

**A Model of National ICT Policy for  
Sustainable Development of Ghana:  
A System-theoretic Approach Based on SOCAR (Separation of  
Concerns, Aspects & Roles) Analytics**

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*This is a technical contribution. It does not imply an offering of Securities.*

## 1. Introduction

This paper presents a semi-formal model to be used as a framework for discussing, crafting and executing Ghana's National ICT Policy. It emphasizes the semi-structured, analytic paradigms of SOCAR (separation of concerns, aspects and roles) and SWOT (strengths, weaknesses, opportunities & threats).

Formulating and implementing a national ICT (information and communications technologies) policy is a fairly complicated undertaking. Like similar complex endeavors such as building skyscrapers, ships, aircraft, spacecraft, airports, road and transportation networks, etc., a semi-formal model (or *architectural plan*) can act as a *map* for guidance and orientation. The model can highlight the interrelationships, inter-dependencies and context-sensitivity of the various components. It can also be used to establish criteria for evaluating, monitoring, adjusting and updating the National ICT Policy that eventually emerges.

One small illustration of the fundamental power of ICT in modern life is that the theoretical tools that underlie ICT can be used in describing the model and the derived ICT policy. Thus, the ICT policy itself, like most information and knowledge representations can be self-referencing and introspective.

### 1.1. Characterizations of (Sustainable) Development

The type of Development of interest in the National ICT policy is Economic and Political Development. Nevertheless, it is also a given that once the economic-political development is established, other related types of development will also have the room to flourish, including social development, cultural development, personal development, gender development, youth development, generational development, ethnic development, tribal development, religious development, urban development and rural development.

The term *sustainability* as a modifier for Development is meant to convey the requirement that Politico-Social Economic Development must be long-lived, progressive, evolving and capable of adaptation, fault-tolerance (repair, adjustment and maintenance), migration and transition. The sustainable aspect can be likened to running a marathon, climbing a mountain, or even a marriage. In all such endeavors, there is typically enthusiasm at the beginning, the so-called "honeymoon" period, when the participants are eager and energized and everything seems to be possible and full of potential. What is typically harder to maintain is continuity and upkeep over the long-term.

Therefore, one immediate requirement (derived from sustainability) in the ICT Policy is the need for Political Continuity. This means that the National ICT Policy should be formulated in a manner that ensures it survives (peaceful) transitions of the government of the country. One immediate good test is that it should incorporate elements that are identifiably continuous and compatible with the relevant aspects of the Vision 2020 of

the previous Ghana government.

It is important that it is recognized that a “successful” implementation of any effective National ICT and Development Policies, when positive results can be demonstrably and measurably apparent, is likely to take a period of at least 20 to 30 years. This planning horizon covers (optimistically) the lifetimes of 3 to 4 constitutionally mandated changes in the presidency, (with each President serving no more than 2 terms, each term being of the duration of 4 years).

## 1.2. Characterizations of ICT

ICT (information & communications technologies) is a modern term that now embraces and encompasses several others that were used in the immediate past (since the 1960's), including, IT (information technology), Informatics, Telematics, computerization, DP (data processing), EDP (electronic data processing), and ADP (automatic data processing).

Some of its aspects and components include computers, hardware, software, firmware, electronics (for computing), micro-electronics, consumer electronics, industrial electronics, semi-conductor technology, nano-technology, MEMS (micro-electronic & mechanical systems), telecommunications, telephone networks, data communications, fax networks, telegraph networks, telex, satellite communications, radio communications, wireless communications, cellular communications, mobile communications, coax cable networks, fiber optics networks, WDM, ISDN, ATM, LANs (local area networks), MANs (metropolitan area networks), WANs (wide area networks), GANs (global area networks), DANs (desk area networks), HANs (home area networks), CANs (campus area networks), SANs (storage area networks), PANs (personal area networks), Internet, intranets, extranets, ultranets, (national) information infrastructure (NII), (national) data / information superhighway, Web or online services, email, e-commerce, information utilities, information “dial-tone,” RCMT (representation, content & media technologies), and C3L (communications, computing & content logics), MIS (management information systems), IS (information systems), EIS (executive IS), DSS (decision support systems), OLTP (online transaction processing), OLAP (online analytical processing), document management systems, data warehousing, workflow systems, collaborative groupware, interactive media, sci-data viz (scientific/data visualization, modeling and simulation), computer graphics, etc. There are also several ICT related terms that cover vertical market segments.

