Artificial Intelligence in Urban Development

Opportunities, challenges and ideas for the German Development Cooperation

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Summary

Cities worldwide will be crucial for both sustainable development and human-centric digitalisation. The majority of the world's population already lives in cities; by 2030 they will be home to at least 60% of humanity, rising to around 75% by 2050. Two thirds of sustainability goals (SDGs) can only be achieved in and with cities. Cities are home to many of the key requirements for the digital transformation, including digital innovators and ecosystems, data and infrastructure. At the same time, digital technologies can be used as levers to develop urban spaces while protecting the environment and ensuring a high quality of life. This discussion paper describes the opportunities artificial intelligence (AI) in particular can provide for sustainable urban development, and the role it can play in an integrated approach to implementing the 2030 Agenda.

The introduction describes relevant stakeholders, actors and technical requirements, as well as the implications of AI for low- and middle-income countries. Chapter two looks at uses cases from the fields of urban planning, water, mobility, waste and construction to shed light on the ramifications of AI for cities and the risks associated with it, as well as the positive effects that AI can bring for sustainable urbanisation. Finally, in Chapter three of this paper, we discuss how cities should prepare to make the most of the opportunities that come with AI at the same as minimising any risks. We also provide recommendations on how to position German development efforts and how this work can tap into existing initiatives and potential implementation partners.

Thus, this paper aims to provide guidance, ideas and inspiration for everyone concerned with how AI can be used in cities and city-regions.

In order to promote coordinated implementation of the 2030 Agenda in cities, the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH should contribute its expertise, and in particular its many years of experience of working together with multiple partners to develop and design user-orientated concepts and plans, as well as its proven ability to develop and strengthen both individual skills and institutional capacity. To achieve these aims, GIZ will have to further develop its own technical capabilities at the same time as building new partnerships.

Disclaimer:

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1. Introduction

The continued breakneck speed of urbanisation is one of the most significant and influential megatrends of the 21st century. What we do in cities will determine whether or not we meet the 17 sustainability goals incorporated into 2030 Agenda. Around two thirds of all the sub-objectives within these goals can only be achieved in, or in conjunction with, cities. To achieve these objectives, administration at all levels will have to be fully integrated with various different stakeholders, sectors and areas, acting in line with the implementation principles set out in 2030 Agenda.

A second megatrend of the 21st century is the fourth industrial revolution. This revolution is being driven above all by artificial intelligence, supported by other new technologies that grew out of the IT (or third industrial) revolution, such as the Internet of Things (IoT), blockchain, robotics, bio- and nanotechnologies and quantum computing. Thanks to increased computing power, breakthroughs in research and an ever-growing pool of data, AI technology continues to develop at an impressive pace.
Scientists assume that **cities** around the world will be among the **biggest beneficiaries** of these new technologies,[1] because it is in cities that **large quantities of data, computing power and digital innovation ecosystems are concentrated, alongside the kinds of problems these technologies can help to solve**. Artificial intelligence can help to optimise sustainable, inclusive urban development in a number of areas, from urban planning to the provision of infrastructure and services, public administration and citizen participation. The use of digital technologies like AI can act as a lever for a coordinated approach to implementing the 2030 Agenda. For AI to make this positive contribution, it is vitally important that 1) AI is used in line with local requirements; 2) barriers to entry for the population at large, research and businesses are lowered; and 3) datasets and algorithms are transparent, with civil liberties and human rights playing a central role[2].

1.1. What is AI?

There is currently no single accepted definition of the term 'artificial intelligence'. It is used in a general sense to describe **efforts by scientists to teach machines how to learn independently** or, in other words, to **automate cognitive processes** such as pattern recognition, planning, language and text or speech recognition. Hence, **'AI' is not a single technology, but rather a range of technical processes** most of which use variations of machine learning (ML). In these technical processes, data and learning algorithms (code) are incorporated into a software model, from which inferences (probability-based conclusions) are then drawn supported by powerful hardware (see the image recognition example on page 4).

This basic procedure within ML processes – i.e. using training data to teach the machine, which then makes inferences when it meets new data – is the basis for most AI systems. **Unlike traditional software, where all inputs and outputs are defined in advance, AI systems can self-learn, and thus keep getting better at what they do**. Most current AI systems are designed to carry out a specific task (this is known as 'narrow AI'). They assist humans, making it easier for them to do their jobs and, to some extent at least, automating these tasks. Despite recent progress, researchers are still decades away from the 'general AI' described in generations of science-fiction films.

[1] Barns, 2016; Bibri, 2018a; Lim, Kim, & Maglio, 2018; Allam & Dhunny 2019, p.81
[2] BMZ [Federal Ministry of Economic Cooperation and Development], 2019 Toolkit Digitalisierung in der Entwicklungszusammenarbeit, 2.9.2

Example: image recognition. In image recognition systems, pictures of cyclists (for instance) are specially assigned to a category called ‘cyclists’ (this is known as ‘labelling’). During the training phase, this labelled data provides answers (or targets) for the automation process. The aim is to teach a software model to identify, or ‘learn’, patterns in the training data that allow it to identify pictures of cyclists according to category with a high degree of accuracy. The data, consisting of hundreds or thousands of marked images of cyclists, is first processed by algorithms, which identify, or ‘learn’, the patterns within this training data. Once learned, these rules can then be applied to the system to help it categorise previously unknown images. When used in the real world, the software model is capable of assessing the likelihood that any new data it encounters will fit the patterns it has learned (i.e it makes inferences). This in turn allows software models used for live camera footage in autonomous vehicles to recognise pictures of cyclists automatically, for instance. (Source: Lorenz/Saslow, 2019, Demystifying AI & AI Companies)

1.2. Actors and stakeholders

Over the last few decades, AI has been developed primarily by university research institutes, and has been focused on **mathematics and computing**. ML technology is now increasingly being used in other disciplines, including medicine, climate research, architecture and social sciences.

Currently, it is **private-sector actors**, notably **US firms** like Google, Apple, Facebook, Amazon, Microsoft and IBM, and **Chinese companies** such as Baidu, Alibaba and Tencent, that are developing and applying the latest AI technologies. They concentrate the key components of AI systems, specifically *data*, *computing power* and the *AI specialists* who program the *algorithms*. The progress made by these tech companies tends to be rather technology-driven, and their systems often lack contextual knowledge (this is particularly true of systems outside China and the United States). At the same time, many of these companies share their algorithms and training databases on open platforms and work closely with universities and research institutions. Alongside the main players, **there is also a growing number of AI start-ups worldwide** developing new AI systems for their own specific purposes, including in partner countries in which GIZ is engaged in development work.

In addition, many **governments** around the world recognise the potential of AI and are following ambitious strategies to establish themselves in the global AI landscape[3]. **The state plays three roles in these strategies:** it acts as a **facilitator**, for example by building infrastructure or making public data available to AI companies; as a **regulator** by setting the legal framework for the development and use of AI, and as a **user** of AI, for example in public administration or to provide public services.

A number of **civil society** organisations are also concerned with AI around the world, such as the WWW Foundation[4], the AI for Good Foundation[5], DataKind[6], DataPopAlliance[7] or AI4ALL[8]. Their primary aims are to prevent the misuse of AI technology and to ensure AI is used inclusively for

[3] Groth, Kaatz-Dubberke, Straube, 2018, 2019. Vergleich nationaler Strategien zur Förderung von Künstlicher Intelligenz
[4] https://webfoundation.org/
[5] https://ai4good.org/
[6] https://www.datakind.org/
[7] https://datapopalliance.org/
[8] http://ai-4-all.org/

the common good. In Germany, the *Stiftung Neue Verantwortung* (New Responsibility Foundation[9]) and the *Bertelsmann-Stiftung* (Bertelsmann Foundation[10]) are particularly important in raising awareness of issues around AI and its position in society.

Developing human-centric AI systems requires close cooperation between a wide range of actors and stakeholders, acting within new kinds of formal and informal networks to make use of data, computing power, human capital and decision-making ability.[11]

1.3. Implications for low- and middle-income countries

Numerous studies have highlighted the significant contribution AI technologies could make to solving development-related problems and implementing the 2030 Agenda.[12]The **German government's AI strategy** also assumes that AI will play a key role in sustainable development, as this quotation from page 9 shows:

"In particular, we want to use AI's potential for sustainable development, and thus to make a contribution towards achieving the 2030 Agenda sustainable development goals...Specifically, we see major potential for using it to understand complex natural systems, economic issues and societal progress. The Federal Government will drive forward research on AI technologies and data-based applications, as well on the use the AI, with a view to making key areas of society more sustainable in Germany and around the world. Examples of such areas include mobility, energy systems, agriculture and food security, health, conservation of resources or climate change."

