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**Intelligence solutions and machine learning applications
to budget for the Sustainable Development Goals:
integrated Budget Intelligence Toolkit****Summary**

Cascading systemic shocks have exacerbated the challenges that Arab economies face in managing their limited fiscal space to finance the Sustainable Development Goals (SDGs). The perennial question remains: how can Governments effectively deliver quality public goods and services while attending to the diverse range of socioeconomic and environmental priorities within persistent budgetary constraints. Successful, risk-informed financing solutions therefore hinge on prudent financial planning, management, and budget execution. Yet, all financial decisions face an anomaly of risks arising from several layers of dissonance, both explicit (where only limited public funds are available to deal with diverse SDG priorities) or implicit (when public spending collaterally degenerates SDG outcomes). Nevertheless, evidence-based assessments on how the two risk strands interact and on how budget expenditures impact SDG performance at the country level are almost non-existent.

Recognizing the importance of SDG-centric public financial management and budgeting for the SDGs, the Economic and Social Commission for Western Asia (ESCWA) developed an integrated Budget Intelligence Toolkit (i-BIT) that enables policymakers to identify the most impactful budget lines with proven influence on advancing the SDGs. The primary objective of the i-BIT is to optimize available fiscal space, maximize SDG progress, harness SDG synergies, enhance public spending efficiency, and provide insights to ensure budget credibility and the sequencing of financing decisions.

The Committee on Financing for Development in the States Members of the Economic and Social Commission for Western Asia is invited to take note of the potential financing solutions offered through the i-BIT to support the transition to SDG budgeting, enhance public financial management, support budget planning/execution and ensure higher returns on fiscal space that maximizes SDG progress.

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Introduction

1. Following the fallout from the COVID-19 pandemic and the war in Ukraine, the Arab region has been grappling with a triple crisis of food, fuel and climate, prompting many Governments in the region to adjust their spending and consumption patterns. Amid rising inflationary pressures, Arab Governments have faced a multitude of investment/disinvestment decisions. National ministries, public agencies and state-owned enterprises may not be fully geared to react promptly or effectively to the decline in purchasing power, which can hinder their ability to maximize the impact of taxpayer funds and deliver quality public goods and services. While inflationary pressures may eventually subside, the cascading crises raise, yet again, a perennial question: how can Governments meet the diverse development priorities of the people they serve while managing fiscal constraints and honouring existing budgetary commitments?

I. Addressing the fiscal policy trilemma: budgeting for the Sustainable Development Goals

2. Addressing this fiscal policy trilemma requires successful risk-informed financing solutions, including advancing prudent financial planning, management, budget execution and evaluation. Yet, all financing decisions across the budget cycle face an anomaly of risks arising from several layers of dissonance, both explicit (i.e., when resource mobilization capacities do not render anticipated public revenues, or where only limited public funds are available to address a diverse – and at times conflicting – range of Sustainable Development Goals (SDG) priorities) and implicit (i.e., when funds spent in a particular functional domain collaterally degenerate SDG performance in another). While the latter risks brew interest in sustainable financing, the former prompt the need to harness SDG synergies. Nevertheless, quantitative evidence-based assessments of how the two risk strands interact and how different budget expenditures impact SDG performance at the national level are almost non-existent in the Arab region and at the global level.

3. Budgeting for the SDGs (B4SDGs) enhances decision-making processes by optimizing the allocation of public resources across different budget lines. It identifies the specific budget lines or budgetary allocations that have consistently demonstrated a positive influence on SDG progress, taking into account both direct and indirect interactions among the targets within the 17 SDGs, as well as the interplay between those Goals and the intertemporal budget itself. B4SDGs offers insights on the effective delivery of public goods, the effective use of public resources, and the efficiency of budget planning, delivery and evaluation. It enables policymakers to ensure that public investments (whether capital or recurrent, and whether mobilized through domestic, international or debt leveraging) are consistently rendering the desired impacts in a sustainable manner, not only in terms of financing, but also in terms of safeguarding incremental SDG progress.

