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QUALITY 5.0: FROM CHALLENGES TO REALITY

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A B S T R A C T

The A world is in process of rapid changing in all areas of living. In all of them exists old and new problems with urgent needs for solving. Transition from Industry 3.0 to Industry 4.0 changed view on industry in 21st century and also there are answers on challenges based on Quality 3.0 and Quality 4.0 concept. In last ten years is developed concept of Japan's „Society 5.0" which needs Quality 5.0 concept. This is main motive for researching possibility for transition quality into Quality 5.0.

In the paper are presented basic information about Industry 4.0 and Quality 4.0 based on new challenges in 21st century. Based on literature and own research is defined concept of Quality 5.0 and ways of transition to Quality 5.0, essecialy in transition counties as Serbia in next 30 years. The first analysis pointed out that it is possible with using smart technologies, smart leadership, smart people and other smart „things" for achieving smart/integrated quality, quality of life, resilience and all human-centric achivities.

1. INTRODUCTION

The trend in 21st century is to establish smart society in which is included more than 27 smart components. For this research are interesting smart industry (Industry 4.0) and smart quality (Quality 4.0). This process in located in all technology advanced states, but also in some states with big Intellectual Capital (IC). These concepts are defined for each components of smart society. There is problem of integration and including human being and problems of sustainability, quality of life, resilience etc. These are challenges for developing concept of Quality 5.0 dedicated to „Society 5.0"developed in Japan. It is great transition with for fundamental themes:

- creating new values for industry development in future and social transformation,
- reorganizing economic and social challenges,
- higher support for science,
- technology and innovation (STI), and
- establishing system cycles of human resources, knowledge and capacity for innovation.

For its realization is necessary investment in R&D minimum 4% of GDP from private and public sector, from state government minimum 1 percent. With introduction „Society 5.0"in Japan expect enhancing GDP circa 3.3%. The goal of „Society 5.0" is to achieve economic rise/wellbeing and in same time overlapping social challenges and in total prosperity of global society.

According Tompston (2014) we are recognized four waves of changes until year 2050., i.e.:

1. First wave (2010-2020) with slow development of technologies and first introduction of smart solutions,
2. Second wave (2020-2030) with development strategy innovation related to RFID, telemetric, integration, etc.,
3. Third wave (2030-2040) with self-assembly, massive 3d printing, self-purchasing, etc.,
4. Fourth wave (2040-2050) with paradigm of confidence, supported by advanced robotic and ai, autonomous vehicles, sensing material.

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In smart society is higher role of ethical and well-being aspects. Ethical government realizes through: (1) impact of regulative, (2) regulation of collective actions, (3) building/modernizing existing regulation, (4) anticipating strength of transformation of collective adaptive systems (ACS), (5) balancing government decisions, (6) deciding adaptive government, etc. Based on China (2018) are emphasized challenges in smart cities which need quality answers in following areas:

- Smart economy,
- Smart environment,
- Smart living,
- Smart mobility,
- Smart quality and safety and
- Smart education (Arima, 2003).

Transition of concept Industry 4.0 to Society 5.0 has impact on planning big social transformation in Japan with destroying five walls related to:

- Ministries/agencies,
- Legal system,
- Technology,
- Human resources and
- Social acceptance.

A transition from Industry 4.0 to Industry 5.0 is practically transformation of digital manufacturing to digital society (Skobelev & Borovik, 2017) with convergence of science and technologies in society 5.0 from technology to society.

A concept of enterprise value management defined for smart enterprise in Industry 4.0 could be make broader for Society 5.0 and Quality 5.0 (Fujitsu Consulting, 2002).

According Martin and Leurent (2017) value dimensions from converging technologic have levels:

1. value for the factory,
2. value to the firm (enterprise),
3. value to the industry,
4. value to society, and
5. value to the individual.

In all of the levels are included elements of Quality 4.0 (level 1, 2 and 3) and Quality 5.0 (level 4 and 5).

Kupper et al. (2019) analyzed Quality 4.0 and concluded that cca 63% companies had not decision or plan for it, but only 16% had some form of implementation. The challenges of implementation were: (1) cost of quality check, (2) first-pass yield, (3) defect rate, (4) rework rate, (5) on-time delivery, (6) customer satisfaction, (7) warranty claims, and (8) product-related complaints. All challenges are base for Quality 4.0 and Quality 5.0, also on levels 1 and 2 in value creation.

A Quality 5.0 concept is connected with Industry 5.0 (Nahavandi, 2019) with advanced technologies: (1) networked sensor data interoperability, (2) multiscale dynamic modeling and simulation: digital twins, (3) shop floor trackers, (4) virtual training, (5) intelligent autonomous systems, and (6) advances in sensing technologies and machine cognition.

