
SMEs can overcome challenges and improve sustainability through preventive management strategies: some empirical evidences from a cluster of chemical industries in Western India

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Abstract: The paper presents details regarding several interventions that helped SMEs substantially reduce energy and material losses. The initiative by SMEs was part of a preventive strategy to reduce vulnerability to vagaries caused by inclement markets, growing costs of energy and materials, related international considerations and the time taken to resolve them. Based on this approach they rectified equipment, enhanced heat and other energy transfers, improved performance of mechanical functions, modified production

schedules, recovered materials lost earlier as waste and optimised material conversions in unit processes and operations. Nearly 20 to 25% energy savings and 15 to 20% material savings were achieved with enormous implications for economic sustainability. SMEs that face similar challenges will derive useful lessons from the evidences reported and convert the adversity into an opportunity to innovate and overcome challenges. In this context we propose a framework for collective action christened 'Alliance to save SMEs'.

Keywords: small and medium scale enterprises; SMEs; preventive management; energy efficiency enhancement; India.

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1 Introduction

Several deliberations on the implications of the recent economic crisis on production and profitability of SMEs in particular have drawn the attention of bilateral and multilateral agencies and industry forums world over (UNIDO, 2011a, 2011b; Calogirou et al., 2010; EIM Business & Policy Research, 2011; GIZ, FICCI, 2011; The International Bank for Reconstruction and Development, 2012). They compare the levels of preparedness of SMEs to take cognisance of issues and evolve appropriate adaptation strategies including expansion of niche markets. The response of the governments to the impacts of the crisis on their respective economies depended on the degree of their vulnerability to external shocks as a function of their integration with global economy through trade and financial flows. The implications of access to finances were highlighted by an interesting study carried out by three major international financial accounting institutions including the Association of Chartered Certified Accountants, the Certified General Accountants Association of Canada and CPA Australia (CPA, CGA & ACCA, 2009). Reportedly, the overarching influence of trade linkages across countries and regions in a globalised

business context has been significant; thereby creating an almost ubiquitous negative impact. This creates the context to ask if adequate safeguards could be built through appropriate policies and plans to tackle such contingencies in the future.

2 Environmental performance by SMEs in the context of the economic crisis

Some of the important questions in this context pertain to the contribution of the SMEs to the overall gross domestic product of the country and the extent to which their trade is linked with countries that are as vulnerable to the vagaries of world markets or are relatively resilient. The specific focus of this paper is however on the ability of SMEs to tackle pressures through efficient and cleaner production supported by energy efficiency enhancement measures. This could have enormous implications for avoiding costs as part of a positive framework of action. However, detailed empirical evidences will be needed to justify the direct link between costs avoided and improved resilience especially in the context of pressures caused by the global economic crisis.

Significant and authentic information is available in the public domain about the size of the SMEs sector, its production areas, contribution to the economy and the overall impact of the economic crisis suffered especially through 2008 and 2010 with respect to exports. However, information regarding expenses incurred to improve environmental efficiencies and consequently the costs avoided through improved environmental compliance and performance related market advantages is not available for ready use. This gap in empirical information is more so, for comparisons between the pre-crisis and during – crisis periods. The present paper therefore proposes to highlight the fact that cleaner production, waste minimisation and energy efficiency enhancement initiatives continued through the crisis-period by the enterprises, however with greater zeal that such measures will help them improve their resilience.

The paper presents recent information regarding the importance of SMEs and the impacts stated by several agencies/investigations with respect to the economic crisis from several parts of the world. India-specific information is also provided to highlight the fact that literature cited does not examine the precise linkage stated above but only present a cursory view of the impacts and the preparedness of the government to tackle them. It is however important to recognise that others too have taken note of the paucity of information on these linkages especially with respect to the timing of the present analysis. On the other hand the present paper creates the context for viewing preventive strategies as essential and integral interventions for the way forward as countries tackle the impacts of the crisis. Environmental efficiency has to be seen as an essential cost reduction tool only to reinforce the double dividend paradigm stated by Michael Jacobs in the early 90s of the past century. This paper also presents some valuable empirical evidences on the benefits and feasibility of cleaner production and energy efficiency enhancement as useful pointers to the scope for improvement.