4. The limited availability of internationally endorsed empirical techniques and theoretical foundations for B4SDGs can be attributed, in part, to the complexities associated with tracking the utilization of budgetary allocations and assessing the effectiveness of different public expenditures in achieving their intended outcomes at the national levels. The inherent intricacies of the SDG framework itself present an additional challenge when it comes to quantifying interlinkages (both synergies and trade-offs) among its 232 indicators, some of which may not be directly quantifiable. The absence of a standardized methodology for measuring socio-economic or environmental well-being, along with the difficulties in obtaining high-frequency data to monitor SDG performance and establish links between performance and the intertemporal design of the budget and medium-term expenditure frameworks, poses significant obstacles to effective budget planning and evaluation.

5. Establishing SDG-budget markers/interactions requires detailed, consistent and reliable data to trace SDG performance at the indicator level and equally track budgetary outlays and how they are spent over long-time horizons. An important consideration for B4SDGs is that SDG interlinkages and their reaction to public expenditures are a dynamic consideration, unique to each country, and their magnitude (scale and direction of influence) remains in a state of flux. This is because SDG performance and budget resources and allocations oscillate owing to a host of considerations, including changes in consumption/production patterns,

technological advancements, the structure of the economy and a country's capital and resource endowments, boom-bust cycles, austerity, and rent-seeking, as well as the nature of reforms enacted by Governments.

6. B4SDGs is further complicated by the absence of a theoretically-backed economic framework or established empirical methodology that links SDG progress to government spending and domestic public resource mobilization capacity. Traditional econometric and statistical methods cannot be applied to capture the dynamics of this relationship at the national levels, which is needed to deliver robust evidence-based practical guidance to integrate the SDGs in national budgets; to identify the optimal allocation of budgetary resources in a way that maximizes SDG outcomes simultaneously along the 17 SDGs; and to establish with a high degree of confidence the budget lines that directly and indirectly contribute to the advancement of the SDGs. An accurate representation of this relationship is also needed to capture how SDG interlinkages manifest themselves in national contexts and to account for asymmetric development levels and inherent trade-offs in public spending decisions.

II. The shifting paradigm on SDG-budgeting: the power of machine learning

7. The integration of machine learning (ML) and artificial intelligence (AI) into economic research has grown rapidly in recent years. Advancements in computing power and the development of increasingly sophisticated algorithms have made it possible to forecast, project and simulate the behaviour of economic variables and their trajectories with greater accuracy than ever before. These new technologies and their various applications uncovered new insights and relationships, free from traditional pre-specified assumptions on the stochastic relationship between input and output variables. These insights include assessing how national budgets impact SDG performance and how they can be optimized to improve countries' sustainable development trajectories and prospects.

8. Machine learning applications garner appeal as they overcome major limitations of standard regression analysis, namely its inability to capture the dynamic relationships and behavioural interactions involved in the process of B4SDGs. As mentioned earlier in the document, there is no established economic theory that standard regression models can resort to in order to fully capture the complexity of the interaction between the different budget lines (along the Classification of the Functions of Government (COFOG)) and their direct and indirect impacts on SDG outcomes.

9. Given that a host of unknown determinants affect SDG performance – other than apparent or measurable public spending decisions – multiple factors need to be accounted for when assessing the impact of public spending on the SDGs, including the effect of the different public sources of financing, the efficiency of spending and government procurement, asset management and overall project-based implementation capacity and efficiency, and the operational efficiency of state-owned enterprises.

III. Introducing the i-BIT

10. With the aim of offering a solution to the fiscal policy trilemma and associated B4SDG challenges listed herein, the Economic and Social Commission for Western Asia (ESCWA) developed an integrated Budget Intelligence Toolkit (i-BIT). The i-BIT fills a knowledge gap in public financial planning and management, and is among the few tools that quantitatively unravel the impact of general government expenditures on SDG performance at the national level, and inherently account for country-specific idiosyncrasies, including the conditions dictating economic rationalization and fiscal consolidation. The i-BIT enables Arab Governments to establish how to link available resources to desired outcomes, boost the impact of public resources and enhance the returns on taxpayer funds. Through the i-BIT, Governments can maximize their fiscal space and enhance public spending efficiency while optimizing SDG outcomes and the returns on domestic public resources mobilized to advance the social compact.

