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# Zero Defect Zero Effect (ZED) as a Maturity-Based Quality and Environmental Improvement Framework for Indian MSME Manufacturing

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**Abstract- Indian micro, small and medium enterprises (MSMEs) face pressure to improve product quality while also lowering their environmental footprint, yet most existing schemes deal with the two goals in isolation. The Zero Defect Zero Effect (ZED) scheme, cleared by the Government of India under the 12th Five-Year Plan, brings both into a single certification framework. Drawing on the official guidelines [2] and the accompanying model document [3], this paper studies four aspects of ZED: the structure of fifty parameters across five maturity levels; the calculation that turns level marks into ratings from Bronze to Platinum; the three-stage assessment and subsidy arrangement; and the governance role of the Quality Council of India (QCI). Indian evidence on zero-defect practice is confined to case studies, and one of them [5] is examined to illustrate the enterprise-level outcomes against which a ZED-type programme could be judged. The paper makes no claim that ZED certification causes better performance, because the sources reviewed contain no controlled or multi-firm data. It raises design questions on scoring granularity, self-selection and consistency among assessors, and offers an indicator set and a research agenda for empirical validation.**

**Keywords: Zero Defect Zero Effect; ZED; MSME; maturity model; quality management; environmental performance; process capability; India.**

## I. INTRODUCTION

In small manufacturing units, poor quality and environmental burden tend to go together. Scrap, rework and rejected lots waste materials and energy, and weak process control, inadequate maintenance and unplanned layouts push up both defect rates and resource consumption. Even so, the literature on small firms has generally handled quality systems, environmental management and technology upgrading as separate subjects. Studies of environmental management systems in small firms, for instance, emphasise the motivations and barriers specific to adoption [1], while work on smart-manufacturing maturity examines technology readiness apart from quality [7].

The ZED scheme was conceived to assess these concerns together. According to the official guidelines, earlier certifications addressed systematic functioning (ISO), product quality (BIS) and energy efficiency, yet no integrated system rated MSMEs jointly on quality, productivity, energy efficiency, pollution control, finance, human resources, and design and intellectual property [2]. To close this gap, the Office of the Development Commissioner (MSME) and QCI built the ZED Maturity Assessment Model in consultation with credit-rating agencies and industry. Dutta and Dutta [4] present ZED as a pathway to green growth for MSMEs, which positions it as an environmental initiative as much as a quality one.

This paper addresses four questions: (i) how ZED maturity is defined and scored; (ii) which institutional mechanism provides assessment and support; (iii) what evidence exists on enterprise-level effects of zero-defect programmes in Indian industry; and (iv) what should be measured in order to test ZED empirically.

## II. METHOD

The study is a qualitative document analysis. The primary sources are the 2016 scheme guidelines, including the annexure that lists fifty assessment parameters [2], and the ZED model document, which sets

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out the vision, mission and sector parameters [3]. The secondary sources are a small group of peer-reviewed papers on zero-defect practice and on quality and sustainability in MSMEs. Analysis followed four steps: the parameters were grouped by theme; the scoring rules were reconstructed and checked against the worked example in the guidelines; the assessment and funding process was mapped as a sequence of control points; and measurable indicators were drawn out for future testing. No survey, interview or firm-level financial data were collected.

## 1. The Zed Model

### 1 *Principles*

The model is built on two principles. Zero Defect looks toward the customer and means no non-conformance or non-compliance and no waste. Zero Effect looks toward society and means no air pollution, liquid discharge or solid waste, and no wasteful use of natural resources. The stated vision is to lift Indian industry to a position of eminence in the global market through the 'Made in India' mark [3]. The scheme carried a budget of Rs 491 crore for 22,222 MSMEs, of which Rs 365 crore was to come from the Government of India [2].