In Industry 5.0 is appropriate to use concept of Lean Innovation because is based on value management (Ozkeser, 2018). Relations among Quality management in the 21st Century and Industry 4.0 are analyzed in Prashar (2023).

In this research are emphasized following quality topics for Industry 4.0 (Tsaramirsis et al., 2022):

1. Economic aspects,
2. Decision models in quality,
3. Business models,
4. Human aspects in quality (including leadership),
5. Technological aspects in quality.

Authors conclude that is necessary to make alignment between human aspects and technology revolution in quality management.

A concept of Quality 5.0 is connected with concept Society 5.0. Council (2014), China (2018), Dixon (2018), Smith et al. (2018) and Messner et al. (2019) are defined fundament goals:

- Goal 1: Leave N_0 Person Behind,
- Goal 2: Empower Users through Good Digital Idents,
- Goal 3: Make Business Work for People,
- Goal 4: Keep Everyone Safe and Secure,
- Goal 5: Build new rules for a new game,
- Goal 6: Broke through the data barrier

Author concluded that start is beginning.

2. CHALLENGES IN 21ST CENTURY

In 21st century are expecting a lot of challenges (Klein et al., 2017). In this study are emphasized the megatrends of tomorrow's world divided into five categories:

- Society,
- Technology,
- Environment,
- Economy, and
- Politics.

For Society 5.0 and Quality 5.0 are specially highline:

- Artificial intelligence,
- Augmented reality,
- Digitalization,
- IoT,
- Climate change,
- Concentration on wealth,
- Demand for customization,
- Environmental awareness,
- Focus on transparency,
- Globalization,
- Partnership models,
- Resource scarcity,
- Sharing economy,
- Social media,
- Industry consolidation,

- Urbanization,
- Geospatial technology,
- Terrorism defense, etc.

A way from Industry 4.0 to Society 5.0 and Quality 5.0 needs a big societal transformation, with challenges to avoid or override barriers related to:

- Ministries and agencies,
- Legal system,
- Technologies,
- Human resources, and
- Aging of populations, etc.

The challenges are related to:

- Data availability, security and accuracy,
- Technology,
- Competences,
- Openness,
- Ecosystem,
- Project solutions,
- Security of realized system.

A big challenge is related to citizen, i.e. happiness or quality of life in modern society (Kanazawa et al., 2015). It is now element of concept Quality 5.0.

In Gladden (2019) is analyzed „Society 5.0" from aspect of anthropological post humanized societies in future. In this study is asked answer on questions:

1. How different types of human and non-human members can collaborate, besides difference among them,
2. How can make concept dynamics of members of „society 5.0", and
3. In which aspects are different members of „society 5.0" from societies 1.0 to 4.0.

At the end are stated three questions:

1. Does exists something real new in concept 5.0? Answer: is positive.
2. Does the paradigm society 5.0 could be applied from japan? Could with some adaptations.
3. How have to collaborate all stakeholders in purpose of realization of society 5.0? Answer: on theoretical and organizational level.

As extension of Society 5.0 is developed concept „Living Laboratories" and „Living Services" (Carayannis & Morawska-Jancelewicz, 2022) based on IoT in broad applying and close relations among people, machines and environment.

In Society 5.0 a quality has higher impact and „glue" role. A complexity of these requests, challenges, needs to develop a new paradigm: Quality 5.0, what is explained in next chapters.

3. CONCEPT OF QUALITY 5.0

Quality 5.0 concept in Society 5.0 is directly related with sustainability, sustainable digital innovation, digital culture, social innovations, and quality of life. In figure 1 is presumed quality in context of sustainability.