11. The i-BIT employs a supervised machine learning technique to provide an integrated set of budgeting tools with dynamic features to address some of the most pressing questions related to the advancement of sustainable development at the national level. It is specifically designed to overcome several aspects facing the transition to SDG-budgeting. The i-BIT is a data-driven, country-tailored application that captures intertemporal budget variations/constraints and serves as a catalyst to accelerate the transition to evidence-based SDG-centric budgeting.

12. The i-BIT offers a dynamic AI-powered medium. It has been tested in several Arab economies and showcased in the 2023 Financing Sustainable Development Report. The i-BIT provides unique insights for policymakers, notably that SDG progress is not solely dependent on how much Governments spend (scale), but also on how resources are allocated and spent (direction and efficiency of spending).

13. The i-BIT is able to establish the links between the different budget lines (in terms of scale and direction) and the corresponding influence on SDG performance. The employed machine learning technique identifies the specific relationship between each budget line (explanatory variables) and the corresponding reaction on the 17 SDGs, along all measurable indicators (dependent variables), optimizing the balance between variance and bias of the model. Whether policymakers seek to evaluate the extent by which the budget has been advancing the SDGs across time or determine how to effectively distribute additional financing or rationalize spending (while optimizing the use of available fiscal space to maximize the impact of public spending on the economic, social and environmental dimensions of sustainable development objectives), the i-BIT offers the necessary insights and answers to the following questions surrounding the optimization, efficiency and alignment of budgets with national development priorities:

- (a) Which budget lines are consistently advancing/regressing the SDGs at the national level?
- (b) How impactful are budget spending allocations and decisions in advancing SDG performance?
- (c) What is the contribution of current spending on SDG performance among other financing sources?
- (d) Is the current budget optimally aligned and effectively advancing SDG performance?
- (e) How can budgetary allocations be re-distributed to render maximal SDG outcomes?
- (f) How can Governments optimize current spending patterns while securing SDG progress?
- (g) What is the optimal allocation of the budget that advances the SDGs given a need for austerity?
- (h) How much more could the SDGs progress if the additional financing was optimized?
- (i) How much additional public resources need to be mobilized domestically and internationally to meet the national sustainable development priority?

IV. Exploring i-BIT features and functionalities

14. The i-BIT is embedded with 5 dynamic tools that furnish 40 applications, with 10 distinct features across 4 policy-priority scenarios that are linked to the SDG-costing and financing of ESCWA. Through this integrated system of functionalities, the i-BIT provides a holistic appreciation of a wide array of financing for development interactions.

15. **Tool 1- Budget Compass:** This tool is able to identify the configuration of budget lines that have consistently been advancing or regressing SDG outcomes, giving a dissection of how SDG interactions reveal themselves at the national level. By doing so, the Compass singles out the budget lines that are directly and indirectly responsible for advancing/regressing a country's SDG performance and provides insights on how SDG interlinkages manifest themselves in national contexts during a specified timeframe given the intertemporal variation in public spending.

16. **Tool 2- Budget Connectivity Evaluator:** This tool establishes the degree by which the current budget – or a proposed variation thereof – is advancing/regressing SDG performance across each of the 17 SDGs, along all measurable indicators. Through this tool, policymakers can assess with a high degree of confidence how current or proposed budgets are influencing (both directly and indirectly) SDG progress, and how fiscal space associated with intertemporal budget constraints is influencing SDG performance.