However, the tendency for the components of AI systems to become ever more concentrated in the hands of a few large companies, combined with a hesitant attitude to the adoption of AI, **brings with it the risk that low- and middle-income countries will become technologically dependent in future**. This is particularly problematic given that developers in the United States and China are working based on their own environments and value systems. As the German government's AI strategy notes (p.43):

"As AI is a key global technology, it is very important to prevent [low- and middle-income countries] from being left behind technologically, not just in terms of the establishment and development of relevant scientific and technical expertise within the education and professional training sector, but also when it comes to the commercial use of AI technology, the provision of support via open-source and open data-based approaches, and infrastructure connected via satellite to communications and data streams from industrial countries. It is important to ensure that AI applications from developed countries are suitable for users from low income countries and do not discriminate against them, for example because of missing or inaccurate training data or the use of an overly-restrictive normative analysis framework."

At the same time, the underlying models and technologies for machine learning have already been developed. This means that, thanks to the Internet, AI technologies can be adapted and applied by actors and stakeholders in any location, in real time and at low cost. The falling cost of technology, near-ubiquitous availability of computing power via the cloud, open online courses teaching people how to develop AI systems, and an increasing number of open data initiatives

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[9] https://www.stiftung-nv.de/

[10] https://www.bertelsmann-stiftung.de/de/unsere-projekte/ethik-der-algorithmen/

[11] World Bank, 2019, Information and Communications for Development: Data-Driven Development p.47

[12] MGI, 2018, Notes from the AI Frontier. Applying AI for Social Good USAID, 2018, Making AI Work for International Development; Microsoft & University of Pretoria, 2018; Artificial Intelligence for Africa: An Opportunity for Growth, Development, and Democratisation.

are allowing innovators to apply the technology to their problems from the bottom up[13]. **In countries like Kenya, India, Nigeria, South Africa or Tunisia a number of systems based on AI innovations are already being developed, most of them concentrated in major cities.**
The **German Ministry for Economic Cooperation and Development (BMZ) also sees AI as a 'key technology for development[14]'** and is already using part of the German Federal government's AI budget to support the 'FAIR Forward' programme, a project being delivered by GIZ and involving partners in five countries (Ghana, Uganda, Rwanda, South Africa and India[15]).

Other national and international development organisations (for example the International Labour Organisation [ILO], International Telecommunications Union [ITU], the World Bank, the UN, USAID and Britain's Foreign, Commonwealth and Development Office [formerly the Department for International Development]) are already engaging with issues surrounding AI in low- and middle-income countries in order to strengthen local innovation systems, improve their own ability to deliver projects, and highlight dangers and risks.

Regional developments

In contrast to the last industrial revolution, the development of artificial intelligence will not be driven solely by OECD countries; countries in East and South Asia will also play a decisive role. However, there is still a danger that countries in the global south will be left behind by the fourth industrial revolution. This is the conclusion reached by Oxford Insights in its overall analysis of the Government AI Readiness Index. The Index ranks 194 countries according to their scores in various categories, e.g. legal and policy framework conditions, infrastructure and data, expertise and education, and public services.[16] The top of the ranking is dominated by developed economies in North America, Europe and Asia, with middle-income countries like Tunisia, Mexico and Malaysia in the global midfield. The bottom end of the table features less developed countries in Africa and the Pacific region, as well as a number of very small countries and territories (such as Monaco).
If we assume that **access to AI specialists, data and computing power are the decisive factors for the success of AI systems**, we have to anticipate that the current **AI superpowers, China and the USA**, will continue to consolidate their already dominant positions. The USA is still in the lead when it comes to AI research and applications. However, China is already investing more than any other country in expanding AI infrastructure and research, at an estimated USD 300bn.[17] The West takes a critical view of China's use of big data and AI to conduct surveillance of the population and public spaces. The Chinese government is also expanding its Belt and Road Initiative, in which many low- and middle-income countries are already involved, to include technologies such as AI-assisted surveillance technology.[18]. With this in mind, **European countries** in particular are keen to establish a framework for regulating AI that represents a 'third way' somewhere between the *laissez-faire*-approach seen in the USA and China's 'techno-Confucianism'. At the same time, **Africa** is becoming increasingly important for AI research[19]. Weak regulation is leading major tech companies increasingly to rush towards the African market as a venue for testing AI applications. At the same time, however, they are also helping to develop

[13] Li & Pauwels, 2018 Artificial Intelligence for Mass Flourishing. United Nations University.
[14] BMZ [Federal Ministry for Economic Cooperation and Development] 2019:Digitalisierung für Entwicklung, p.8.
[15] FAIR Forward has been part of the sectoral programme 'Digitialisierung für nachhaltige Entwicklung" (Digitalisation for Sustainable Development) since October 2019.
[16] Oxford Insights 2019: Government Artificial Intelligence Readiness Index 2019
[17] Jens Jäger 2018: Mit Künstlicher Intelligenz an die Weltspitze
[18] Freedom House, 2018, Freedom on the Net 2018, The Rise of Digital Authoritarianism p.9; Council on Foreign Relations, 2018 Exporting Repression? China's Artificial Intelligence Push into Africa.
[19] MIT Technology Review 2019: The Future of AI Research is in Africa

digital skills in local areas and to encourage innovation. For example, in 2018, Google opened an AI laboratory in Accra, Ghana. Moreover, in 2020 the International Conference on Learning Representations, one of the world's biggest conferences on AI research, will be held in Addis Ababa, Ethiopia. Given the long distances prevalent in much of Africa, often combined with poorly-developed supply and mobility infrastructure and a variety of ethnic groups, AI offers major potential to increase participation in social, political and economic processes, as well as to improve access to services, including in remote areas, if ICT infrastructure and technical expertise can be expanded sufficiently. A similar situation exists in **Latin America**, although the latter continent is more technologically developed. Multinational companies like Unilever are testing AI solutions in South America before rolling them out worldwide. Such initiatives are made possible by a combination of high demand for new AI systems among in the economy and a high level of acceptance of, and demand for, high-tech solutions among politicians and consumers in the region. AI holds the promise of comparable benefits for both regions, and they also share the challenges associated with the expansion of AI. For instance, areas of the economy and society that are fundamental for the development of AI, such as the education system the ecosystem for research and innovation, will need to be overhauled if these regions are to make the most of the benefits offered by AI. In a region where 10 per cent of the population already controls 70 per cent of the wealth, the risk of job losses linked to automation must be taken seriously, and appropriate measures taken to reform the labour market and mitigate this risk.[20]

1.4. Technical requirements for AI applications

Apart from stable Internet access and reliable power supplies, developing AI requires large quantities of data, access to computing power and AI specialists, whose job it is to develop AI systems and adapt them to specific circumstances.

Data

The types of data to which potential AI innovators have access will determine the kinds of products and services they are able to develop. Comprehensive **datasets need to be 1) available; 2) consistent with the applicable legal framework; and 3) technically usable – i.e. structured, machine-readable and labelled as appropriate**. The labelling of training data to be used in algorithms is especially labour intensive and could prove **a significant source of employment** in low- and middle-income countries in the future[21]. Although a large number of datasets for training AI algorithms are available online, there is a general lack of such datasets for low- and middle-income countries[22], and a specific lack of public datasets for specific applications connected to the 2030 Agenda. On the other hand, **Internet connectivity** has improved markedly in many low- and middle-income countries over recent years, particularly in urban areas. This development generates large **volumes of data as a by-product** [23]. Scientists predict that **mobile phone networks and financial services data** will be the most likely sources of AI training data in these regions in the coming years[24]. Governments are also increasingly making **datasets from ministries and public bodies** available for this purpose, for example as part of the Open

[20] Accenture 2017: How Artificial Intelligence can drive South America's Growth
[21] Financial Times, 2019, AI's New Workforce. The data-labeling industry spreads globally.
[22] WWW Foundation, 2017: AI, The Road Ahead in Low -and Middle-income Countries ; IDRC: Artificial intelligence and human development
[23] World Bank, 2018 Digital Adoption Index
[24] IDRC, 2018: Artificial intelligence and human development, p.57

Government Partnership[25]. This data is complemented by large amounts of third-party data (e.g. **geoinformation service (GIS) data**, Internet usage) that is either immediately relevant for AI or could otherwise prove valuable. There is a risk that AI development will be confined to countries in which there is already a large quantity of available data, and that innovators will work on the basis of the data available, rather than focusing on how it can be used effectively in practice.