### 2. *Parameters and levels*

The model contains fifty parameters, each defined at five levels: Struggler, Beginner, Organized, Achiever and World Class. They fall into two groups. Enabler parameters (categories A to N) deal with process design for quality, pre-production, production and maintenance, product design, post-production activities, the environmental counterparts of these, facility layout and materials handling, human resources, outsourcing, and protection of trademarks, designs, copyright and patents. Outcome parameters (categories O to R) deal with outgoing, in-process and field quality, employee involvement, scrap, process capability (Cp/Cpk), overall equipment effectiveness, use of natural resources, energy performance, environmental compliance, turnover growth, operating profit, safety and inventory turnover [2].

Level descriptors progress from absent or reactive practice to measured and continually improved practice. For process capability, the lowest level has no capability data, the middle levels require a Cpk of at least 1.00 for half and then three quarters of critical processes, and the top level requires a Cpk of at least 1.33 for every critical process. Outgoing quality advances from a defect level of 2% or worse to 100 parts per million or better. Thresholds of this kind make the upper levels verifiable, whereas the lower and middle levels of many enabler parameters rest on qualitative phrases such as 'preliminary measures' or 'partially in place', which leave more to the assessor's judgement [2].

### 3. *Scoring and rating*

An applicant must meet twenty essential parameters and at least ten more that suit its sector, so a minimum of thirty parameters are rated. The five levels carry marks of 0, 2, 3, 4 and 5, and the rating follows from the mean mark across the applicable parameters. Table 1 gives the rating bands [2].

Table 1. ZED rating bands [2].

| Average score | Rating |
|---|---|
| Above 2.2 to 2.5 | Bronze |
| Above 2.5 to 3.0 | Silver |
| Above 3.0 to 3.5 | Gold |
| Above 3.5 to 4.0 | Diamond |
| Above 4.0 to 5.0 | Platinum |

Two features of this arithmetic deserve comment. First, the mark scale has no 1: a Beginner receives 2 and a Struggler 0, so the step from the bottom level to the next is worth two marks while later steps are worth one. A unit with many Struggler-level parameters is therefore penalised more heavily than the level descriptions alone would suggest. Second, the mean is simple and unweighted across whichever parameters are chosen. Since only twenty parameters are compulsory, two firms with an identical rating

may have been judged on different parameter sets, which weakens comparison between them. Whether this weighting is suitable is an empirical question that the guidelines leave open.

The worked example in the guidelines [2] shows the calculation. An enterprise rated on 35 parameters, with

18 at Level 5, 12 at Level 4 and 5 at Level 3, obtains (18 x 5 + 12 x 4 + 5 x 3) / 35 = 153 / 35 = 4.37, which places it in the Platinum band.

**2. Assessment Process And Institutional Design**

Assessment proceeds in three stages: a free online self-assessment, a desktop assessment priced at Rs 10,000, and a complete assessment priced at Rs 80,000. An additional ZED-Defence rating, which brings in twenty-five defence-specific parameters, costs a further Rs 40,000. The government meets 80% of the fee for micro enterprises, 60% for small and 50% for medium enterprises, with an extra 5% for units owned by SC/ST entrepreneurs or women or located in the North-East and Jammu and Kashmir, and with preference given to small enterprises; micro enterprises may make up no more than 50% of participants. A rating remains valid for four years, with surveillance audits conducted by QCI. QCI issues the certificate on the recommendation of rating agencies, which must hold QCI accreditation, and assessors must hold QCI certification [2].

The institutional design has three tiers. A Screening and Steering Committee chaired by the Development Commissioner sets policy and reviews applications; QCI serves as the National Monitoring and Implementing Unit; and implementing agencies such as the National Productivity Council, MSME Development Institutes and the Bureau of Energy Efficiency provide awareness, training and consultancy. An Appellate Committee handles complaints about ratings. Assessor quality is controlled through compulsory examinations for assessors and consultants and through QCI validation of a sample of each rating agency's certifications, fixed by the committee at 8% to 10%, with half-yearly reporting [2].

Support after rating is linked to improvement. Certified units may obtain subsidised gap analysis, handholding and consultancy, with consultants paid in four instalments against verified milestones within six months. Re-assessment is subsidised only when the rating improves; otherwise the enterprise pays the full Rs 40,000. Subsidy is thus tied to demonstrated progress, a feature that distinguishes ZED from fee-reimbursement schemes for ISO certification [2].