Cleaner production and waste minimisation interventions that do not exert significant costs can be useful entry points to complement larger systemic changes to improve resilience. While several studies in the past (UNEP, 2003a, 2003b, 2003c; Energy Efficiency Report 2012; FICCI, 2012) have highlighted the importance of these opportunities, industry associations and governments have also launched on capacity building programmes to improve preparedness of SMEs on these lines. These have

however been sporadic and created only a few isolated case examples of success. The majority of SMEs are not yet mainstreamed due to the obvious absence of long term and concerted efforts to capture the low – hanging fruits of waste minimisation and cleaner production including energy efficiency enhancement measures. A predominant focus has been on enhancing access to finance for the benefit of SMEs based on stricter lending norms. It is however equally important to ask if SMEs have adequate technical know how to assess improvement opportunities and adopt preventive management strategies to optimally use the finance they may be assisted with.

SMEs do not have even rudimentary management information systems essential to monitor performance and take appropriate preventive measures. While this is essential for a focused bottom-up strategy, sector level information on the opportunities for intra-sector knowledge transfer and capacity is also sparse. The most important issue is the lack of empirical evidence regarding the precise spread and depth of impacts of the economic crisis; albeit some patchy information about its impact on exports.

Very little is known especially of the individual and synergistic impacts of local economic conditions and in countries SMEs trade with and policy enablers of preventive management. The latter could create a dominant milieu that determines preparedness of SMEs in particular, through a history of regulations, fiscal and non-fiscal measures and institutional arrangements. It is therefore essential to launch on a systematic and integrated assessment of these three cross cutting factors to create a framework for improved resilience against inclement market and financial crises, should such externalities be generated in the future, duly recognising the pervasive influence they will any way exert. Only then will it be possible to conclusively understand the resultant drivers of resilience better.

The present paper:

- 1 Takes stock of insights about the stated importance of SMEs for the economy and their contribution. While it could be obvious that SMEs are indeed quite significant for the economy, it is important to ask if they have been enabled to adopt preventive practices to conserve energy and materials and avoid losses through these streams. This could be the first step towards larger scale resilience because it does not call for large financial or technical inputs from outside the industry and hence almost zero – dependence on external systems.
- 2 Presents information on significant gains achieved by SMEs through energy efficiency enhancement measures and minimisation of material wastes thereby adding to the body of knowledge about some of the well known examples from India. This is with special reference to the ceramic sector in Gujarat wherein much of the work was carried out during the period of the economic crisis. Insights regarding the chemical cluster in the State of Gujarat are also presented to complement the findings stated in the report of the Bureau of Energy Efficiency. These were derived while coordinating field interactions and carrying out assessments as part of the Green Environment Services Cooperative Society cited in the report. This will accordingly serve as the first contribution to the understanding of SME preparedness during the period under consideration.

3 Important considerations of production output by SMEs world over

The global economic crisis has been unprecedented since the Great Depression of the early thirties of the past century, with implications for investments in the manufacturing sector (ASEM Forum, 2010; UNIDO, 2011a, 2011b; Kumar and Singh, 2012). The larger question is whether the risk of a double-dip in recession exists and about the tenure of stimulus packages related to the sustained interest of the industry to invest to improve output and employ. This calls for newer regulations and institutional mechanisms through policies for industrial development in the future to offset adverse effects. The paper indicates a 5% reduction in exports from Asia by the end of 2008, followed by a steeper decline in 2009. The macro economic impact of the crisis on the manufacturing sector is of significance because of the related impact on prices as a function of the intertwined mechanisms of transmission of impacts across countries. This was however reportedly followed by a surge in 2010. There could have been several reasons for the surge.

Export-oriented manufacturing sectors including clothing and textile experienced significant fall in India as in several other countries. It is however difficult to disentangle the impacts of the crisis from the impacts of underlying economic conditions including the influence of policies that allow cheaper products from other countries. SMEs predominantly adopted defensive strategies to tackle impacts including temporary plant closures, strict control on purchases and avoided newer staff recruitment. Some others linked to external sources of funding, diversified products and markets. Some mavericks however tended to view recession as a window of opportunity to improve, innovate and upgrade in addition to strengthening their local trade linkages.

The analysis however does not refer to the scope for a preventive approach that could complement larger systemic interventions. There is a passing reference however to increasing efficiency including better use of raw materials and energy to improve quality of output. This has to be substantiated with empirical evidences. Despite these successful production process related adaptive strategies to tackle competition, SMEs can be susceptible to the impacts of lower cost products that could flood their markets.