Access to computing power

Training AI algorithms requires computing power, accessed either via **local supercomputers or from the cloud**. Only a very small number of partner countries have their own supercomputers (India, South Africa and Brazil are among the exceptions) and the number of applications they can run in parallel is limited. Therefore, **AI innovators in the global south develop their AI solutions overwhelmingly using cloud services**, and/or make use of pre-trained algorithms. The worldwide cloud computing market is dominated by a handful of firms based in the USA and China[26]. Alternatively, developers and technology partners can train algorithms abroad. All these options come with significant costs, and may be affected by applicable data protection legislation, especially if training involves personal data being transmitted to another country.

Software, algorithms and developers

There is a range of open software environments and algorithm databases that can be used to program AI. However, the software available in these environments has to be adapted for its intended purpose by AI specialists before it can be used. This means that city administrations need to develop new skills and attract machine learning specialists (AI talent) to their regions. These specialists are generally **mathematics or computer science graduates** with knowledge of multiple programming languages and an understanding of hardware and software architectures. To develop AI systems, they work together with an inter-disciplinary team of **data scientists** and **software programmers**[27]. As a rule, this former category of specialists is in particularly short supply in low- and middle-income countries.

In addition to the technical requirements, **AI also requires a regulatory framework** covering the handling of data and digital business models. Users and regulators also need to develop the digital skills required to identify, design and exploit useful applications. These additional requirements are discussed in Chapter 2.2.

2. AI in urban development

2.1. Implications for individuals and society in cities – opportunities and risks

Opportunities

Improved participation & provision of services

AI-powered systems have the potential to help us design more efficient processes, helping to conserve resources at the same time as increasing productivity. It has been forecast that AI

[25] https://www.opengovpartnership.org/our-members/

[26] According to a report by Gartner, Amazon Web Services held almost half the cloud computing market in 2019 (47%). It is followed in terms of market share by Microsoft Azure (22%), Google (GCP) (8%) and Alibaba Cloud (7%). The market share held by alternative providers has reduced in recent years; they now account for around 16% of the market between them.

27 Lorenz/Saslow, 2019, Demystifying AI & AI Companies. What foreign policy makers need to know about the global AI industry. Policy Brief by the Stiftung Neue Verantwortung, p.19

technologies could add up to USD 15bn to the global economy by 2030.[28] Given that infrastructure networks are denser in cities (leading to better electricity and internet provision) and that they are home to large groups of people who can act as data producers, developers and users, cities are best placed to exploit this potential. **Hence, the lion's share of AI-driven innovation will take place in urban centres**. By exploiting the potential benefits of AI, cities should be able to improve the full range of services they provide to their citizens, and to organise them in a more transparent way. The need to install additional sensors to generate data will give cities the chance to optimise their infrastructure. The continual collection of relevant data, combined with the potential to make monitoring systems more comprehensive and effective with the help of AI, could make urban planning and taxation processes more efficient and more evidence-based, as well as allowing technical infrastructure to be operated for longer before it needs to be replaced. As of today, a wide range of applications are already being used to help cities improve the services they provide to their populations. Useful and positive experience has already been gained across a number of sectors. AI is especially evident in the mobility sector (traffic management, autonomous vehicles), energy, water and waste (systems to adjust street lighting, electricity, water and waste systems to local requirements), safety (surveillance in public spaces) and financial services (, face-recognition-based payment systems). We will describe the potential of AI-assisted systems in various strategic sectors for urban development in Chapter 2.3, and illustrate this potential using a number of examples.

In addition, **AI-~~assisted~~ powered systems offer major potential to make citizen participation more effective and transparent**. For example, ML algorithms can categorise all comments made by citizens on a certain topic by clustering, weighting and locating them. This helps to generate a more comprehensive picture of the city and taking all contributions into account leads to better-integrated and more inclusive outcomes. At the same time, being able to visualise planned initiatives and their effects on a variety of factors affecting a city will help citizens to become better informed. Hamburg's city administration has already tested AI-assisted citizen participation, including visualisation.[29] Populating its *CityScope* planning model[30] still requires human input, but the machine can then suggest solutions in line with set criteria. For instance, it can use its location finder tool to suggest areas that may be suitable for development. However, in order to comply with the 2030 Agenda principle that no-one should be left behind, such digital citizen participation systems should be complemented by analogue ones. Previous experience with such systems in Germany has underscored the need for these analogue alternatives[31]. Specifically, in an international development content, groups affected by development initiatives should also be afforded the opportunity to participate through direct consultation/support ('last mile offer'). In this regard it is worth highlighting a number of hybrid solutions in which data is collected via non-digital interfaces where this is more appropriate for the group concerned, such as using the buttons on a mobile phone or voice-to-text to enter data[32]. The Digital Principles for Development[33], and particularly that of 'designing with users', offer useful guidance in this area.

Handling data

As set out above, solid underlying data is a basic prerequisite for any AI system. There are significant regional differences when it comes to the introduction and development of AI systems

[28] Oxford Insights 2019: Government Artificial Intelligence Readiness Index 2019

[29] Apitz & Müller 2019: Künstliche Intelligenz in der Planung – Digitale Revolution in der Verwaltung, p. 12-15

[30] HafenCity Universität Hamburg 2019: CityScope

[31] Zebralog 2019: Project overview

[32] Viamo 2019: Featured Case Stories

[33] Principles for digital development 2019: Principles Overview

and AI-assisted services and infrastructure in urban areas. This is i.e. because the spread and usage of the sensors that generate relevant data differs from city to city, and because the extent to which cities have digitalised the underlying data sources (for example census or land registry data) is similarly variable. Attitudes to computer-generated data collection, assessment and handling also vary for cultural and historical reasons and are subject to different legal framework conditions in different jurisdictions. **Ensuring that humanity as a whole benefits from the advantages of digitalisation means developing secure systems and making sure that personal data is protected appropriately**. Decentralised AI systems show significant potential to provide the required level of data security, and to promote participation at the same time. Complementary *blockchain* technology is already helping to ensure that land registries are managed more transparently and to ensure that transactions involving securities remain secure. Adding ML algorithms to these kinds of decentralised data management techniques can make the system even more secure, because the algorithm allows any irregularities or fraud to be identified and reported immediately. The DECODE pilot project, which is funded by the EU, is testing new technologies that aim to give people more control over the way they store, manage and use personal data stored online. The project is developing practical options for handling data and demonstrating wider value to society. In two pilot studies, in Barcelona and Amsterdam respectively, newly developed technology is being tested and the social advantages of widely used open data commons examined. The aim is to highlight how a data-orientated digital economy can be developed in which data gathered from citizens, the Internet of things and networks of sensors can be harnessed for the common good, and appropriately protected.[34]

Consequences for the labour market

One of the concerns that surfaces again and again in discussions about digitalisation and AI is that it may lead to job losses, as machines take over low-skilled production and simple processing work as well as office jobs. As most production for processing industries (e.g. textile manufacturing) takes place in cities, they stand to be particularly badly affected by this change, and this is especially true of cities in low income countries. **Up to two thirds of all jobs in low-income countries could disappear as a result of automation**, further widening the gap between rich and poor. On the other hand, progress in digitalisation and expanding Internet access will come with huge potential to transform labour markets and create new jobs. As networks become more global and digitalised, they will enable increased participation in global processes and access to knowledge (e.g. open algorithms), services (advice) and tools (such as cloud storage), which in turn serves to encourage 'leap-frogging', local innovation and job creation. **Overall, it is widely assumed that digitalisation and AI will create more jobs than they destroy.[35] However, this will only be the case if digitalisation takes place under the right conditions**.[36] With this in mind, the education sector will have an important role to play in building capacity and developing technical expertise. If this can be achieved, the transformation of the labour market triggered by the advent of AI can make a positive contribution to 2030 Agenda's promise of 'leaving no-one behind', because any physical restrictions workers may face are less likely to affect jobs in the digital/AI sector, and because inequalities can be reduced through additional training. Moreover, computers and robots can assume routine tasks, support people in their work and encourage participation, thus freeing up more space for creativity. Here too, **cities will be at the centre of developments, as it is in densely populated cities that people working in labour-intensive trades and professions mix with well-educated digital pioneers and entrepreneurs. Hence, cities provide the best conditions for the transformation of the labour market, and it is in cities where that transformation will be**

[34] DECODE 2019: Giving People Ownership of their Personal Data

[35] Höffken et al. 2019: Künstliche Intelligenz – Die Transformation gestalten, p. 3

[36] BMZ [Federal Ministry for Economic Cooperation and Development] 2019: Digitalisierung für Entwicklung

most keenly felt. The concentration of actors, knowledge and users in one place, along with relatively widespread access to digital infrastructure, will help cities to present themselves as places where innovation and transformation occur, and thus to attract investors and partners.