A robust characterization of ICT, (that will withstand the vagaries of changes in conceptual fashions and tastes), is that it encompasses the **automation** of the *information* and *meta-information* (meta-object) aspects and representations of people, items, goods, systems, tools, equipment, instruments and machinery. It necessarily embraces *data capture* (gathering, collection, entry, acquisition, measurement); *data storage* (recording, archiving, logging), *data retrieval*, *data processing* (manipulation, calculation, computation, analysis, modeling, representation, presentation, simulation); and *data*

*communication* (transfer, flow, interchange, exchange). The term *data* is meant to include data, information, knowledge, represented intelligence / know-how, content and media (text, images, audio, video, hypertext, picture, etc.).

As will be described below, such information automation can be used in all industry and commercial sectors, and for all organizational and institutional transactions, processes, routines and procedures. For example, industrial automation, hospital automation, educational technology and automation, government automation, bureaucracy automation, and transportation automation.

It is also important to note here that ICT can only exist in the context of another group of technologies that may be labeled as *MMIT* (mechanized & motorized industrial technologies) or *MEMOT* (mechanized energy & material objects technologies).

## 2. Semi-Formal SOCAR Models

### 2.1. Economic Development

Economy (and Economic Development) can be represented as the engine, mechanism, tool or driver to effect a transition between the present social/economic condition or *State*<sub>PRESENT</sub> (which is deemed undesirable), to a future social/economic condition *State*<sub>DESIRABLE</sub> (which is deemed more desirable).

Economic/Political/Social (Conditions/Status) *State*<sub>PRESENT</sub> → **Economy/Development** → Economic/Political/Social (Conditions/Status) *State*<sub>DESIRABLE</sub>

Under-developed,  
Undeveloped,  
Less developed,  
Developing,  
Emerging,  
Least developed  
Poor

→

Advanced,  
Developed  
Industrialized,  
Modern,  
Wealthy



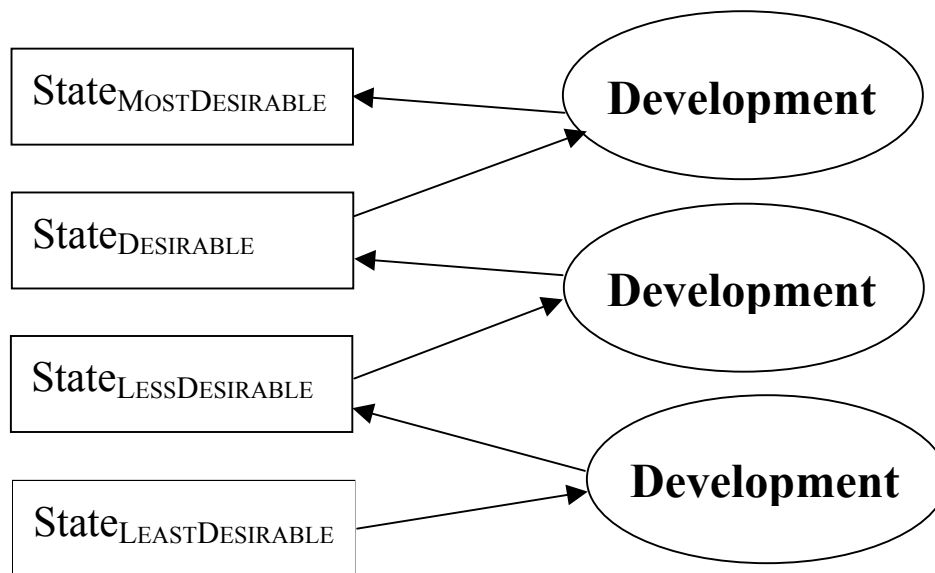
The above representation is an example of a 2-state *transition net model* of (sustainable) Economic Development.