The debate on policy responses to the global economic crisis to assist SMEs focused mainly on monetary and related mechanisms through financial institutions (OECD, 2009, 2010). The report highlighted the predicament faced by SMEs in 11 countries in the OECD. Access to financial services continued to be difficult as reiterated by the IFCs Global Trade Liquidity Program. The Bologna + 10 high-level meeting established the case for a green growth strategy calling for a specific focus on technology and management practices in SMEs in particular, in response to such emerging trends as the growing call for climate efficient technologies and production systems. The strategy assumes a multi-pronged approach including removal of barriers for green growth, promoting a trajectory shift through market and non-market instruments, support for transitions by upgrading workers skills and addressing distributional effects of structural change through an integrated accounting framework. This is further substantiated by Iraldo et al. (2010), International Labor Organization (2009), and Ardic et al. (2011).

Governments appear to be keen on keeping financial institutions robust with support to maintain exports by SMEs through a wide variety of interventions that reduce distortions. They also wish to stimulate domestic demand by raising consumer confidence and expenditure to match demand from overseas. They however do not seem to focus on capacity building of SMEs for waste minimisation and energy efficient production systems and reduce dependence on external inputs.

The global financial crisis caused US imports to drop significantly over December 2007 through June 2009 (Nanto and Donnelly, 2011). Subsequently, the trend has been reversed. Nanto and Donnelly cite the World Trade Organization release as of April 2011 that reported rebounds marginally greater than the contraction of world goods exports in 2009.

An excellent review of the structure of SMEs with respect to investment levels has been presented by Senturk *et al.* (2008). They refer to the diverse definitions of the World Bank, and the European Union for instance and their significance for their respective economies. Some of the major advantages appear to be their ability to work with comparatively less capital and management costs. They also trace the evolution of SMEs across several decades and argue that they are not as susceptible as the large industry to economic crises. Limited opportunities for research and development however are amongst the causes for SMEs vulnerability in addition to the effects of negative competition they often are subject to.

The 2010 report of PLANETA and the Danish Teknologisk Institute defines the linkages between the profile, output and activities of SMEs in the European Union from an environmental management perspective. The situation in 13 European countries is considered with respect to the environmental impacts they cause and administrative burden related to compliance with implications for competitiveness and leadership in emerging environmental business opportunities. They indicate that data is rather scarce in this area of policy analysis and that SMEs find it more difficult to comply with environmental legislation than the large industry. However, they reportedly appear to have the potential to take the initiative to achieve significant levels of eco-efficiency twinned with energy efficiency enhancement. A salient finding reported is that SMEs that create significant environmental impacts are likely to invest in environmental solutions to capture the benefits of becoming cleaner and more compliant. The other drivers could be increasing costs of energy, materials and water and newer legislation on compliance.

Muhammad *et al.* (2010) defined the context of competition by SMEs in the global business environment from the Malaysian perspective. They recognise the importance of SMEs for the economy and that the government is assisting them cope with recent economic challenges. They also refer to the influence of trade and capital flows with significant implications for SMEs to improve competitive performance. They however cite literature that highlights difficulties of SMEs in tackling recession due to poor management abilities, technologies and regulatory burden. Maverick SMEs on the other hand become internationally competitive, notwithstanding the overall negative impacts of liberalisation; predominantly through cheaper products that flood the market. Difficulties are further compounded by poor access to sparse resources and capital.

A more recent study of the EIM Business & Policy Research (2011) discussed the scope for market expansion of SMEs in 12 countries in the European Union with respect to other countries including India against the back drop of the crisis. The Dalberg (2011) indicates that SMEs face unfavourable lending conditions due to stricter standards posed by lending institutions post-crisis. Most importantly, the report indicates that data on the impact of the crisis is only now emerging and is presently fragmentary at best. Genia *et al.* (2011) highlighted the importance of information support for SMEs to adopt measures that will improve energy use and that access to finances alone does not create the most suitable milieu for transitions to higher levels of efficiency.

Recently, Chowdhury (2011) assessed the adaptive abilities of SMEs in several countries including China, India, Malaysia, the European Union and the USA. The focus was however, predominantly on the dynamics of credit crisis and market demand and that the impact was not uniform across the globe. While insolvency was reported by SMEs in Denmark, Norway, Sweden, etc., those with significant domestic markets in some developing economies could tide over the crisis. The influence of mechanisms of access to finance and the response of banking systems was reported by Prelipcean and Boscoianu (2012) calling for a more detailed understanding of the determinants of resilient investment strategies.