Risks and recommendations for action

Discriminatory algorithms

Discriminatory outputs from an AI system can be caused by three things: **biased algorithms, unrepresentative training data**, or data **representing specific and unwanted distortions that are present in reality**.

1) Algorithms are assumptions about the world as expressed in the weightings assigned to individual factors and variables (bias). This weighting is influenced by developers' worldviews and their underlying knowledge. At the same time, the requirement that AI should be 'non-discriminatory' and use 'fair algorithms' demands a certain knowledge of the context in which the systems will be used and the everyday reality of life for potential users. As most AI developers around the world are men from the educated urban middle and upper-class, there is a risk that the algorithms they develop will be **one-sided and prejudiced** (i.e., that they will be biased). Accordingly, it is important to ensure that development teams are diverse, and that they incorporate end users' views of the world.
2) Another problem that can lead to discriminatory algorithms is the use of **insufficiently representative training data**. This is what happens if a face recognition system is trained primarily using pictures of white people, meaning it struggles to identify people with darker skin. Bearing in mind the principle that no-one should be left behind, it is therefore very important to ensure that training data is both comprehensive and representative.
3) **Algorithms create correlations, but they do not explain causation**.[37] This means that even well-balanced algorithms trained on a wide range of data can still produce discriminatory outputs if they **reproduce inequalities that exist in the real world**. This can happen i.e. if a recruitment algorithm sees that a large majority of applicants for a position are men and draws the conclusion that women might not be able to do the job. Other examples include chatbots making homophobic or racist comments because they learnt so in the 'real world', or when algorithms for so-called 'predictive policing' predict high levels of crime in areas of cities that are already heavily patrolled by police.

Other steps that can be taken to reduce the risk of discriminatory outputs and errors include ensuring the system specification is clear, putting appropriate safeguards in place, and being careful to take specific local circumstances and all sections of the communities covered by the systems into account.

Explaining AI decisions: the 'black box' problem

One of the biggest fields within AI research is 'explainable AI', or how to explain decisions made by AI systems. Up to now, it has proved extremely difficult to explain exactly how an ML system learns, how it draws conclusions, which elements of the data entered into the system it recognises and regards as relevant, where this relevant information is stored, and how influential it is in the machine's decision-making. This has given rise to what researcher call the 'black box' problem. As far as the algorithms are concerned, there are number of precautions that can be taken to reduce the risk of discrimination and arbitrary decisions, starting with the type of algorithms system developers decide to use in the first place. Public bodies are generally advised not to use pre-developed algorithms that have not been adapted to take account of specific relevant circumstances. For instance, after assessing the performance of the SKALA predictive policing

[37] Höffken et al. 2019: Künstliche Intelligenz und Stadt, p. 7

system and weighing it against the logic and transparency of the decisions it made, users concluded that "'decision trees' (hierarchical models in which a single dataset is progressively split up into multiple disjunctive – i.e. separate – sub-groups with no elements in common as they pass through multiple decision nodes) were preferably to neural networks.

This is why the German government's AI Strategy also insists that in order for algorithms to meet legal requirements, it must be clear how they take decisions, regardless of whether they are designed to support decision-making by humans or operate autonomously. Current approaches in explainable AI research are allowing researchers to open this black box, and may also make it easier to explain how AI networks think by showing which elements of the input data affect outputs and why (this technique is known as 'layer-wise relevance propagation').[38]
There is also a need to apply the principle of **algorithm transparency**, according to which the factors that play significant roles in the algorithm's decision-making process must be clear and transparent for the people using and regulating the system. This principle also allows for reverse engineering if the algorithm comes to one-sided, prejudiced or discriminatory conclusions.

Cyber-security
Alongside the risk that artificial intelligence may be developed in a way that produces undesirable outcomes, there is also a danger that they could be deliberately influenced – i.e. that AI systems could be manipulated, or their supporting infrastructure attacked. Such attacks could be carried out by hackers working on their own or in groups, or by state actors carrying out planned operations. Although the reasons behind such attacks might vary, the consequences of a successful attack would be identical, ranging from spying on and abuse of personal data to deliberate manipulation to serve the attackers' own interests or to damage others. In cities, for example, citizens' sensitive personal data could be stolen and misused, or plans for investments (in infrastructure or construction, for instance) subjected to undue influence, perhaps in an attempt to get the investment moved elsewhere. With this in mind, the **issue of cyber-security must play a significant role in the development of urban AI systems, especially when it comes to development and international cooperation projects**. Particularly as far as data protection is concerned, it must be made clear exactly where the data used by such AI systems is stored (at a local data centre or in the cloud) and who has access to it.

Abuse and surveillance
Collecting personal data in public spaces and feeding it into AI systems has the potential to make urban spaces safer, for example by making it easier to find criminals and record crime, allowing more effective management of police forces and other emergency services, and speeding up evacuations during major incidents. It may also allow various processes to be made more efficient, for example by using intelligent traffic light phasing to control traffic. On the other hand, this form of 'surveillance' may result in personal freedoms being curtailed and/or in people being dictated to by the state, and there is therefore a risk that these systems, and the data underpinning them, could be abused. **The prospect of systematic surveillance of public spaces combined with a social credit system like the one that has been developed in China** (and that is expected to be rolled out nationwide during 2020) **has prompted concern in many parts of the world and given rise to considerable fear**. Thanks to state support, Chinese firms are developing into market leaders in face or gait recognition software (such as Watrx)[39], and they are selling these systems to low- and middle-income countries. Particularly in countries with authoritarian regimes, weak institutions and inadequate provisions to protect human rights, there

[38] Höffken et al. 2019: Künstliche Intelligenz und Stadt, p. 8
[39] Axel Dorloff 2019: China – Künstliche Intelligenz als Staatsziel

is a **danger that these systems will be used for state surveillance, abused in order systemically to disadvantage certain sections of the population, or worse.**
In addition to the risk of external manipulation, algorithms can also be internally falsified, for example by programming them in a one-sided or prejudiced way. This might manifest itself in a system that favours certain groups or sections of the population in participatory procedures, or that advantages certain districts when it comes to the development of city infrastructure and the provision of public services. Thus, AI algorithms can be used to exacerbate differences between different sections of society and systematically to disadvantage individual groups or areas. In order to prevent abuse and reduce the risk of internal manipulation, AI algorithms should be developed openly, which is to say, developed by a number of actors working together using a participatory and/or cooperative approach. Various private companies, governments and civil society organisations are also working on guidelines for ethical and human-rights-based AI systems, as summarised by researcher's at Harvard University's *Berkman Klein* Center[40].

The digital divide
A further risk, especially in an international development and cooperation context, is the differing levels of digitalisation between high-income countries and their low- and middle-income counterparts. This ‘digital divide’ is wide and growing. **In comparison to the development of other forms of infrastructure, such as water and sewerage systems, digital infrastructure is expanding at a significantly faster rate**. This is shown by the fact that average mobile broadband coverage rates in Africa in 2016 were higher than they were in Europe in 2009, or in the United States in 2010[41]. This development ought to even out access to broadband globally, which would create positive conditions for digital applications and citizen participation via global networks. However, digital infrastructure in general, and in particular the expansion of sensor systems as a result of the generation of data, is developing appreciably faster in the global north than it is in the global south, with China, the ‘Asian Tiger’ economies and the USA playing leading roles. Inadequate underlying data is a common complaint in many developing countries, with many African observers going as far as to describe it as ‘Africa's statistical tragedy’. This lack of data prevents solid conclusions from being drawn based on statistics, which in turn undermines efforts to draw up targeted development strategies, as well as stopping local innovators from developing AI systems adapted to local conditions. **Since digital applications and AI solutions are based on a combination of solid and large underlying data sets, this highlights the danger that, as AI systems are developed and used in cities around the world, the gaps between these cities will become wider, resulting in people in developing countries being left behind**. Moreover, we can already observe major differences in this respect between large cities and smaller ones, as well as between cities and rural areas. **In 2015, 89% of city-dwellers had access to mobile broadband connections, compared to just 29% of the rural population**[42] . Especially in developing countries, the bulk of state and private-sector investment is concentrated in cities. At a societal level, it is also possible to discern significant differences between various sections of the population, especially in developing countries. While the well-to-do in African cities usually have access to 4G Internet connections, many people in informal and rural settlements have only basic mobile phones or have no access to the Internet, meaning they are excluded from web-based solutions and processes. **This lack of access has the further effect of exacerbating the difference in digital skills between different sections of the population, which makes it harder to ensure comprehensive, integrated, development of digital systems, and to make sure they are implemented such that the whole population can make use of them**. Providing support for ‘last mile offers’ could present significant business

[40] Fjeld et al., Berkman Klein Center, 2019: Principled Artificial Intelligence
[41] Broadband Commission 2016: The State of Broadband: Broadband catalyzing sustainable development
[42] Broadband Commission 2016: The State of Broadband: Broadband catalyzing sustainable development

opportunities for GIZ, as it can bring its many years of experience in capacity-building, advice and mediation to bear in this area.