To be more realistic, one can explicitly represent the Development to be a sequence of state transitions through a gradation or spectrum of states, characterized semi-formally by such fuzzy-theoretic terms as:  $State_{UNDESIRABLE}$ ,  $State_{LEASTDESIRABLE}$ ,  $State_{LESSDESIRABLE}$ ,  $State_{DESIRABLE}$ , and  $State_{MOSTDESIRABLE}$ .

Economic Development (ED) operates as the engine or tool for transition between consecutive states:

$$State_{LEASTDESIRABLE} \xrightarrow{\begin{matrix} E \\ D \end{matrix}} State_{LESSDESIRABLE} \xrightarrow{\begin{matrix} E \\ D \end{matrix}} State_{DESIRABLE} \xrightarrow{\begin{matrix} E \\ D \end{matrix}} State_{MOSTDESIRABLE}$$

One can also visualize the States as being stacked one top of each other on a cylinder and the Economical Development (ED) transitions link the  $State_X \rightarrow State_Y$  in a helical or spiral structure. This extended state transition sequence enables the modeling of such intuitive developmental concepts such as “leapfrogging” and “skip-level” crossing of Developmental stages. Without a loss of generality, this multi-stage extension of the transition net model will not be considered further in this report.



A set of *indicators*, measures, criteria and *indices* can be used to characterize each Socio-Economic  $State_x$ . Several such indicators and indices are available from the UN technical agencies such WHO, UNESCO, ECA, etc., and other multi-lateral organizations such as the World Bank and IMF, to describe the national *standard of living* and *quality of life*.

Semi-formally, all the items and entries that go into socio-economic indicators for each Socio-Economic  $State$  can be grouped, classified and reduced to Abram Maslow's

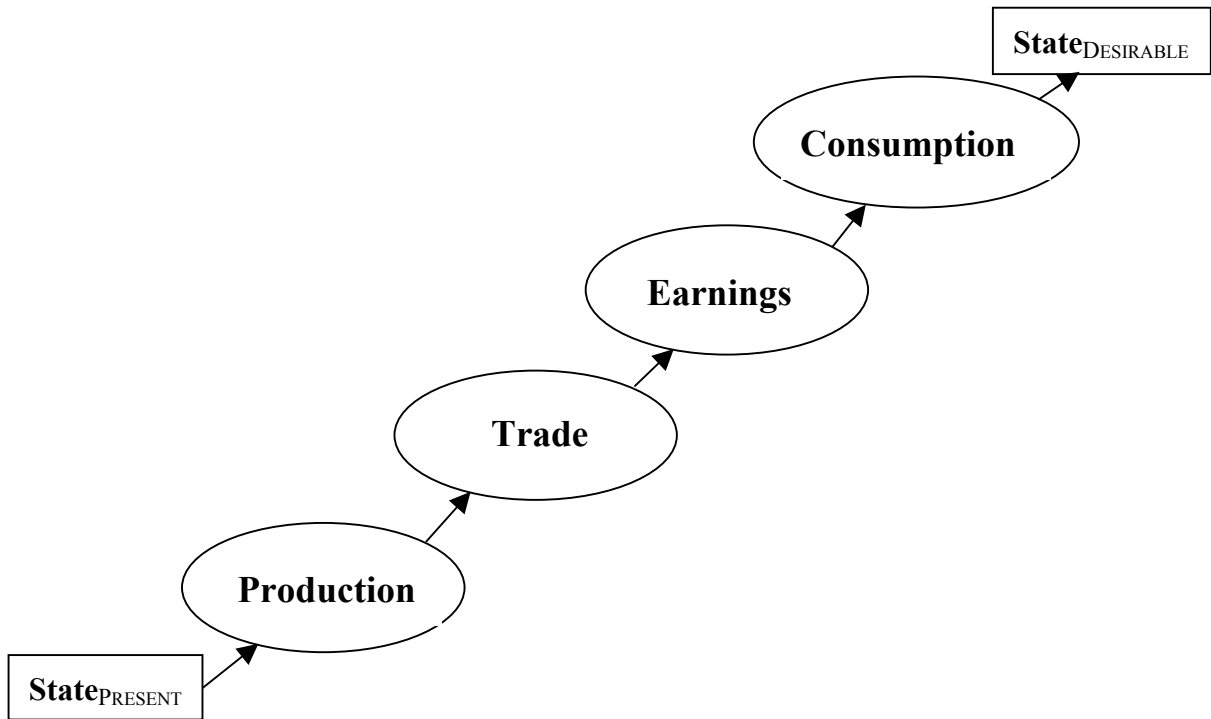
hierarchy of (human) needs and the degrees of their satisfaction in that *State*. Namely,