It will be obvious from the above that the focus of research has been on the dynamics of access to finances and market linkages, with significantly lesser attention on the actual benefits of efficient energy and environmental systems. It is therefore essential to launch on a detailed assessment of the correlates of benefits of improving efficiency to create and sustain market advantages in comparison with the possibility of initial high costs. Such factors as willingness to invest in improvements, proactively consider environmental improvement measures and access information on alternative pathway of production also become important. This is especially so in the context of continually evolving regimes of financing for SMEs that wish to integrate a wide variety of safe guards.

4 Facets of environmental performance that support SME resilience

In this context it will be useful to take note of the some of the predominant initiatives on cleaner production assessments and energy efficiency enhancement that were carried out with a special focus on SMEs including some in the USA and the European Union. This is only to help decision makers recognise the potential of these interventions and duly integrate them with SMEs developmental strategies. Table 1 presents a snapshot of some of the well known initiatives.

Table 1 Some important efforts worldwide and interpretation of preparedness of SMEs to tackle economic challenges and meet environmental standards

Frame work plan of June 2003: Marrakech, Morocco	UNEP (2003a)
Waste minimisation circles, UNIDO, India	UNEP (2003b)
USA small business administration, Industrial efficiency and pollution control project, Indonesia, Eco-efficiency Centre, Nova Scotia and the Community eco management and audit scheme, EU	UNEP (2003c)
SMEs in a globalised world economy	Kuhndt at al. (2003)
Environmental product declaration, Sweden	Piper at al. (2003)
Clean energy and SMEs	LaRocco (2003)
Cleaner production measures in Brazilian SMEs through networks that helped achieved 18 fold savings of water and energy and avoided emissions	Ricardo et al. (2003)

Table 1 Some important efforts worldwide and interpretation of preparedness of SMEs to tackle economic challenges and meet environmental standards (continued)

CEFIC's CARE+ supporting chemical SMEs to improve energy efficiency in Europe through 'intelligent energy Europe' framework, reduced energy cost by 10 to 20%	http://www.cefic.org/Documents/PolicyCentre/Care+-brochure.pdf
Energy efficiency to improve competitiveness of SMEs in Argentina, GTZ. Achieved 15 to 45% reduction in energy consumption in tyre remoulding, bakery, brick production, etc., 2006	http://www.giz.de/Themen/de/SID-C6734E52-DFC83325/dokumente/en-ir-competitiveness-smes.pdf
Significant energy saving potential assessments in India including SMEs, 2010	http://www.asiaesco.org/pdf/presentation/6-2.pdf
Approach to energy efficiency among micro, small and medium enterprises in India, field survey, UNIDO 2011 including contribution of SMEs to India economy	http://www.asiaesco.org/pdf/presentation/6-2.pdf
Energy conservation in polishing section ceramics, SMEs cluster, Morbi, Gujarat, Bureau of Energy Efficiency 2010	http://www.dcmsme.gov.in/reports/morvicceramic/MRV_CRM_Energy_Conservation_in_Polishing_Section_MRV_CRM_EPS_06.pdf
GEF experience	http://www.thegef.org/gef/sites/thegef.org/files/publication/Investing-Energy-Efficiency-English.pdf

5 The Indian context and the western India focus: significant positive evidences

With special reference to India, Mehta (2009) indicates that the global economic crisis retarded her economic growth by about 2.1% compared to the period 2003 to 2008. The National Manufacturing Competitiveness Council of India aims to strengthen SMEs, and emphasises the need for better coordination across departments and the scope for tax instruments to bolster growth. The Micro, Small and Medium Enterprises Development Act 2006 aimed to strengthen these further. Tanuku (2009–2010) argues that SMEs in India were resilient because of lesser dependence on export oriented markets. De (2009–2010) highlights difficulties faced by SMEs in accessing finances. Malla (2010) on the other hand argues that Indian MSMEs were hit hard indeed due to a fall in export market and difficulty in payment realisation. He indicates that about 26 to 30 million MSMEs represent 45% of India's manufacturing sector. This compares with about 68% share in exports through SMEs in China at about 60% share in the manufacturing sector. The Global Innovation Index 2012 (Rajan, 2012) has indicated the need to foster innovation abilities in SMEs in particular on account of a perceived paucity in this ability due to a large number of constraints and establish robust linkages with the large industries.