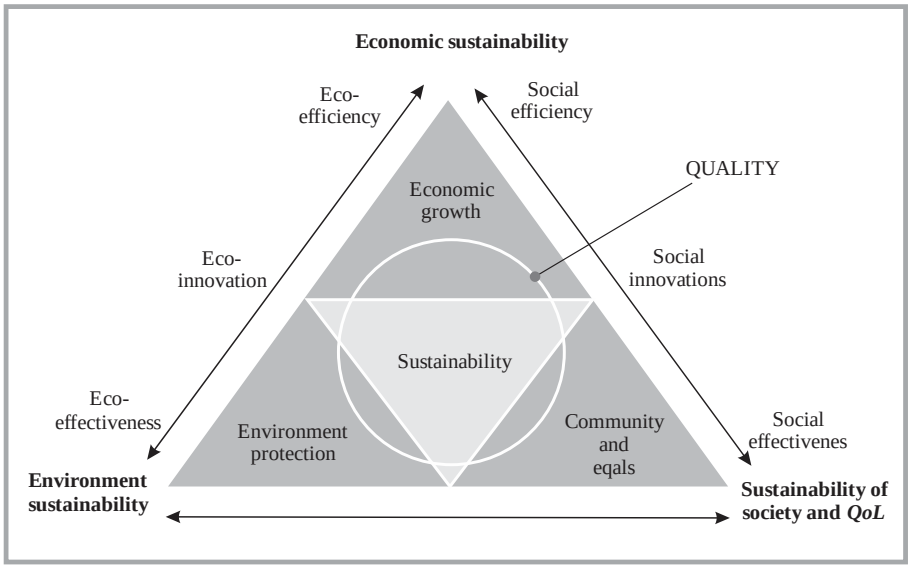

Figure 1. Quality in context of sustainability

In this model quality is incorporated in all elements of Society 5.0. It is enabler of economic growth, sustainability, environment protection, community and equals of peoples, and sustainability of society and quality of life (QoL).

It is defined for extension of existing situation (Quality 3.0/Quality 4.0 in first phase) and creating new reality in future (second phase). On figure 2 is presented structure of concept Quality 5.0 and relations with environment.

This concept started from a quality practice (on the button) divided with different areas, as industry, education, food, etc. On higher level is quality science with different themes. Each theme has different depth of development and introduction in practice. On higher levels are Quality 4.0 and Quality 5.0 connects with

mutual relationships, and also relationship with presented entities in social and spiritual cyber area (environment).