<i>Food</i>	Nutrition, Diet, Hunger, Starvation, Satiety Drinks: Water, Beverages
<i>Shelter:</i>	Homelessness
<i>Safety:</i>	Security, law & order, personal, public Peace: Civil strife, crime, terrorism, war Domination, conquest, colonization, imperialism Coping with disasters
<i>Health:</i>	Personal/Public, Fitness Medicine, Drugs, Pharmaceuticals
<i>Leisure:</i>	Entertainment, Travel, Tourism, Relaxation, vacation
<i>Wealth:</i>	GDP, resources, power, poverty, dependency, debt
<i>Culture:</i>	Inclusion, participation, exclusion, discrimination, isolation, alienation, society, arts, crafts
<i>Education:</i>	Learning, training, skill, know-how, experience, learning Illiteracy, ignorance, practice, knowledge, information
<i>Religion:</i>	Worship, culture, rituals
<i>Rights/freedoms:</i>	Nutrition, safety, security, property, education, health, expression, person/body, knowledge, fruits of own labor
<i>Transcendence:</i>	Self-development, self-worth, Suicides, self-empowerment

The indicators characterizing the socio-economic *States* are to be established on the national level. Nonetheless, they can also be provided as (sub-) State patterns for sub-fields and smaller scales, such as for: rural, urban, infants/children, youth, adults, seniors, minorities, men, and women roles in the country. Similarly, they can also be expanded to larger scale entities such as regional, continental and global socio-economic *States*.

## 2.2. Economic Development Processes & Transactions

Economic Development (effecting State transitions) is a transactional process having an extended, flow or progressive structure. For the purposes of this report, it can be modeled as having a 4-tier structure:

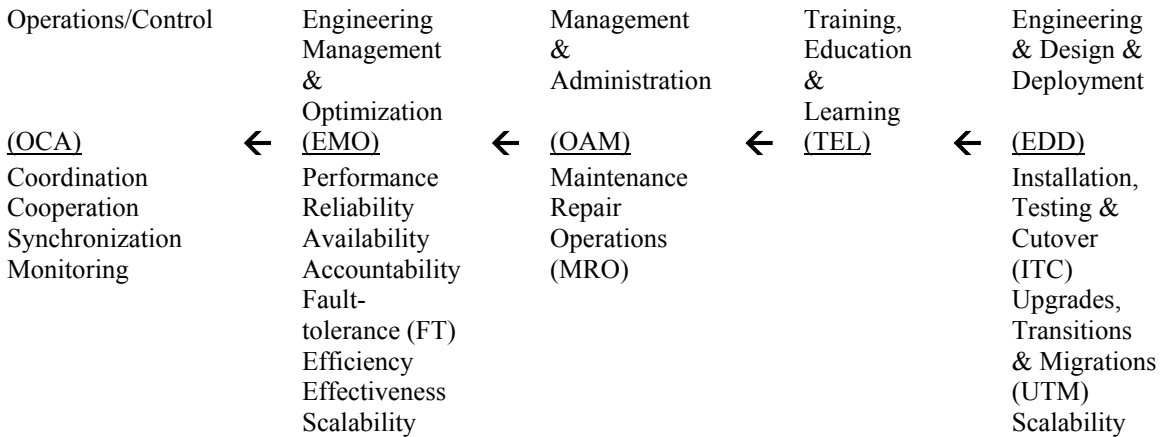


	<u>ED Tier<sub>1</sub></u>	<u>ED Tier<sub>2</sub></u>	<u>ED Tier<sub>3</sub></u>	<u>ED Tier<sub>4</sub></u>	
<i>State<sub>PRESENT</sub></i>	<b>→Production</b>	<b>→Trade</b>	<b>→Earnings</b>	<b>→Consumption</b>	<b>→State<sub>DESIRABLE</sub></b>
	Harvesting	Commerce	Payments	Services	
	Extraction	Exports	Settlements	Imports	
	Processing	Surplus	Foreign	Utilities	
	Refining		Exchange	(Lifestyle(s))	
	Manufacturing		Income		
	Synthesis		Wealth		
	Assembly		(Jobs)		
	Construction		(Employment)		
	Fabrication				
	Separations				
	Repackaging				
	Co-production				
	Value-added				

The tier structure of Economic Development completely captures the roles and the aspects of the involvement of all the industry sectors in the country's development.

### 2.3. Life Cycle Model

Once again, each tier of Economic Development is in turn a transactional process that can be further decomposed into smaller constituents (sub-tiers). This refinement will not be attempted here. Instead, each Development tier is modeled as having a *life cycle* structure. The life cycle stages or phases are represented here as levels or layers, and consist of:



### 2.4. Infrastructures

Each Development tier requires certain supporting “instruments” in order to successfully accomplish its purpose. These instruments are better known under the term *infrastructures*, which include tools, capacities and capabilities, and flows, distributions, allocations and network embodiments of the interrelationships, associations, synchronizations, co-operations and inter-dependencies of the instrumentalities. Thus, there exist requirements for Production Infrastructures, Trade/Commerce Infrastructures, Earnings (financial settlements) Infrastructures, and Consumption / Service Infrastructures.

There is also a requirement for inter-tier infrastructures linking Development tiers to each other, (for example, to support the transactional sequence shown above: Production → Trade/Commerce → Earnings → Consumption/Services).

Thus, one obtains *intra-tier infrastructures*, as well as the *inter-tier infrastructures*.

The SOCAR model for infrastructures results in the following characterizations of types and aspects of infrastructures, (including those belonging to ICT proper, for completeness):

**Infrastructures:**

Energy, Fuel

Power

Water

Telecommunications\*

Broadcast media, publications\*

Data Communications \*

Transportation: sea, air, land networks

Distribution networks

Human capital / Human Resources (HR): networks of skills

Professional services: e.g., repair, maintenance

Financial capital / credit networks

Legislative, Judicial, Law Enforcement networks

Merit, transparency

\* belongs to ICT proper

The model that has been developed so far clearly shows the roles that ICT can play in the country's (economic-social) Development. It is exactly these roles that the National ICT Policy has to be crafted to support.

The (National) ICT Policy, as an intentionally and deliberately constructed artifact, has to support,

- (a) The life cycle stages / levels of each Development tier.
- (b) The intra-tier infrastructures of each Development tier.
- (c) The inter-tier infrastructures.

Therefore, at the level of refinement reached in the modeling so far, ICT (and the associated National Policy) is required to support 25 ( $6 \times 4 + 1$ ) roles in the country's economic development. The National ICT Policy must carefully establish a policy specification for each such role that has been identified.

The presence and concurrent operation of the other group of technologies, MEMOT (mechanization energy & material objects technologies) or MMIT (mechanization, motorization & industrial technologies) is mandatory, in order for ICT to be successful and effective in its assigned roles. This context-sensitivity needs to be reflected in the National ICT policy. To summarize, both the **automation** and **mechanization / motorization** groups of technologies are required for National Development Policies to be viable over any planning horizon.