The Small Industries Development Bank of India in its Annual Report 2010–2011 (SIDBI, 2011) refers to the Prime Minister's Task Force that is developing policy guidelines to support SMEs. A major line of credit from Japan is aimed at improving energy efficiency in SMEs, supported by another line of credit on cleaner production.

Green loan schemes, green rating projects and Programmatic Clean Development Mechanism appear to set the agenda for improved efficiency in the SMEs.

The most recent assessment of the economic challenges faced by MSMEs in India was reported by the Federation of Indian Chambers of Commerce and Industry (2011 and 2012) corroborating the numbers stated above and that obsolete technologies could impede transitions to cleaner and efficient production regimes. The Credit Linked Capital Subsidy Scheme <http://commerce.nic.in/whatsnew/StrategyPaper.pdf> to help upgrade technologies is meant to tackle this lacuna, aligned with India Government strategy to double exports in the next three years.

The significance of waste minimisation and energy efficiency enhancement measures came to light when the Bureau of Energy Efficiency carried out detailed assessments in chemical industries in the Vatva Industrial estate located in the city of Ahmedabad, Gujarat, India. The Green Environment Services Cooperative Society, a forum for collective environmental action in the estate facilitated these assessments. Sixteen focal areas helped derive significant energy savings including 1,35,11,500 kWh electrical energy, 2,20,462 tonnes per annum wood (Dye stuff & intermediate Sector, Winrock International India and 1,23,41,500 Nm³ gas in about 600 chemical dyes and intermediates manufacturing SMEs. These interventions included [http://www.beeindia.in/schemes/documents/smes/clustermanual/Ahmedabad%20\(Chemical\).pdf](http://www.beeindia.in/schemes/documents/smes/clustermanual/Ahmedabad%20(Chemical).pdf) replacement of conventional horizontal agitator system with vertical agitator system, manual filter press with mechanical filter press, matching the centre of motor axis with ball mill axis, conventional gear system with planetary gear system in reaction, improving insulation of hot air generator and distribution system, conventional wood fired tray dryer system with solar tray dryer system, insulation of cyclone system in spray dryers, installation of exhaust gas heat recovery system in spray dryer and conventional v belts with flat belts in various drives.

Earlier technical assistance provided by the Gujarat Cleaner Production Center also <http://www.gpcggujarat.org.in/> also helped achieve significant gains in dyes and intermediates sectors through improved hydrolysis and condensation, efficient use of the chilling plant, good housekeeping, etc. Similar gains have also been achieved in the pharmaceutical sector, textile and fish processing SMEs.

Detailed investigations over 2010–2012 on the energy efficiency enhancement potential in a cluster of ceramic industries established significant savings. Based on these savings a potential of approximately 14 million USD is projected in a group of 500 SMEs. Similar gains have been established earlier in several sectors including dyes intermediates through reduction of consumption of about 55,000 kg caustic per annum with implications for extending the life of scrubbers (20,000 USD/yr) and lesser formation of waste by products and resultant waste disposal and product contaminant losses as a function of lesser use of chlorine (2,000 USD). It was also possible to establish energy efficiency gains in common effluent treatment plants by diagnosing about 11% lesser efficiency performance in pumping systems (4,800 USD). This is true also of some specialty chemicals manufacturing SMEs that gained from enhanced yields, lesser consumption of water in the process and hence lesser expenses, in addition to avoiding several thousand tonnes of carbon dioxide equivalents through emissions. The ECO III energy conservation and commercialisation project of the USAID in India (ECO III Project, 2009) presents detailed insights regarding energy efficiency enhancement opportunities in several sectors including production of chemicals in the city of Ahmedabad in western India and others across the country. It will be obvious from the

above that the potential for savings through energy efficiency enhancement and process improvement measures is indeed quite large. These insights were gathered through interactions and assessments in over 250 SMEs especially in the period of the crisis.