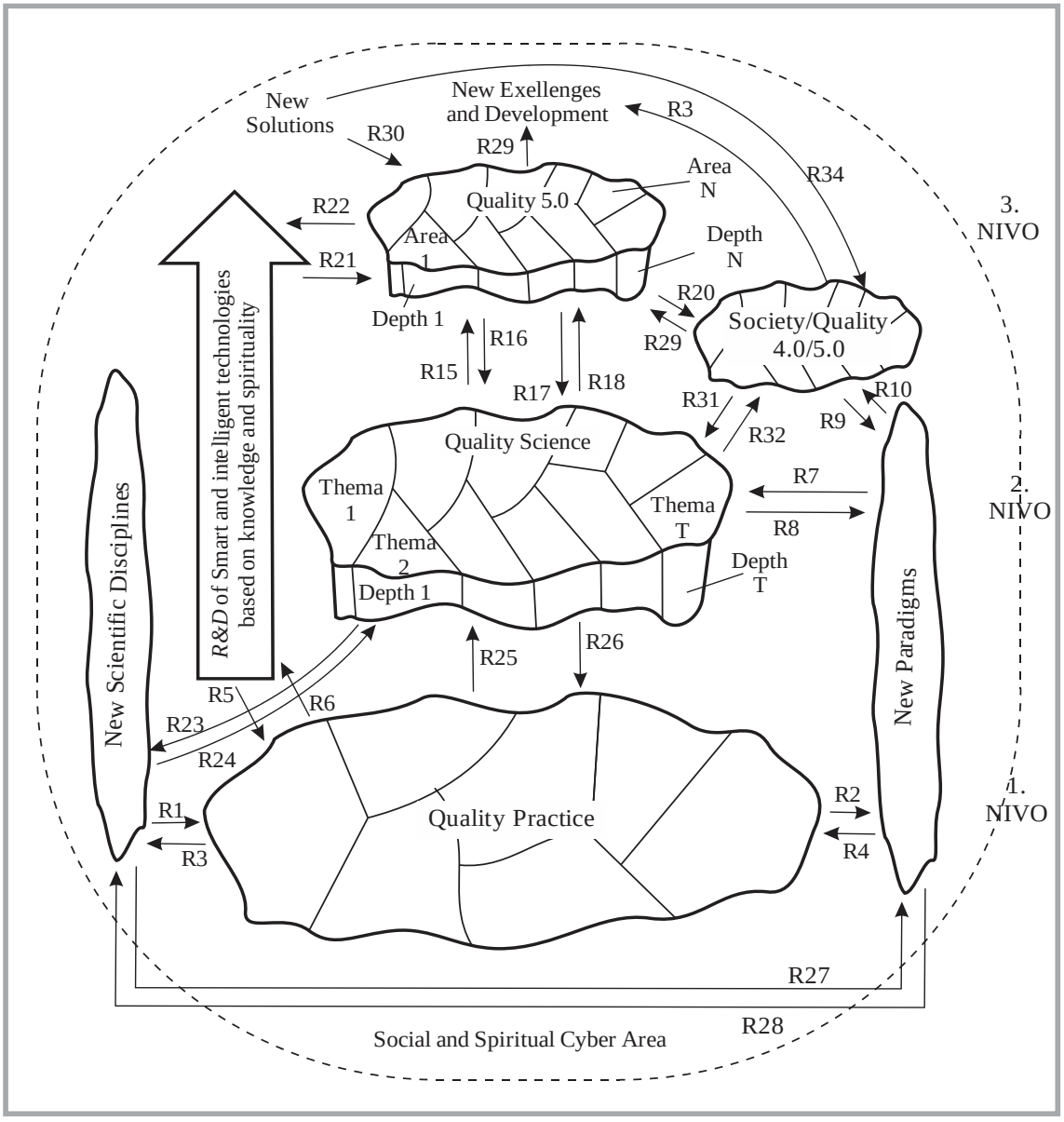

Figure 2. Levels to achieving a Quality 5.0

A Quality 5.0 consists from different areas (1 – N). Each area of quality has own depth. Through relation R19 and R20 is performed correspondence with socially 4.0/5.0 as present level of development. On the highest level in the model is Quality 5.0 which has inputs through relations:

- R3: new technological, social and other solutions,
- R21: research and development of intelligent technologies based on knowledge and spirituality,
- R19: common elements from Society 4.0/5.0, and
- R15, R18: new themes from paradigm „Quality Science“ (on second level).

On second level is emphasized:

- Quality science and
- Society /quality 4.0/5.0.

Each relation in this level with elements in other levels has own content, related entities and in total own anthology. An example, R24 represent impact and results of research of conscious fields on innovativeness or customer decision.

According Alzahrani et al. (2021) LNS research a Quality 4.0 has 11axes, i.e.:

1. Data,
2. Analytics,
3. Connectivity,
4. Collaboration,
5. Application development,

6. Scalability,
7. Management systems,
8. Compliance,
9. Culture,
10. Leadership, and
11. Competency.

Each axis has own sub-elements.

It highline scientific method versus data science. On this approach Quality 4.0 is defined as CIA:

- C (Connectedness),
- I (Intelligence) and
- A (Automation).

in appropriate Quality 4.0 Ecosystem. In center of this system are Neural Networks and Deep Learning. Some elements of her model of Quality 4.0 are oriented to excitement (drive out fear, build safety and quality culture, and find meaning and purpose) and on this way is connected with Quality 5.0 concept.

Mourtzis et al. (2019) emphasized aspects of internal complexity and ICT based relations in digitalized manufacturing system (Cyber-Physical Systems) of Industry 4.0.

Integration of Quality 4.0 and Quality 5.0 concepts are presented in figure 3.