17. **Tool 3- Budget Optimizer:** This tool renders a simulated outcome of how an optimal budget allocation should look like to guide decisions towards enhancing public financial management. The tool identifies the optimal distribution and allocation of public funds through the budget (by function and sector) and is able to simulate the effect of austerity decisions while maximizing SDG outcomes or to control for potential damages arising from foreseen budget cuts. The tool is embedded with several features that detail the scale of budgetary outlays that optimize SDG progress on each goal or a combination thereof. It exploits algorithmic SDG-budget reactions and SDG synergies to deliver its assessment, which provides insights on the scale of resources that ought to be allocated -at the budget line level- to maximize both the direct and indirect impacts responsible for progressing each SDG distinctly and overall sustainable development outcomes. The tool also provides two distinct applications to simulate two contrasting budget decisions of expansionary versus austere/rationalized fiscal policy (austerity or damage control scenario), be it brought about by boom-bust economic cycles or unforeseen international shocks. In its first application, the tool provides an estimate of SDG progress achievable in the short term, while the second application associated with disinvestment or rationalization of public spending provides a depiction of the optimal budget distribution that minimizes the losses in terms of SDG performance.

18. **Tool 4: Budget Alignment Estimator:** This tool is able to determine the contribution of each budget line to the SDGs. By doing so, policymakers are able to improve budget outcomes by either changing the scale of resources assigned to each budget line or the distribution of available funds to impact selected SDGs or a combination thereof.

19. **Tool 5: SDG Budget Financing Simulator:** This tool provides policymakers with a holistic appreciation of the country's financing exposures and propensities to achieve the SDGs by connecting the results of the i-BIT with the costing and financing simulators of ESCWA. The SDG Budget Financing Simulator is able to show, through a series of interactive graphic representations, the SDG progress that could be achieved for any given budget allocations in terms of bridging the SDG-financing gap, as opposed to the potential SDG progress that could be achieved by optimizing the efficiency of budgetary allocations in terms of both scale and direction.

20. Four different versions of i-BIT are available depending on policy-making priorities:

(a) In the baseline scenario, all SDGs are given equal weight within the Government's priorities. In other words, the baseline scenario assumes that the policymaker wants to optimize the distribution of budgetary outlays to maximize the progress on all 17 SDGs at the same time;

(b) Under a socially conscious scenario, priority is assigned to SDG 1 (no poverty), SDG 2 (zero hunger), SDG 3 (good health and well-being), and SDG 4 (quality education). In this scenario, the i-BIT takes its cue from the government priorities to progress social-related SDGs. Consequently, the i-BIT can be used to monitor progress towards achieving the specific national targets and suggest the reallocation of budgetary resources in a way that supports this aim;

(c) In the economically biased scenario, priority is given to SDG 8 (decent work and economic growth), SDG 9 (industry, innovation and infrastructure), SDG 10 (reduced inequalities), and SDG 11 (sustainable cities and communities). As in the socially conscious scenario, the i-BIT follows the government's priorities by concentrating public spending on the budget lines that positively affect these goals while factoring the trade-offs arising from the allocation of resources on budget lines that hold back economic progress;

(d) In the environmentally friendly scenario, the same premise is applied. Priority is given to SDG 7 (affordable and clean energy), SDG 13 (climate action), and SDG 15 (life on land). The i-BIT is then aligned

to the government's priorities, focusing public spending on the budget lines that positively affect these goals, while disinvesting the budget lines that hold considerable adverse or negative impacts on the environment.

21. The i-BIT metrics are versatile and can also be adapted to capture various combinations of goals and targets drawn from any national-specific priority configuration. This feature allows for the simulation of alternative scenarios tailored to support the evolution of national sustainable development strategies. Navigating the complex and ever-changing financial landscape is an arduous task, particularly in the absence of clear evidence to guide how public resources should be allocated to achieve desired developmental outcomes. Bridging the gap between financing decisions, their policy implications and ultimate outcomes is crucial to enhancing the effective use of domestic public resources, achieving greater financial transparency and policymaking agility, and ensuring optimized development outcomes.