The National ICT Policy, in a large measure, is exactly a detailed specification of the Government of Ghana's (GOG) role in enabling, facilitating and enhancing the various in-context roles and aspects for ICT that have been identified and modeled above. The tools available to the GOG for use in supporting these roles and aspects are mainly legislation, laws, codes, regulations, public education / indoctrination, agendas / initiatives and strategic choices of various types.

Clearly the National ICT Policy *has to accommodate all the components* that have been identified in the SOCAR model. A model like the SOCAR model is necessary and has been presented for that very reason, in order for the Policy formulation to achieve the needed comprehensiveness.

Therefore,

**The formulation of a National ICT Policy is really about the government's (and the society's) choices concerning the distribution, allocations and apportionments of (national and donated) resources and endowments to all the roles, aspects and concerns. The roles and aspects can be identified using the SOCAR model. The resources include assets, investments, costs, expenditures, profits, returns, financial capital, land / property resources and human capital.**

ICT, as a system-theoretic and transactional artifact can itself be modeled as having a life cycle structure. Restated differently, Ghana's national ICT, as an organic construct, can fruitfully be modeled as having a life cycle structure, in its own right. Thus, applying the SOCAR analysis, the national ICT can be seen as having the following stages: R&D (research & development), EDD, OCA, EMO, OAM, and TEL levels / layers.

Except for ICT R&D, the aspects and roles for the other life cycles layers have already been dealt with above. ICT R&D pertains to the Science & Technology, and Science & Engineering that underlies the creation of actual ICT technologies. Initially, just like ICT itself, the ICT R&D has to be imported from the Rest of the World (ROW). Nevertheless, the National ICT policy can make provisions to encourage some ICT R&D, at the national or inter-country regional level, in the chosen planning horizon. To be an effective and world-class R&D, the correct approach will be to emphasize extensive R&D specialization. Ghanaian (and/or sub-Saharan) ICT academic and industrial researchers must focus on specific and appropriate ICT *R&D niches* in the global, worldwide context. A detailed discussion ICT R&D (as part of the National ICT Policy) is beyond the scope of this report and will be the subject of a separate future contribution.

## **2.5. Affordability**

To recapitulate, Sustainable Development requires Sustainable Infrastructures, which in turn require Sustainable Technologies (ICT and MMIT / MEMOT). Restated differently,

Sustainable Technologies (including ICT) will result in Sustainable Infrastructures, which will then ensure Sustainable Development.

There is a subtle aspect inherent in the concept of Sustainable that needs to be exposed and treated explicitly. This is the concept of *Affordability*. To be sustainable, technologies (including ICT) *must be* Affordable Technologies. Similarly, Sustainable Infrastructures must be Affordable Infrastructures and Sustainable Development must be Affordable Development. This consideration will play a key role in the viability of any National ICT Policy that is eventually formulated and implemented.

One effective approach to characterizing Affordable (ICT) Technology, Infrastructure or (Economic) Development Tiers is to use SWOT Analytics. SWOT is an acronym for: (S = Strengths; W = Weaknesses; O = Opportunities; and T = Threats).

There is definite linkage between the various aspects of SWOT. For example, a consideration of Strengths leads to insights about Opportunities, and an exploration of Weaknesses leads to an identification of Threats. Furthermore, Strengths can be used to cope with Threats via Opportunities and through Weaknesses. These inter-relationships can be represented compactly as:  $(S \rightarrow O) \& (W \rightarrow T) \& ((S \rightarrow O) \rightarrow (W \rightarrow T))$ .

An important strategic and tactical choice will be to use ICT (& MMIT/MMET) technologies to:

- (a) Leverage, amplify, optimize, maximize, accelerate ( $S \rightarrow O$ )
- (b) Minimize, limit, contain, FT, graceful degradation, repair, correct ( $W \rightarrow T$ )

An application of SWOT analytics to the modeling and formulation of the National ICT Policy will be the subject of a future contribution. As a taste of what is to come, consider following fragment of the preliminary analysis:

(S) Strengths                      (O) Opportunities                      (W) Weaknesses                      (T) Threats