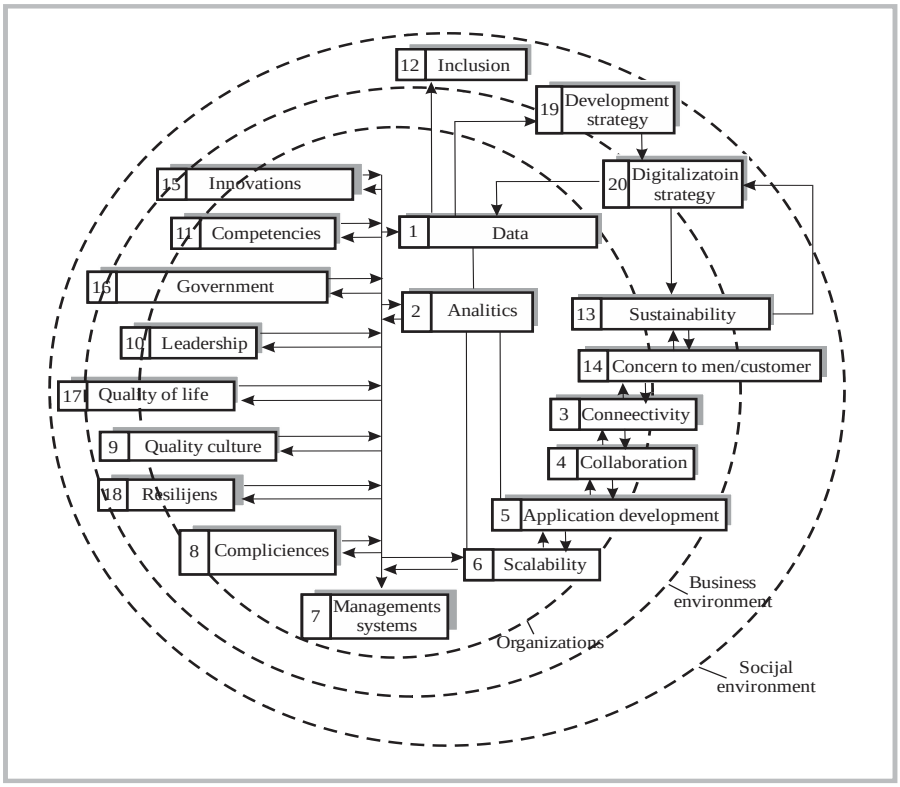

Figure 3. Integration Quality 4.0/Quality 5.0

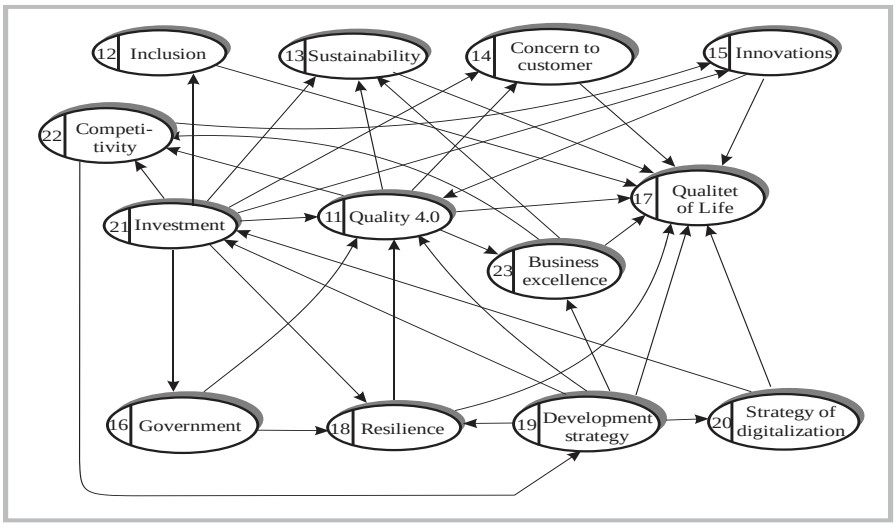

Figure 4. Integrated Quality 5.0 model

In purpose to make concept Quality 5.0 is necessary to integrate Quality 4.0 with external entities. Besides previous described variables (1-11) in Quality 4.0 model and (12-18) in Quality model, in integrated Quality 5.0 (figure 4) are included variables (Arsovski, 2019):

- V19 – strategy of development,
- V20 – strategy of digitalization,
- V21 – level of investment in Quality 5.0,
- V22 – competitively level, and
- V23 – level of business excellence.

There are a lot of relations and problem in model testing are data (present low level), its reliability in future and appropriate methods. Proposed solution is to concept national project „Quality 5.0“ to find optimal strategy to transit from existing Quality 2.0/3.0 to Quality 4.0/5.0.

Quality 5.0 is very closely connected to Quality of Life (figure 5).

