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METHODS FOR IMPROVING THE OPERATIONAL EFFICIENCY OF LAND RECLAMATION MACHINERY IN IRRIGATION CANAL CLEANING AND RECONSTRUCTION

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Abstract

The paper examines technical and organizational methods for increasing the productivity, reliability, and resource efficiency of machinery used for irrigation canal desilting, vegetation removal, bank reshaping, and reconstruction. A literature-based analytical approach integrates canal condition surveys, machine-to-task matching, optimized excavation and spoil transport, preventive maintenance, digital positioning, and performance indicators. A comparative table identifies suitable equipment and limiting operating conditions. A conceptual workflow diagram presents an integrated improvement sequence. The review indicates that effective mechanization depends not only on nominal engine power or bucket capacity but also on canal geometry, moisture conditions, site accessibility, transport logistics, hydraulic requirements, and the quality of planning. The proposed framework can guide engineering decisions; site-specific productivity gains must be confirmed through field trials.

Keywords: irrigation canal; land reclamation machinery; desilting; reconstruction; excavator; operational productivity; maintenance; mechanization.

Introduction

Irrigation canals are exposed to sediment accumulation, vegetation growth, erosion, bank instability, and deterioration of lining and hydraulic structures. These processes reduce conveyance performance and increase maintenance expenditure. Canal cleaning and reconstruction therefore require a coordinated combination of earthmoving machinery, transport units, surveying equipment, and hydraulic engineering measures. FAO guidance stresses that maintenance demand differs substantially between earthen and concrete-lined canals and that sediment deposits are not uniformly distributed along canal reaches (Food and Agriculture Organization of the United Nations [FAO], n.d.-a).

The relevance of more productive and efficient canal maintenance is particularly high in Uzbekistan. The World Bank (2025) described an irrigation-modernization program involving canal lining, re-sectioning, and improved water-control infrastructure. The objective of this thesis is to systematize practical methods of raising machine utilization, lowering avoidable idle time, and maintaining the design parameters of irrigation canals without compromising safety or environmental protection.

Main Part

Before equipment mobilization, engineers should map canal cross sections, sediment thickness, bank accessibility, water levels, buried utilities, and locations of structures. Approximate sediment quantity between two surveyed sections can be assessed with the average-end-area method: $V = [(A_1 + A_2)/2] \times L$, where A_1 and A_2 are sediment cross-sectional areas (m^2) and L is the distance between sections (m). Repeated section measurements improve work-volume estimates and prevent over-excavation (FAO, n.d.-a).

Machine selection should be based on canal width and depth, reach requirement, soil properties, the possibility of draining the canal, and spoil-disposal distance. Long-reach hydraulic excavators are

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useful for many bank-accessible canals, while draglines are appropriate where reach and side-casting are important. Amphibious excavators or dredging equipment may be necessary in continuously wet reaches. Graders and bulldozers support access-road preparation, berm reshaping, and spoil leveling, but should not replace specialized equipment where slopes or lining are vulnerable (FAO, n.d.-a; FAO, 1992).

