including infrastructure for transport and distribution of the sorghum.

The projected timeframe for implementing the measures of this action plan is between 0 – 10 years. Provision of adequate training, formulation and enactment of relevant legislation, intensification of research coordination and formulation of policies on provision of agricultural credit and loans to farmers will be undertaken in a short-term period, between 0 – 5 years. Implementation timeframe of development of functional markets outlets and intensification of research efforts is envisaged to be medium-term period of up to 10 years. The implementation of the action plans for drought resistant, sorghum varieties is estimated to cost Kshs. 7.04 billion with provision of training and agricultural credit and loans to farmers taking the bulk, Kshs 50 billion and KShs 2.0 billion, respectively.

The implementation strategy of this action plan will involve various actors involving Public Private Sector, Civil society and community participation. Government ministries will provide the necessary policies, infrastructure, and funding; public institutions like KARI, Universities and private sector will undertake research and training while business community will facilitate agri-business initiatives. The donors will collaborate with the government financial institutions and private sector to provide the required funding for the action plan. The farmers will implement the policies through use and adoption of technology and also provide human and financial resources.

The foreseen main risks, which would affect the implementation of action plan, are inadequate funds, lack of cooperation and collaboration of stakeholders, ineffective communications, and inadequate political goodwill and support.

The proposed action plan for drought tolerant sorghum varieties technology is summarized in Table 2.2.

Table 2.2: Proposed Action Plan for Drought Tolerant Sorghum Variety Technology

Measured/ Actions Needed	Why the Measures/Actions Needed	Main Actors	Timeframe	Cost (Million Kshs)	Sources of Funds	Indicators of Success	Indicators of Risks	Outcome
1. Provide adequate training	To improve farmers skills	• Ministry of Agriculture and KARI – Develop training curriculum • KARI – Trainers using the curriculum developed • Kenya Breweries and Kenya Seed Company – training on effective planting and management of drought tolerant sorghum • Farmers-beneficiaries	Within 5 years	5000	• Government • AfDB (ClimDev Africa Special Fund) • Private Sector like Kenya Breweries, Kenya Seed Company • Communities	• Targeted farmers trained on the technology • Improved communication and extension services on sorghum varieties • Awareness on the technology and its benefits created	• Inadequate funds • Lack of cooperation and collaboration • Ineffective communication, extension and training approach • Inadequate awareness	Improved farmers skills in use and diffusion of the technology
2. Formulate and enact legislations, regulations and policies on research and multiplication and marketing of drought tolerant sorghum varieties	• To provide enabling environment for research, development and multiplication of drought tolerant sorghum varieties • To encourage participation of other investors e.g. Private Sector into the Agricultural Sector	• Ministry of Agriculture – Policy and legislation formulation • Min. responsible for ASALs –Policy on effective management of ASAL areas • AGs office – Advise and drafting of Legislations and regulations • Private sector, farmers and business communities – implementers of policy	Within 5 years	5	• Government • EU (Global Climate Change Alliance) • Civil Societies lobby groups • Private Sector	• Policies, legislation and regulations formulated, enacted and operationalised	• Inadequate government commitment • Lack of promotion of unreleased technology	Conducive policy and legislation framework for adoption of drought resistant sorghum

3. Intensify co-ordination between research institutions, seed multipliers and marketers	• To improve collaboration and cooperation e.g. research/Extension/Farmers • To integrate formal and informal markets • To provide adequate technological information	• Ministries of Agriculture, ASALs and research institutions – spearhead policy and implementation coordination, and networking • Private sector, farmers, civil society and business community – enhance networking and collaboration • Farmers – Formulation of active groups like cooperatives and associations for networking amongst themselves and with government, private sector (wholesaler, retailers and distributors) and business communities.	Within 5 years	10	• Government • Farmers Cooperative Societies • Private Sector like Kenya Breweries and business communities • Civil Society organizations • Communities • AfDB (ClimDevAfrica Special Fund)	• Collaboration improved • Markets intergraded • Improved collaboration and cooperation	• Lack of good will • Poor communication and approach • Poor collaboration and cooperation	Collaboration of all key players including harmonization of their policies in development and adoption
4. Intensify research efforts and funding	• To release varieties in time • Increase research funding • To enhance capacity for research	• Min. of Agriculture in collaborations with MHEST – develop research policy and guidelines. • Private sector and farmers – implement research findings and also identify research gaps	Within 10 years	20	• Government • Germany (International Climate • Initiative) • Private Sector	• Varieties released in time • Sufficient research funding available • Enhanced capacity for Research • Adequate and easily accessible technological information	• Lack of goodwill and support • Inadequate funds • Prematurely released varieties • Inadequate information and communication	Release of improved varieties of drought resistant sorghum for various ecological regions on time.

5. Provision of agricultural credit and loans to farmers	• To increase accessibility of financial resources to farmers • To facilitate purchase of inputs • To train farmers on agricultural credit management system	• MOF and Central Bank of Kenya – Policy formulation • Financial institutions including AFC and micro-finance institutions policy implementation. • Farmers, agri-business communities and traders – beneficiaries of policies	Within 5 years	2000	• Government • Financial Institutions including Micro-finance • Agri-Business Communities GEF (Adaptation • Fund (AF))	• Loans and credits available to target farmers • Agricultural credit funds in financial institutions available • Trained of Farmers on Agricultural Credit Management Systems	• Lack of political good will • Poor loan recovery mechanisms • High default rates	• Accessible and affordable credit to farmers for purchase of inputs and efficient use of funds
6. Establishment of functional agricultural produce market outlets and agribusiness for farmers	• To improve agricultural marketing, agribusiness and income for farmer s • To improve infrastructure for transport, distribution, and marketing of drought tolerant sorghum variety	• Ministry of Trade and Industry – lead agency and set standards • Min. of Local Government – provision of market centres • Min. of Cooperatives – helping farmers to develop marketing cooperative societies • Private Sector and business community value addition, research, market networks, wholesalers and retailers of seeds and produce and trading partners • Farmers – beneficiaries	Within 5 years	10	• Government • Marketing Cooperative Societies • Private Sector • Business Communities • Farmers	• Functional seed and produce markets established • Improved infrastructure • Improved supplies of inputs	• Inadequate involvement of key stakeholders • Lack of market regulations	• Functional market outlets established leading to improved incomes
		Total (Million KShs)		**7045**				