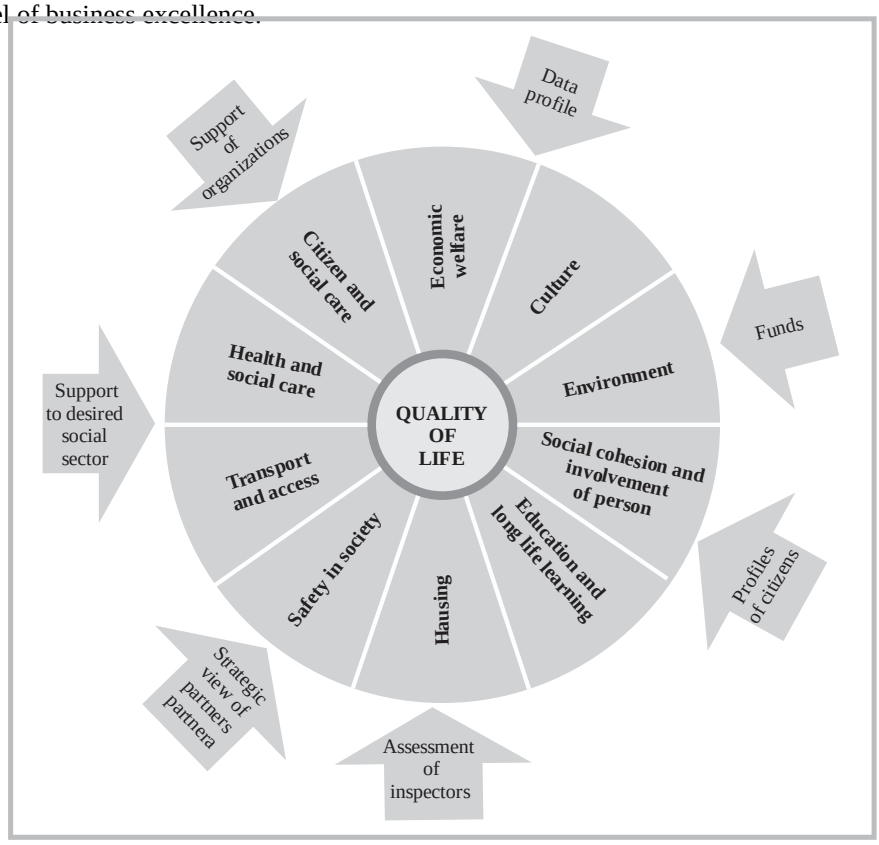

Figure 5. Impacts on Quality of Life (QoL)

After analysis elements of Quality 5.0 concept is possible to define appropriate ontology (figure 6), based on Zdravković et al. (2011). Each of impacts has different mutual collision. Because that on level of local community is necessary to develop strategy of sustainable community (Arsovski, 2019).

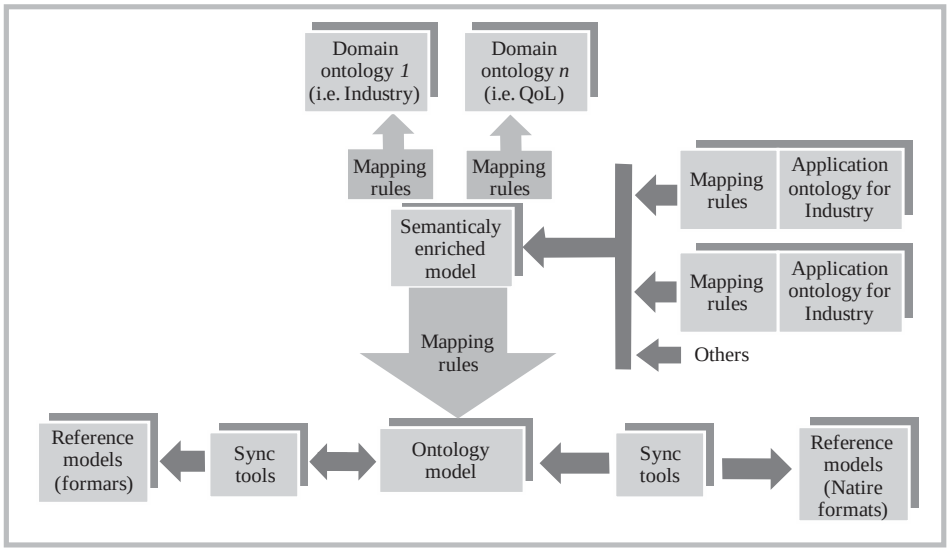

Figure 6. Framework for semantic environment of reference models for Quality 5.0

For this framework are curtail domain anthologies and mapping rolls, tools and application ontologies for different elements of Quality 5.0, presented through hierarchical model (figure 7).

On the top of pyramid is quality of person, as highest goal of our civilization. A Quality 5.0 is enabler together with QoL. On lower level is smart society (platinum Society 5.0) based on resources, smart technologies, resilience, sustainability and success of each component of smart society. A base for all are needs, requests and hopes of people.