6 Towards an integrated approach to improve preparedness of SMEs to sustain positive roles

It is important to note that SMEs by and large do not have adequate spread and depth of information on the diversity of waste streams, the causes of their origin and management options. This is possibly because the feasibility of achieving and sustaining the desired results has not been demonstrated especially by tackling newer and emerging challenges. Despite the fact that a large number of sector – specific capacity building initiatives have attempted to orient SMEs to the importance and use of relevant information for preventive management, successful implementation of continually evolving preventive strategies is only in a few cases and far between. The typical case in point is of the Cleaner Production Assessments supported by the Department of Forests and Environment of the Government of Gujarat through a World Bank assisted initiative and of the Small Grants Programme of the United Nations Development Programme through the Global Environment Facility framework targeting emission reduction. Industries in the Vatva industrial estate and the neighbouring Naroda Industrial estate have been part of these initiatives and several others including the eco-industrial development framework at the industrial estate level facilitated through the German technical cooperation programme (GIZ). It is important to sustain the gains through longer term programmes that build capacities of SMEs to quantify losses and corresponding gains through preventive practices.

India is launching her 12th five-year plan covering the period 2012–2017. Several mutually reinforcing missions have been developed duly considering the cross cutting imperatives of material and energy efficiency in industry. Lessons and pathways for integrated development emerged out of the mid-term appraisal of the 11th five-year plan (Planning Commission, 2011) including a clear focus on the SMEs. The micro and small enterprises cluster development programme targets capacity building and skill development across four hundred industrial clusters aligned with the objectives of the National Manufacturing Competitiveness Programme. Eco-industrial development and networking could be important thrust areas as part of these initiatives.

The Hacke for model (Hallinan, 2003) offers strength to the networking framework and is applicable even in the Indian context. Useful lessons on the potential of energy efficiency enhancement can be derived also from the recent analysis of the International Energy Agency (International Energy Agency, 2012). Turkey (Turkey Country Report, 2012) and Portugal (Portugal Country Report, 2012) have taken note of the urgent need to facilitate energy efficiency enhancements recognising the impact of the economic crisis. Turkey has the Energy Efficiency Law that is in force from 2009 supported by a dynamic facilitation of regulatory and financial instruments and an energy efficiency project to meet efficiency targets. A fall in energy consumption as a function of lowered productivity has been reported with respect to the crisis period. This is reportedly followed by a rebound in the immediate past. Portugal has defined the National Energy Strategy 2020 and encourages behavioural changes in stakeholders through efficiency enhancement projects.

Initiatives on capacity building by regulatory agencies and institutions are fragmented and most often the impacts are co-terminus with the period of intervention. It is therefore important to address regulations, market mechanisms, adaptations and institutional mechanisms simultaneously. Given the present gaps in information regarding processes and energy consumed vis-à-vis wastes generated it is not possible to rise up to the rigors of assessments on fungibility, accountability, transparency, consistency and measurements especially with reference to carbon credits. It is therefore essential to develop detailed management information systems that incorporate all relevant information in a historic manner to derive appropriate correlations. Investigations in the future should focus on the preparedness of SMEs to adopt these frameworks and accordingly help design continually evolving systems of management. This could help countries with comparable challenges and imperatives of economic growth twinned with environmental protection and efficiency goals.

The most important challenge is probably the market related uncertainty compounded by diminishing finances. It is therefore important for SMEs to reduce losses and improve efficiency through as many preventive techniques as possible; an imperative in a changing environment. Policy makers in regulatory and financial institutions should be enabled to gain useful insights from empirical evidences about the influence these dimensions exert to devise mutually reinforcing management tools. It will then be possible to identify and foster locally relevant and feasible action; essential for sustainable development (Seidel et al., 2008). The need to cater to the specific information and capacity building needs of the SMEs is quite significant. It may be useful to create a framework of technical cooperation that assumes the form of an alliance involving academics in a significant manner. This is based on the premise that SMEs can continue to deliver through the important niche they occupy with respect to the economy of the state and the country. The alliance to save SMEs is an approach that is being discussed with the SMEs in the Naroda and Vatva industrial estates as a dynamic network to demonstrate the feasibility of modifications proposed to deliver. This approach emphasises a locally relevant intervention to provide much needed technical assistance for the benefit of the SMEs, with the scope to capture, embody and interpret information through an interactive management information system essential to diagnose causes of origin of waste streams that can be avoided. Appropriate end-of-pipe and in-process interventions can be proposed to sustain benefits. This will be the starting point for an integrated approach that justifies the economic and environmental benefits for preventive management options; central to sustainable development.

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