2.2. Implications for control and administration at city level

Technical implications: data governance

One of the basic technical requirements for developing AI systems is that the problem the AI is supposed to solve has to be mathematically measurable (for example, using statistics), so that it can be taken over into an algorithm. At the same time, there must be sufficient data available for the system to solve the problem. For algorithms to be able to draw accurate inferences, developers must have access to **a large quantity of structured, labelled data in a machine-readable format** (this is the technical definition of 'data quality'). Particularly for societal applications, the algorithms also require **highly representative (training) data**, for example in terms of the social groups and city districts it covers. This reduces the risk of distorted or downright discriminatory conclusions being drawn by the system (see also Chapter 2.1., Risks). **Keeping personal data secure** is also essential[43]. For most applications, the collection and processing of data are continuous, rather than one-off, processes, and therefore require a suitable **data management system**. In addition, many applications of AI systems require the **integration of data from a variety of sources**. This is also the case for the kind of geographical (GIS) data required for most city-based systems.

In the context of a city, the following **data sources** are of particular relevance:

Data source	Possible types of data
Citizens as users of mobile phones and social media, motorists and users of city services, participants in crowd-sourcing campaigns	Complaints, requests and opinions; Images, location and movement data, speech data
(Local) governments and public service providers Sensors and smart meters RFID (Radio-Frequency Identification) tags (e.g. in rubbish bins or buses)	Census data, energy and water usage, traffic surveillance data Air pollution measurements, climate and weather data, movement patterns for public transport
Firms such as mobile network operators (MNOs), taxi firms, social media, financial services providers	Localisation and movement data, financial translations, opinions, pictures of current events (such as disasters)
Non-location-dependent data sources: Earth observation satellites or drones, language data	Geospatial data, language datasets (as a basis for chatbots and similar)

The opportunity to use analysis of large datasets to create additional value for a city and its citizens is greatest where data is already available and/or can be easily collected. Therefore, it would appear that AI solutions are likely to be developed in sectors and areas that are already

[43] Computer-assisted anonymisation processes have now been developed for this purpose.

digitalised and generating suitably large quantities of data, such as telecommunications and finance.[44]

In areas where large quantities of data are not yet available, the **costs associated with collecting and managing the data have to be weighed against the potential increase in efficiency that AI services could bring**. **Hence, the creation of open data pools in areas relevant to sustainable urban development could represent an important focus for Germany's development efforts, as this would reduce the barriers to entry for local AI developers.**

In order to combat a lack of available data, AI innovators may look to go into **data partnerships** with public bodies, research institutes and local or international data firms[45]. **Data** can also be generated **from industrial processes**, although this requires a certain level of automation and digitalisation of the industrial sector[46]. Another way of obtaining data is to interact with users at the point at which the data is to be collected. In so-called **'crowd-sourcing'** campaigns, the aim is not just to collect data, but also to raise awareness among the participating citizens of a certain cause or issue. For example, GIZ supported a joint German-Indian project[47] in which an algorithm using data on blockages in the sewerage system is used to suggest to local authorities how best to prioritise their sewer cleaning activities.

Organisational implications

AI projects are change projects that can only work if the actors involved have a good understanding of the context and the problem to be resolved. Hence, the effectiveness of any AI project is conditioned by the effectiveness of **cross-sector cooperation** between city authorities, universities, private companies, civil society and citizens to identify, design, implement and monitor the AI project. For a city administration, this requires sufficient **political will and management capability** to implement projects as part of multi-stakeholder partnerships. This in turn requires an integrated approach to administration involving close cooperation across multiple departments within the city authority (for example IT, procurement and individual sector-based departments). In this respect **smaller cities may enjoy an advantage** over huge metropolises with particularly large administrative bureaucracies.[48] One potential approach might be to start by testing AI projects at the level of individual districts before scaling them up to cover whole cities. Particularly when collaborating with private-sector IT companies, a **thorough understanding of the technology at all levels of the administration** is essential, in particular for procurement processes (for example, procurement departments must have a basic knowledge of IT terminology), but also in order to adapt back-end processes. Previous experience in the UK has shown that when private firms implementing and advising on IT projects have a significant advantage in terms of their technical knowledge, this can create **imbalances within multi-stakeholder partnerships**[49]. **With this in mind, it is crucial to draw up a good communications strategy** that ensures the interests and expectations of all those involved in the joint project are mutually compatible, and that constantly reinforces the message to technology-focused private firms that the AI project they are working on is for the public good.

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[44] McKinsey Global Institute 2017, Notes from the AI Frontier p.15

[45] GIZ, 2017: Data for development: What's next? Concepts, trends and recommendations for German development cooperation p.51; Verhulst, S. (2014). Mapping the Next Frontier of Open Data: Corporate Data Sharing

[46] UNIDO, 2018. You say you want a revolution: Strategic approaches to Industry 4.0 in middle-income countries.

[47]GIZ, 2019 IKT-basierte Anpassung an den Klimawandel in Städten

[48] Oliver Wyman Forum: Global Cities' AI Readiness Index 2019

[49] Jankin et al., 2018, Artificial Intelligence for the Public Sector. Opportunities and Challenges of Cross-sectoral collaboration.

At the same time, human-centric AI systems should start from an understanding of the needs of citizens, visitors and local administrators – they should be 'citizen-driven' rather than 'ICT-driven'. Too often, it is the data and the technology that drives projects forward rather than the user experience. This requirement in turn gives rise to a number of criteria for creating successful **interdisciplinary teams**. Their members should demonstrate **not just the technical knowledge required to create AI systems, but also a sound understanding of citizens' needs, administrative processes, data management and analysis, law and the principles of service design**.

To further increase technical capacity for joint projects as part of multi-stakeholder partnerships, researchers suggest that **standards for data collection and ensuring data quality** should be set before data is shared between organisations, in addition to **standards for exchanging data**.[50] Steps must also be taken to guard against cyber-attacks or data theft.

Regulatory framework conditions

Along with the issue of how to ensure the fairness and explicability of AI decision-making, probably the biggest debate currently surrounding artificial intelligence centres on how to reconcile the need for huge quantities of data and the requirement to secure personal data and to protect privacy[51]. The prospect of addressing this problem using an **approach founded in human rights law** in addition to existing data protection legislation is becoming increasingly prominent in the discussion[52]. City authorities' access to data, such as location and connection data from mobile Internet connections, images and opinions from social media or financial transaction data, can be limited by statutory restrictions, or by the refusal of the data owner to pass his or her data on. Therefore, all city-based AI projects must first establish whether the **use of the data** is consistent with applicable regulations relating to data and privacy. This also requires some sector-specific regulation, since "no standards have yet been agreed for the anonymisation and exchange of information obtained from large amounts of data in priority industries like financial services, e-commerce and mobile communications."[53] Secondly, they must take into account the fact that **relationships in multi-stakeholder partnerships** may themselves be subject to statutory regulations dealing with a variety of issues. These might include, for instance, questions as to who is entitled to view certain data and/or to use it as appropriate outside the confines of the project (for example with data partnerships); under what conditions an employee of a state-funded university is allowed to work on behalf of private companies or municipalities; or whether applicable procurement rules permit contracts to be awarded directly to AI start-ups and/or whether a consultation procedure with potential contractors is required. Finally, it is possible that **legal questions may arise in relation to the use of the AI systems to be developed**. Such questions might surround provisions regarding the liability of AI systems, maintenance work carried out on Ai-assisted systems by IT service providers based in another country, or how the values created by the machine can be certified and controlled.