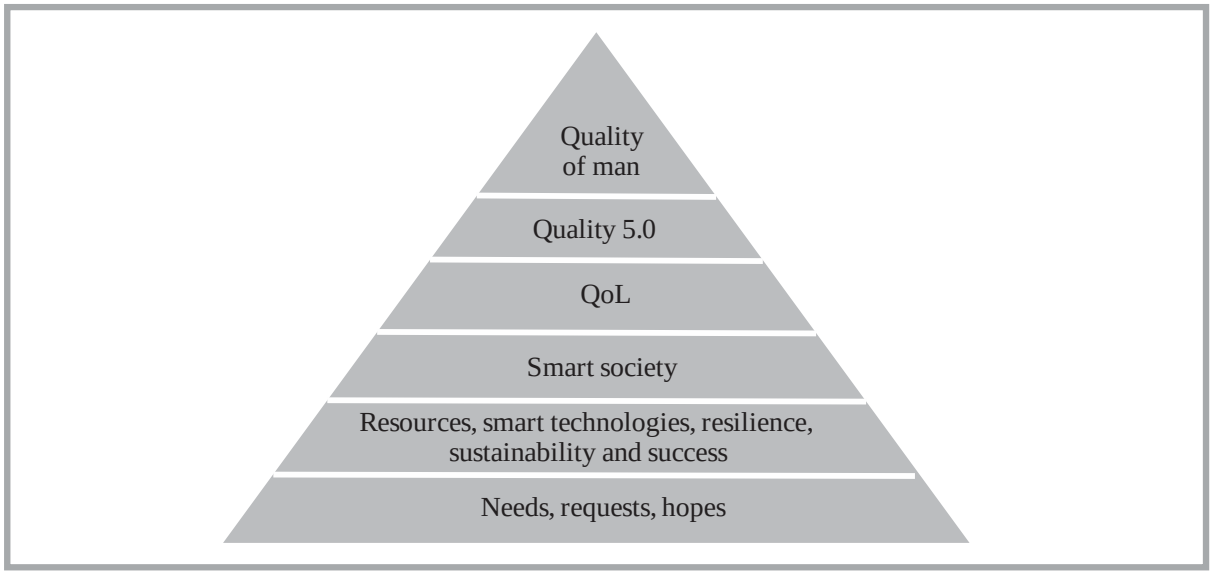

Figure 7. From human needs to Quality 5.0 and Quality of men

On this way, this pyramidal model with quality of men is similar with Japan's pyramid od Total Quality Management with men on the top.

4. WAYS TO REALIZATION OF QUALITY 5.0 IN SERBIA

According to figure 8 the level of quality in Serbia is between low and middle.

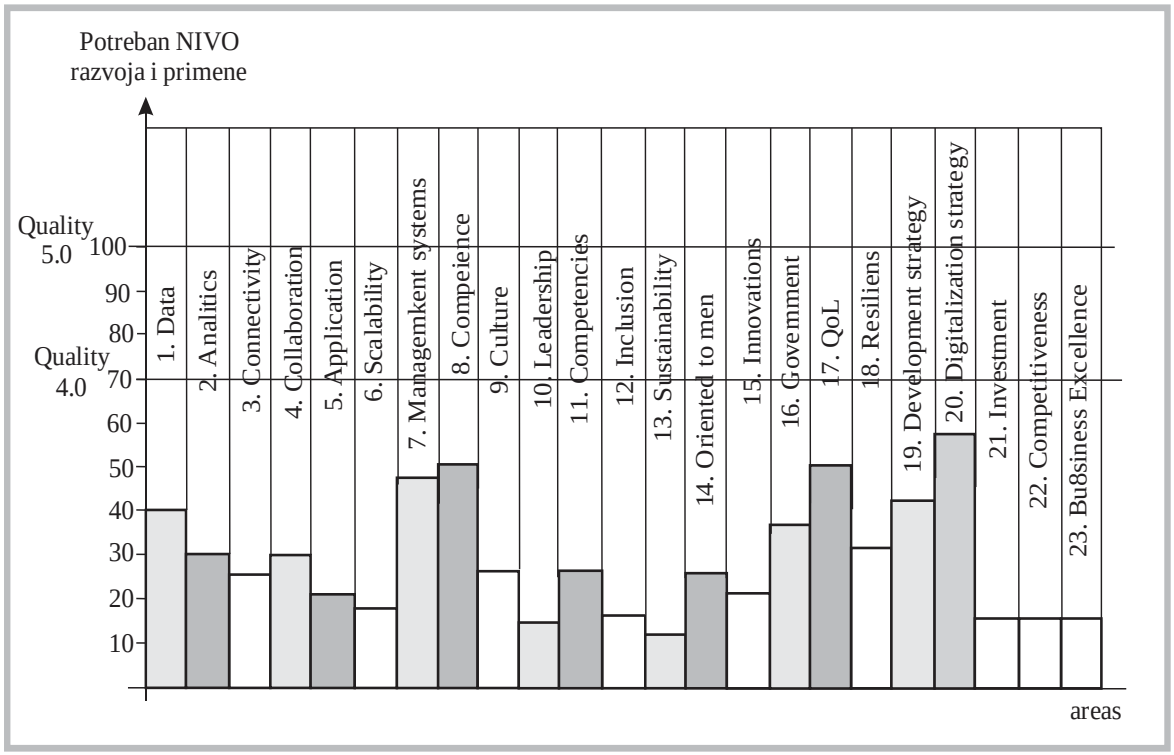

Figure 8. Level of development and introducing elements of Quality 4.0/5.0 in Serbia

This assessment is provided using Delphi method with 15 experts. The average level in Serbia is approximately cca 30% i.e. mixed Quality 2.0, Quality 3.0 and in save cases Quality 4.0. Based on Japan's vision 2050 the process to „Platinum Society“ 2050 with Quality 5.0 consumes a lot of time (cca 30 years) and it is very expensive.