Table 1. Equipment selection and efficiency-improvement opportunities

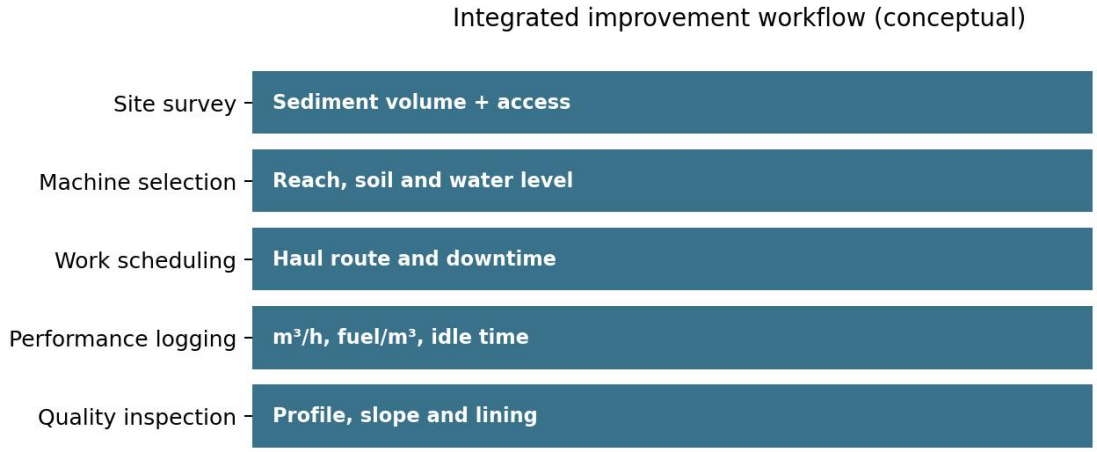
Machinery / operation	Suitable conditions	Efficiency improvement method
Long-reach excavator / desilting	Bank-accessible earth canals; moderate sediment depth	Match boom reach and bucket type; reduce repositioning and unnecessary passes.
Dragline / sediment removal	Wide or deep reaches; side-casting possible	Prepare stable working pads and spoil setbacks; plan continuous travel.
Amphibious excavator or dredger	Wet beds or water cannot be fully diverted	Match dredging method to sediment and water-quality constraints.
Grader and bulldozer / reconstruction	Berms, service roads and earth shaping	Sequence bulk grading after sediment removal; minimize rehandling.
Tipper trucks / sediment transport	Disposal or beneficial-reuse locations off-site	Balance hauling fleet to excavator output; organize loading loops.

Performance management requires simultaneous monitoring of productive machine hours, setup and waiting time, fuel use, effective excavated volume, and rework. Effective productivity can be expressed as $Q_e = V_a/T_o$ (m³/h), where V_a is the accepted excavation volume and T_o is total on-site operating time including unavoidable delays. Specific fuel consumption is $F_s = F/V_a$ (L/m³). These indicators allow comparison across work shifts after adjustment for material type and excavation difficulty.

An illustrative planning example clarifies the importance of utilization: for a machine with a theoretical output of 60 m³/h, increasing productive utilization from 0.55 to 0.70 changes the calculated effective output from 33 to 42 m³/h. This is a mathematical scenario—not an observed experiment or a generalized expected improvement. Actual production must be measured on site, particularly because wet working conditions and haul distances can alter equipment performance (FAO, n.d.-a).

Figure 1. Proposed operational-efficiency improvement workflow

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Digital terrain models, GNSS-assisted guidance where appropriate, and machine telematics can support more consistent excavation geometry and reveal underutilized shifts. However, positioning technology requires calibration, and work near bridges, utilities, unstable embankments, and lined sections still demands direct supervision. Preventive maintenance, safe access routes, routine inspection of hydraulic components, and operator training reduce the risk of failures and accidental damage (U.S. Bureau of Reclamation, n.d.-a, n.d.-b).

Reconstruction needs particular attention to hydraulic compatibility: excavation should restore the approved canal profile rather than simply maximize removed sediment. Lining repair, joint integrity, seepage prevention, and embankment stability should be checked before commissioning. Vegetation management must be scheduled systematically because plant growth raises flow resistance and accelerates deposition (U.S. Bureau of Reclamation, n.d.-c, n.d.-d, n.d.-e). Environmental safeguards include sediment characterization where pollution is suspected, controlled spoil disposal, turbidity management, and preventing fuel leakage into watercourses (FAO, 2002; FAO, n.d.-b).

Conclusion

The operational efficiency of land reclamation machinery can be enhanced through accurate sediment-volume surveys, rational machine selection, coordinated excavation and haulage, improved fleet utilization, preventive servicing, and quality-controlled reconstruction. Assessment should combine productivity (m^3/h), unit fuel consumption (L/m^3), schedule adherence, and conformity with the design canal section. The presented methodology provides a practical basis for maintenance planning but does not claim experimentally established savings. Future research should test machine combinations at comparable canal sections and measure productivity, fuel use, costs, and hydraulic outcomes under real working conditions.

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