In additional, local councils and administrations should work to create targeted legal framework conditions that allow and make it easier for AI innovators, such as local start-ups, to access

[50] Jankin et al., 2018, Artificial Intelligence for the Public Sector: Opportunities and challenges of cross-sector collaboration, p.8
[51] Stone et al., 2016, Artificial Intelligence and Life in 2030. Principled Artificial Intelligence p.46; Fjeld et al., Berkman Klein Center, 2019:
[52] See Lorenz/Saslow, 2019,Demystifying AI & AI Companies. What foreign policy makers need to know about the global AI industry. Policy Brief der Stiftung Neue Verantwortung.
[53] World Bank 2019, Information and Communications for Development 2018, p.48

expertise at universities, specialists working outside their own countries, computing power and, where appropriate, state contracts.

2.3. Examples of use in urban environments

In the following section we will highlight **applications of AI in areas frequently controlled at city level, specifically planning, water/sewerage, mobility, waste and construction**, and illustrate them highlighting examples from cities worldwide.

Urban planning

Urban planning is facing a particularly stern test. As a discipline, it is directly affected by AI. Moreover, it will have to find adequate planning responses to the fundamental and potentially disruptive societal changes that will be, and are being, triggered by digitalisation. The aim must be to shape the transformation process to ensure it meets people's needs.[54] The hopes attached to the use of AI in urban planning are bound up with the promise of a more effective way to manage the complexity of urban spaces in real time, as well as the ability to make precise predictions of future developments.

Exactly how a given city develops in terms of its use of space and its building policies depends on decisions taken at various political levels. Once these decisions have been taken, proposals for specific initiatives with a view to implementing policy aims are then drafted by local city planning departments or by outside planning firms. As a planning concept takes shape, it has to incorporate extraordinarily complex framework conditions, interdependencies and a variety of different interests, as well as a detailed knowledge of the local situation. The complexity associated with these circumstances and interests is close to limitless. Responding to all the relevant issues in this area requires an intelligent, software-based planning procedure that produces comparable results. Until recently this was dismissed as unrealisable due to the complexity of the problem.[55]

However, the increasing penetration of information and communications technology into the public space is making spatial data similarly ubiquitous. From a scientific point of view, there is a wide range of theoretical concepts that might allow value to be extracted from this data with the help of AI systems. These concepts would not only allow the complexities of urban spaces to be recorded in real time, but also permit the use of self-learning systems to make predictions for the future.

From an urban planning standpoint, the potential of AI lies in its ability to create an effective system for managing the complexities of urban spaces in real time, as well as to make predictions of future developments that are accurate enough to be actionable. For instance, an AI system could analyse a variety of data sources and then collate and display the data in order to generate predictions of developments in society, allowing preventative measures to be taken before problems arise.

AI can also make **a positive contribution to participatory procedures in urban planning**. For example, digital written submissions from citizens could be pre-processed using natural language understanding, argument extraction and sentiment analysis systems prior to manual evaluation. This would give quickly give urban planners an initial impression of the opinions expressed, as well as identifying similarities in the submissions and opinions expressed. Relevant arguments could then be extracted, and the machine could potentially go on to suggest solutions that might achieve a consensus based on voting mechanisms. The effects of specific changes, such as planning to add an extra lane to a road, could be simulated and displayed as part of a participation

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[54] Stefan Höffken and Martin Memmel 2019: Künstliche Intelligenz – Die Transformation gestalten, p. 4

[55] Rolf Lührs and Matthias Rehkop 2019: Können Maschinen Stadtplanung, p. 16

system. This would then allow feedback from specialists and from ordinary citizens to be incorporated into draft plans as part of a joint creative process.

All the planning-related applications in which artificial intelligence might be used have one thing in common: the systems are intended not to replace planners, but to support them in defined areas. AI-based tools are designed to act as a cognitive enhancement, improving planners' ability to do their jobs.

All in all, **AI should be viewed as a helpful and complementary tool**, one that can perform certain tasks better and faster than humans. In this respect, it is just like any other tool. However, using this tool will also require cities and planners to improve their own skills and to develop and control their own digital strategies. They should **not resign themselves to the arrival of AI on the basis that it is now inevitable. Rather, they should view it as an emerging issue that they can themselves influence and shape**.[56]

Example

The city of Hamburg uses machine learning and word embedding technology in the context of urban planning.[57] The primary aim of doing so is to make use of new forms of knowledge management and to provide effective support to urban planners. As part of the city authorities' 'Di-Plannung'(Di-Planning) project, a knowledge database has been created for planning, covering not just the full texts of all existing construction and development plans, but also the guidelines according to which these plans are drawn up. This technology has proven to be far more effective than traditional full-text searches when looking for specific cases in large numbers of documents. Alongside the automatic keywords embedded into the system, the system also uses machine learning to generate content-based connections between specific specialist issues and existing plans, and to draft sample texts dealing with individual planning-related problems.

It would appear, then, that the most pressing task for machine learning in urban planning is currently to create conditions that will allow machines to learn how to plan cities. [58]

The Austrian Institute of Technology (AIT)'s *SynCity* project in Ethiopia is another example of AI-supported city planning[59]. The project is focused on digital methods for designing spatial structures within cities. The project stakeholders have developed a computer-assisted drafting strategy that adapts to take account of changing environmental circumstances and takes the views of people living in and using cities into account. Based on this strategy, a master plan has been drafted. This plan is composed of a series of rules derived from the lives and interactions of residents, rather than from abstract geometric concepts. These sets of rules are themselves generated from models combining visibility and accessibility analyses.

Water

Water supply and sewerage networks are among the least modernised of all urban systems and are of fundamental importance for human life. In many western countries, the majority of water infrastructure networks are already several decades old (some of them date back as far as the late 19th and early 20th centuries). As the price of sensors has dropped, water suppliers have moved to equip their systems with IoT sensors and data-driven technologies that continuously collect data on the supply and demand for water. However, until now, these sensors have only ever been used to monitor actual water consumption and to identify and locate contamination or

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[56] Stefan Höffken, Bianca Katharina Lüders and Matrin Memmel 2019: Künstliche Intelligenz und Stadt, p. 8

[57] Urban Digital 2017: Digitale Planungsinfrastruktur der Stadt Hamburg

[58] Rolf Lührs and Matthias Rehkop 2019: Können Maschinen Stadtplanung, p. 18

[59] AIT Austrian Institute of Technology 2019: Syncity Ethiopia

leaks as early and precisely as possible. Machine learning-based technologies, could be used to make the water supply system more efficient and effective by identifying any problems in the system at an early stage, allowing them to be addressed before major defects arise.[60]

*"If you use sensors and can detect that potential fracture before it ever occurs, it's cheaper to fix, you've not wasted a lot of water, you've not disrupted a city and you've taken care of a problem before it actually occurs." (*Kim Nelson; Executive Director, State and Local Government Solutions, Microsoft)[61]

AI systems can also be used to predict peak demand times. When used together with smart meters in buildings, this can help to reduce water consumption by encouraging consumers to use water more efficiently.

Upgrading existing old infrastructure is significantly more difficult and expensive than fitting pipes, pumps and values with sensors when a new system is installed. This represents a major opportunity for low income countries, because explosive population growth in urban areas means that a large proportion of the urban infrastructure required in these countries is still yet to be built. Since water supply networks cover large areas, installing them will require an inter-municipality and cross-district approach to solving problems. If such approaches can be found, they have the potential to strengthen bonds between cities and the surrounding rural areas, thus promoting development across the country.

Forecasting systems for periods of heavy local rainfall represents another area in which AI can be used to improve urban water management. Flash flooding and landslides caused by heavy rains are major challenges for urban water management. Sensor-assisted data collection and self-learning algorithms can be used to predict these rainfall events so that action can be taken before disaster strikes, saving lives and preserving built infrastructure. Examples of such systems include Kisters' Hydromaster[62] or IBM's Deep Thunder[63].