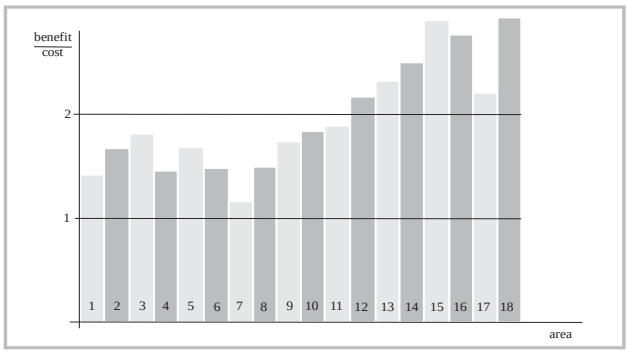

Figure 9. Results of benefit/cost analysis (CBA)

Each component of smart society needs very high investment in purpose to achieve level near assessment 10. For transition society to „Platinum Society 2050“ and Quality 5.0 is necessary in first step to develop vision and strategy for this giga projects which need more than billions of dollars, depend on priorities and constraints for each state. In this moment with respecting cost/benefit analysis is possible to find priorities with best ratio and invest in it (figure 9).

The Quality 5.0 concept is closed with Smart Society (Platinum Society) which also needs huge investment in all 27 areas (Arsovski, 2019), Smart region of Eastern Serbia, ALPEN TEKIJA, Kragujevac, in Serbia). Dynamics of introducing new development solutions related to Quality 5.0 and Platinum Society in Serbia is presented in figure 10, as first approximation.

In this approximation for Quality 5.0 according priorities is needs to invest in quality in all 27 components of smart society in Serbia.

For this study is not included risks in this long period, especially related to natural, ecological, political, health, and other hazards.

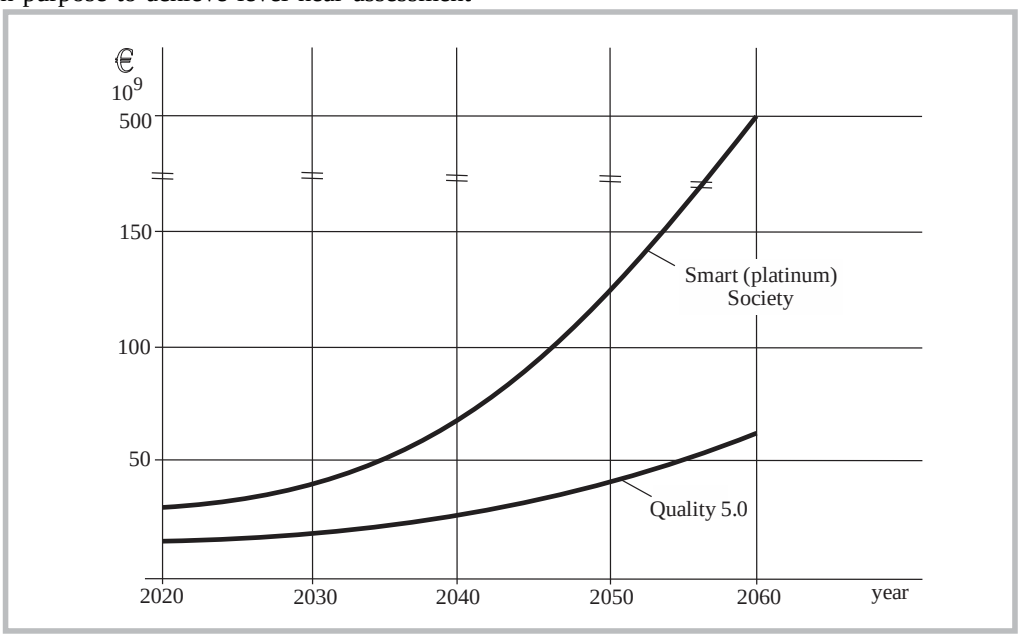

Figure 10. Investment in Quality 5.0 and Platinum Society in Serbia

5. CONCLUSION

A Quality 5.0 concept is now reality but it is partly developed and introduced. Especially for Serbia, it is problem because relative small level of quality and constraints in investments, knowledge and generally human factor.

Author proposed strategy according Japan's long range strategy, with close collaboration all stakeholders, especially government, investitures, local government, business sector, universities and others.

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