Natural Resources  
 Agricultural base  
 Youthful population  
 Abundance of Solar Energy  
 Tropical Location  
 No Obsolete Industrial base

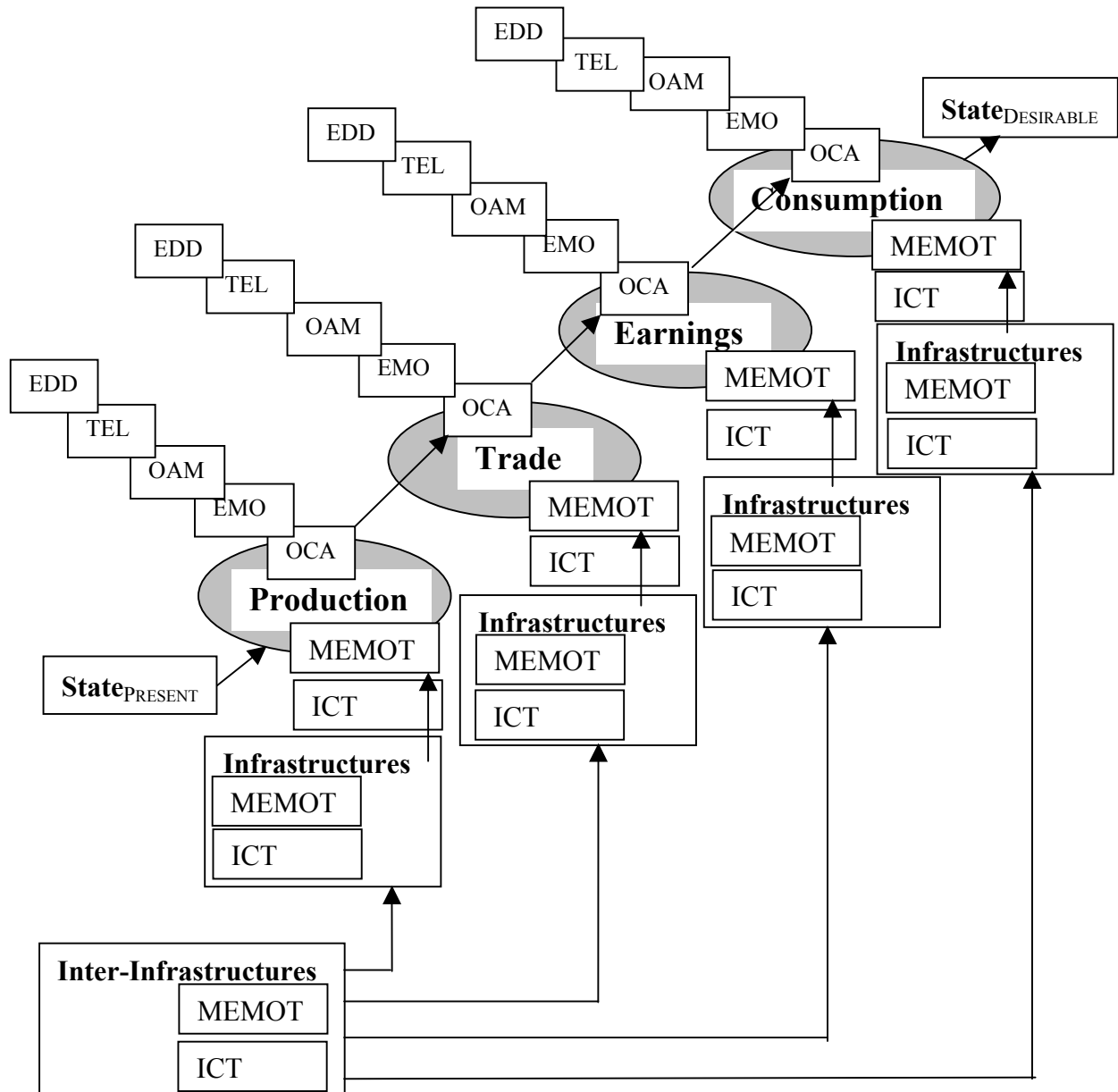
HIV/AIDS  
 Population growth

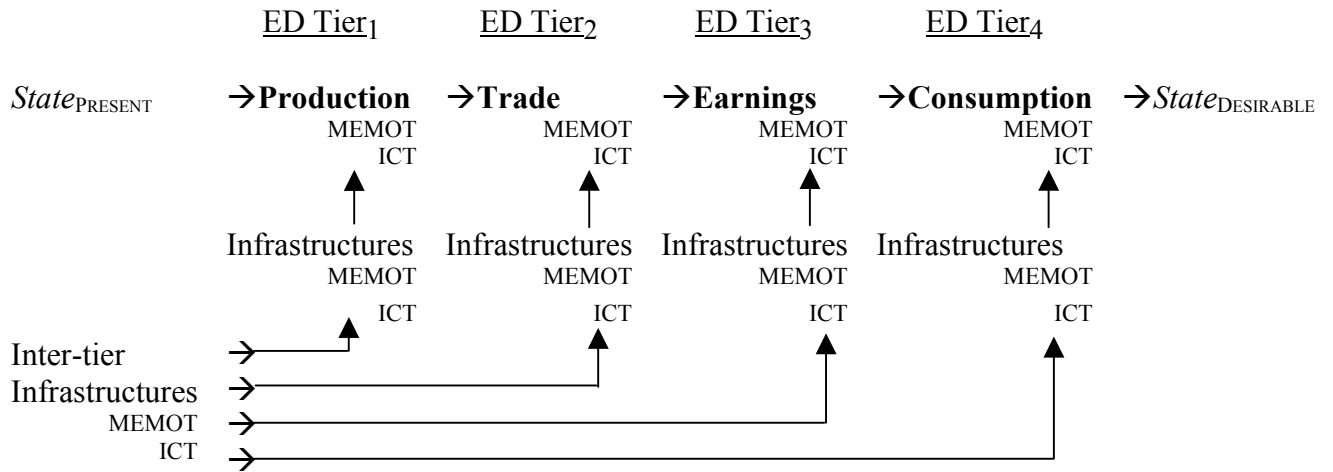
## 2.6. Model of Institutional Participation

It is both convenient and useful to segment the country's human population into classes of types of (institutional) participants in the country's (Economic) Development. In

literature of donor and related aid organizations, the participating segments are typically referred to as *stakeholders*. The segments will be referred to here as (societal) *sectors*. The segmentation is only a partial partition, since the various segments intersect and overlap.

The roles of the institutional participants placed in the context of the ICT-based Economic Development model that has been developed so far is shown below.





*Inst.*

*Participation:*

Private Sector	X	X	X	X
Investors	X	X	X	X
Para-statals	X	X	X	X
Informal Sector	X	X	X	X
Rural Sector	X	X	X	X
Govt. Sector	X	X	X	X
Men	X	X	X	X
Women	X	X	X	X
Ethnic Minorities	X	X	X	X
Disadvantaged	X	X	X	X
Youth				X
Infants				X
Seniors				X
Military Sector			X	X
Educators			X	X
Social Services				X
Traditional Sector				X
NGOs				X
Donors	X	X	X	X
Rest of World		X	X	

An appropriate analytical approach to modeling the roles of institutional participation is to use ROI (return on investment) analysis. Applying ROI analysis to the National ICT Policy is the subject of a future contribution.

### **3. Summary**

The SOCAR (separation of concerns, aspects and roles) methodology has been applied to derive a semi-formal model to be used as a “roadmap” for the formulation, structuring the presentation, as well as the evaluation and implementation of the Ghana National ICT Policy, currently under development.

The model provides a systematic way to answer several questions about the goals, purpose, intentions, missions, bottlenecks, barriers and issues pertaining to both the process and the resultant product(s) of the National ICT Policy.

In future contributions, the SOCAR model will be subjected to SWOT (strengths, weaknesses, opportunities and threats) analysis, in order to derive semi-formal criteria regarding sustainability and affordability that should be incorporated into the National ICT Policy.