Example

Many operators are already using software that use data from sensors to help them monitor and visualise water levels in elevated reservoirs, as well as the status of pumps, turbines and valves. One such operator is the *Zweckverband Bodensee-Wasserversorgung* (BWV), which uses Zenon software to help it provide water around Lake Constance. [64]The water consumption data obtained from the system, together with other data covering variables including temperature and precipitation, can be used by machine-learning assisted systems in order to predict water consumption. This kind of system is already in use in several smaller towns in Spain, as well as in large cities like Montreal in Canada. In addition, AI systems can also make decisions as to how pipe systems should be maintained, based on data provided by sensors fitted to the pipe system. These decisions are taken according to the likelihood of a failure affecting part of the network, cracks in pipework and other defects. This system is already being used in Austria and in Syracuse, USA, where the water system is now too big for the falling population and maintenance is therefore a particular problem. With the help of AI, authorities there have already dealt with 42 of the top 52 damaged areas assessed by the system as most likely to cause problems.[65]

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[60] Alanen 2019: How artificial intelligence is transforming the water sector

[61] Chris Teale 2019: How AI and data turn city water management from an art to a science

[62] Kisters 2019: HydroMaster

[63] IBM 2019: Deep Thunder

[64] Zweckverband Bodensee-Wasserversorgung Transportsystem der Superlative: Trinkwasser für Millionen

[65] Sappl et al. 2019: Maschinelles lernen in der Siedlungswasserwirtschaft p. 364-365

Mobility

In many fast-growing cities all over the world, increasing mobility is pushing infrastructure to its limits, resulting in traffic jams, air pollution and increased CO_2 emissions. **Here too, AI offers major potential to improve relevant systems, for example by enabling more intelligent road navigation and traffic management, optimised logistics, AI-assisted business models for personal urban mobility (i.e. e-hailing/ride hailing) smart parking and congestion pricing*[66]***. Automotive manufacturers are also working together with technology firms to deliver autonomous driving, although using this technology in cities is so fraught with complexity that some observers doubt whether it will become reality in the foreseeable future[67]. In a 2018 study, the McKinsey Global Institute noted that the worldwide mobility sector accounted for more AI applications that had been developed and were in practical use than any other sector of the economy. App-based e-hailing and real-time navigation apps in particular do not require any up-front investment on the part of city authorities, and can deliver immediate benefits to consumers.[68] By contrast, only a handful of cities (including London and Melbourne) have so far adopted applications such as predictive maintenance for public transport and infrastructure with a view to reducing downtime and delays. Coordinated, city-wide traffic light control systems, one of the applications with the potential to make the biggest difference to commuting times and traffic congestion, are at least being piloted in many cities. Smart parking promises to reduce so-called 'search traffic' caused by people driving around looking for parking spaces. However, in many places the relevant sensors and expanded digital payment systems required for the system to work are yet to be installed. Congestion pricing has similarly been implemented on large scale in just a small number of cities (such as Singapore).

Examples

Alibaba's 'City Brain[69]', which first appeared in the city of in Hangzhou, is the most ambitious attempt yet to collect city data from smartphones, sensors and cameras, along with vehicle GPS data, and to store it in the cloud with a view to using AI to solve various mobility-related problems, particularly by improving traffic management systems.[70] 'City Brain' is now in use in six Chinese cities and in the Malaysian capital, Kuala Lumpur. However, the centralisation of such large quantities of data has led to criticism, amid concern that it may be used to conduct surveillance on citizens.

The ***UN Global Pulse Lab*** is testing how AI can be applied in low- and middle-income countries. In Jakarta, a solution for improving transport planning and operational decision-making using real-time data analysis has already been successfully tested[71]. Using data from *TransJakarta*, the city's express bus network, bus and passenger rail stations were analysed to discover trends in passengers' points of origin and destinations, which is useful for planning routes. In order to determine which stations suffered from the longest waiting times, the project used so-called 'tap-in' data (based on passenger numbers) and fleet GPS data (based on bus numbers). The project's methods and outcomes were shared with *TransJakarta* in order to improve route planning and the reliability of services, as well as to support planned expansions of railway station facilities. Based on feedback from the project, the city authorities made a series of targeted alterations and

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[66] Wikipedia 2019: Congestion Pricing
[67] Brandom, 2018: Self-driving cars are headed toward an AI roadblock. In: The Verge, 3 July 2018
[68] MGI 2018: Smart Cities: Digital Solutions For a More Livable Future, June 2018, p.82
[69] Alibaba Cloud 2019: ET City Brain
[70] Toh & Erasmus, 2018 Alibaba's 'City Brain' is slashing congestion in its hometown, CNN 15 January 2019
[71] UN Global Pulse, 2017 Using Big Data Analytics for Improved Public Transport. Jakarta

improvements to their procedures, for example deploying more traffic police and erecting more barriers in order to secure direct routes in areas that are typically highly congested, as well as providing more buses on certain journeys.

GIZ in Thailand is currently working with the e-hailing-service GRAB and UN Global Pulse to build on some of the lessons from this project. **In Thailand, taxi drivers' movement data is being used to represent and control traffic flow**. Those involved in the project have highlighted that it would not have been possible if GRAB had not been willing to share its data. GRAB only agreed to do so after a lengthy and intense process of negotiation. Its data is an integral part of its business model, so it was no surprise that it was initially reluctant to disclose it to third parties (which in this instance included the state and development partners).

The ***'KI-Landkarte'*, or 'AI Map'[72] of Germany's "Platform of Learning Systems"** provides an overview of **mobility-related research projects and testing in Germany, along with other information**.

Waste

Waste collection is a critical aspect of waste management. **About 80% of the costs associated with waste disposal are connected with the use and maintenance of fleets of lorries** travelling around cities every day collecting the waste generated by the population.[73] The interface between AI and the IoT offers major potential to optimise waste collection. Systematically equipping waste bins across a city with sensors or RFID tags connected to the internet allows various data to be transmitted to a server, for example regarding how much waste is in each bin. If the data from each individual bin is merged into a single dataset, this dataset becomes big enough for users to see which bins must be emptied on any given day. Machine learning can then be used to draw up optimised collection routes. This system means that empty bins no longer have to be emptied and provides indications as to where additional bins ought to be provided. **This in turn leads to a reduction in fuel and vehicle usage**. City authorities can also build on these kinds of systems to predict how waste generation will develop in cities in years to come, as researchers[74] in the Australian town of Logan have already demonstrated. Such a system would also provide the underlying data required to measure the success of waste prevention campaigns.

Example

In Granada, Spain, a similar project[75] has been delivered as part of a multi-stakeholder partnership involving local authorities, a construction firm with data expertise, a waste disposal company and a US-based tech firm. Around 420 sensors fitted to public waste bins (amounting to 75% coverage) measure the fill levels and conditions of the bins, as well as weather data. This information is brought together in a platform, where it is used by algorithms to calculate ideal collection routes. These routes are then sent to the waste collection lorries. The project is supported by the University of Granada's 'Urban Laboratory'.

As far as low income countries are concerned, it is worth highlighting that this project requires a system of public waste bins that can be fitted with sensors, and that procuring, installing and

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[72] https://www.plattform-lernende-systeme.de/ki-landkarte.html See the „Anwendungsmarkt (Branche) ? Mobilität und Logistik" [Usage market (Sector) – Mobility and Logistics" tab

[73] Kellow Pardini et al. 2018: IoT-Based Solid Waste Management Solutions: A Survey. MDPI

[74] Abbasi & Hanandeh, 2016: Forecasting municipal solid waste generation using artificial intelligence modelling approaches. In: Waste Management, 56, pp.13-22.

[75] Ferrovial 2017: Ferrovial Services and Granada City Council to implement a dynamic municipal waste collection project

maintaining such sensors would entail major costs. For the continuous data transfer to work properly, the sensors also require a source of power (for example batteries or small solar modules), a stable Internet connection, and a server that can receive and process constantly increasingly data volumes. Both the sensors and their power sources would also need to be secured against theft. With this in mind, a system based on reports of the waste being disposed of by citizens, potentially combined with new types of payment systems (such as so-called 'pay as you throw' schemes), could prove a sensible alternative.

Construction

Between them, buildings and the construction sector are responsible for 36% of global end energy usage and 39 per cent of energy-related CO_2 emissions *(Global Alliance for Buildings and Construction, Global Status Report 2018: p.9).* As structural materials often determine the overall mass of a building, efficient construction techniques and use of sustainable building materials could potentially produce a significant reduction in CO2 levels. With this in mind, various methods for assessing the sustainability of buildings (such as life-cycle assessment) are being used increasingly frequently. However, given the multitude of parameters and variables that determine the environmental impact of a building over its lifecycle, such techniques are not guaranteed to bring the expected benefits. Moreover, the spending required to produce a reliable assessment would appear to be a **significant barrier to the widespread use of life-cycle assessments**. That said, researchers believe that combining tried and tested methods for assessing environmental sustainability with AI technology could represent a major step forward.[76] **Machine learning technology could also lead to significant improvements in energy management within buildings**[77].