## III. EVIDENCE FROM INDIAN ZERO-DEFECT PRACTICE

None of the sources examined offers a direct evaluation of ZED-rated firms. The nearest material is enterprise-level case work on zero-defect methods. Karunakaran et al. [5] describe a supplier of refrigeration valves where manual punching of week and year marks on stop valves led to 587 rework cases during the observation period. Using Pareto analysis, cause-and-effect analysis and why-why analysis, the firm substituted an on-line punching system for the manual operation. The authors report that punching cycle time dropped from 9.17 to 4.18 seconds, productivity increased by 36%, rework and the rejection of 29 units fell to zero, and the annual cost saving was Rs 4,72,503. Gains in delivery, safety and operator morale were also reported through a productivity, quality, cost, delivery, safety and morale (PQCDSM) framework [5].

The case shows how defect reduction can be documented at process level and how results correspond to ZED outcome parameters such as in-process quality, scrap, delivery and safety. It also exposes the limits of the available evidence: it concerns one product in one firm, has no comparison group, presents before-and-after figures over a short period, and does not measure environmental effects. It therefore cannot indicate what a certification programme achieves across many firms, and the authors themselves acknowledge that the study is confined to a single product [5].

## IV. DISCUSSION

- **Integration.** The main design contribution of ZED is to place quality, environmental, human-resource, design and financial outcomes on a single scale. The rating logic presumes that these capabilities improve together, and this can be tested: a firm with high process-capability scores should also show low scrap and

lower specific energy consumption if the presumed link between defect reduction and resource efficiency holds.

- **Assessor consistency.** Because many level descriptors are qualitative, the same firm might be rated differently by different agencies. QCI's sample validation addresses this in principle, but the

guidelines do not state how disagreement rates will be measured or published [2].

- **Self-selection.** Enterprises join voluntarily and bear part of the fee, so participants are probably more quality-conscious than non-participants. Any performance gap between certified and uncertified firms could therefore reflect selection rather than the effect of the scheme.
- **Capacity and awareness.** The scheme earmarks substantial funds for awareness, on-site training in remote regions and the training of officials and assessors, which suggests that its designers expected low awareness and limited technical capacity among small firms [2]. The literature on environmental management in small firms points to comparable barriers of cost, skills and motivation [1], and research on technology adoption in SMEs stresses readiness gaps [7]. How much each barrier matters among ZED applicants remains to be measured.

## V. INDICATORS AND RESEARCH AGENDA

To test whether ZED participation improves performance, studies should follow a common set of indicators taken from the model's own outcome parameters: outgoing quality (ppm), in-process first-pass quality, scrap as a percentage of sales, Cp/Cpk of critical processes, overall equipment effectiveness, specific energy consumption, percentage of water recycled, environmental compliance record, on-time delivery, turnover and operating-profit growth, and lost-time safety measures. Suitable designs include (a) before-and-after studies of certified units over at least three years; (b) matched comparisons with non-participating units of the same sector and size class; (c) analysis of rating transitions between assessments to identify which parameters drive upgrading; and (d) studies of agreement between assessors reviewing identical evidence. Cost-effectiveness should also be examined by setting the subsidy and the enterprise's own expenditure against measured savings, in the manner of the cost figures given in [5]. Work on energy efficiency in smart factories [6] and on sustainability transitions in traditional manufacturing sectors [8] supplies further concepts for the environmental side of such studies.

## VI. CONCLUSION

The ZED model is an ambitious effort to give Indian MSMEs one staged pathway that connects defect prevention with environmental responsibility. The official guidelines specify its fifty-parameter, five-level structure, the thresholds for upper levels, the improvement-linked subsidy and the QCI-based governance clearly [2]. What the available sources lack is evidence of effect: the only enterprise-level results found are single-firm case studies of zero-defect methods. The analysis here thus supports a description of the design and an agenda for measurement, not a claim of demonstrated benefit. Multi-firm, comparison-based studies built on the outcome indicators above are the necessary next step.

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