Examples

A programme in Germany is also researching the requirements for the "creation of an open, Internet-based, standardised data exchange and service platform for delivering new, intelligent services in the context of building automation and people's living spaces, with some of these services covering multiple buildings."[78] The German Aerospace Centre's SOSat project[79] , a partnership with the University of Munich, aims to map global urbanisation trends. It uses satellite data, images from social media and 'open street maps' to create 3D models of the built environment, which can then be used to assess population density, classify buildings by type, identify informal settlements and locate cites within local climate zones. The Platform Lernende System (Platform of Learning Systems) **'*KI-Landkarte* or 'AI Map' also shows a number of research projects and possible applications for AI technologies in Germany's construction and infrastructure sectors**.[80]

3. Recommendations for German urban development initiatives

In order to exploit the opportunities AI-assisted systems can provide for urban development, it will be necessary to ensure that **both decision-makers and citizens have the required skills**, specifically digital literacy and e-skills. A **supportive environment and overall climate** will also be needed, as expressed in legislation, strategies and investments. **GIZ can make use of its**

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[76] D'Amico et al., 2018: Machine Learning for Sustainable Structures: A Call for Data. In:
[77] Seyedzadeh et al. 2018: Machine learning for estimation of building energy consumption and performance: a review
[78] Federal Ministry for Economic Affairs and Energy 2019: Guided Autonous Locations
[79] So2Sat Project team 2017: So2Sat - 10^{16} Bytes from Social Media to Earth Observation Satellites
[80] Lernende Systeme – Die Plattform für Künstliche Intelligenz 2019: KI Landkarte Deutschland

accumulated experience, long-standing contacts and relationships in partner countries to meet these requirements, both from the point of view of education and training and by offering policy advice. That said, GIZ will itself have to develop new skills in order to meet these needs, particularly when it comes to handling, developing and managing algorithms and self-learning systems. It will also have to **forge new partnerships**, especially with private-sector businesses (AI start-ups and international technology firms), scientific institutes (academia) and civil society (foundations and NGOs) that already have expertise in these areas.

For AI to be used effectively as part of an evidence-based approach to urban development, developers must be able to access comprehensive datasets, some of which do not yet exist or will have to be expanded. **With this in mind, Germany's development work should include investments designed to expand publicly available city data pools. This would reduce the barriers to entry for local AI developers looking to build systems designed to encourage sustainable urban development. This investment might take the form of advice provided to partners, or the organisations delivering Germany's development work might themselves step in to play a bigger role in collecting and making use of relevant data themselves.** All work in this area should be in line with the Principles for Digital Development[81]. Pursuing a number of cross-sector initiatives could also provide the framework for comprehensive AI solutions in the future, while computer-assisted data generation, planning and implementation also holds out the promise of a better way of measuring the effectiveness of specific measures, thus contributing to a more efficient approach to urban development. This kind of monitoring has the further advantage that it makes improved contributions to the implementation of the 2030 Agenda more visible, thus highlighting the importance of cities, rather than national governments, as key actors for implementing development policy.

3.1. Ideas for supporting AI in urban development

Strategy

As described in this document, AI systems offer numerous opportunities for a human-centric, integrated approach to urban development, and can therefore make a significant contribution to the implementation of 2030 Agenda. However, these systems should not be deployed in a technology-driven way. Rather, the way in which they will be used by citizens and local administrative bodies should be the key consideration. **Hence, potential applications for AI should be based on the needs articulated by citizens, and citizens should be involved in identifying where AI systems can be used. The systems should be developed using a user-centric approach and carefully explained to users.**

We should never lose sight of the fact that developing AI is cost-intensive. Computing power costs money, as does the work done by AI specialists. Effective implementation of data strategies requires time and coordination. Given the risks set out in Chapter 2, there is a danger of societal and reputation damage if these facts are not taken adequately into account. **Therefore, it is important to think very carefully about the types of AI systems we are looking to develop and why, and the answers to these questions must be clearly defined before we begin developing and training algorithms**. Since an individual AI system can only solve a very narrowly defined problem, it will be important to determine which AI-assisted processes and products should be prioritised. **In view of this, the fundamental strategic decision centres on**

[81] Digital Principles for Development

whether AI should be developed to reduce costs (i.e. to optimise existing procedures) or to open up completely new areas of application. A clear focus in this area will be crucial.

The central focus for the development of AI must be the needs of city residents and the requirements for an integrated, sustainable approach to urban development. AI systems should be used as levers to make processes more efficient, effective, transparent and inclusive, which will in turn allow them to act as levers for the implementation of 2030 Agenda in cities. For this to happen, cities must do the following:

- Develop broad-based partnerships involving public (municipal level) authorities, local and foreign universities (with experience of AI solutions for and in cities), local and international technology firms, and civil society.
- Create fora and formats that allow AI use cases to be identified as part of a participatory process, and that allow expectations to be managed together with citizens.
- The outcomes of these fora should be developed by mapping the system around the selected use case.
- Draw up a data strategy for the application identified (collection, storage, cleaning, labelling, continuous updates, security)
- Conduct cost-benefit analyses

In addition, potential users should be made aware of the benefits of AI-assisted products and services, and they will require support to be in place for the introduction of such products and applications (i.e., strategies for 'last-mile offer' to the end-user must be developed). Such measures might include training staff, reviewing processes and adapting supervisory mechanisms, but they should also cover how to actually use the app on end devices.

Safeguards will be needed in order to meet the requirement for non-discriminatory, human-centric AI (e.g. to ensure privacy is respected, and to provide fairness, transparency and accountability). With a series of scandals triggering increasing concern about the privacy and ethical implications of AI systems, human-centric AI is becoming an ever more important issue. The way this issue is addressed will determine whether AI technologies are seen as legitimate in individual societies over the long term.

- Researchers and civil society stakeholders should carry out risk assessments/algorithm audits

As part of efforts to **build capacity,** it would be sensible to provide advice and support in the following areas:

At individual level

- Raising awareness of digital technologies and how to handle them, as well as training (i.e. improving digital literacy).
- Raising awareness among political decision-makers, administrators, citizens and civil-society representatives about the opportunities, potential, challenges and risks associated with AI.
- Drawing up communication strategies tailored to users
- Providing training on basic IT skills and terminology for administrators and civil society actors
- Developing strategies and options for a 'last mile offer' for users. Civil society groups should be involved in this process as they can ensure participation of marginalised groups, for example by articulating their needs and providing education and training on how to handle digital technology.

At an organisational level

- Create and fill a post of Chief Data Protection Officer or similar.
- Set up procurement procedures that allow for consultative, agile procedures and the participation of local start-ups in tenders.
- Expand physical and personal IT infrastructure within city authorities
- Establish technical standards for the collection and sharing of data, in consultation with actors in the local innovation system
- Introduce a level data management system
- Build service design capability (including for 'last mile offers').

Creating framework conditions:

Infrastructure: Expand networks and platforms to ensure sustainable mobilisation of resources

As local data and computing infrastructure is generally limited, **pools should be set up for anonymous, clean data**, and governments should follow a **consistent, open policy regarding data**. Initial models have already been developed for **city-level data partnerships** between the state, universities and private firms (such as data collaboratives, data marketplaces and open data platforms), for example in Copenhagen[82]. It may also make sense to **pool resources for joint, secure, high-performance data centres**, so that AI systems can be trained locally. Relationships should be built with academics to facilitate the exchange of knowledge and data, and with their students for opportunities such as internships.

Legal framework (national level)

- Introduce data protection legislation, such as clear regulations on the classification of information in terms of confidentiality and sensitivity.
- Draw up an ethical charter for the use of AI technologies
- Provide agile, transparent, process-orientated procurement rules
- Regulate in a way the encourages innovation by ensuring access to computing power (for instance by exempting computers from customs duties) and favouring start-ups (as in Tunisia's Start-Up Act)

[82] City of Copenhagen 2017: City Date Exchange Copenhagen
& City of Copenhagen 2018: City Date Exchange – Lessons Learned from a Public/ Private Data Collaboration

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