



# Six technologies that are shaping climate adaptation in India

With the effects of climate change becoming more pronounced, adaptation will be as important as mitigation, and that requires investments into climate technologies. **Deepak Mahurkar** and **Shardul Fadnavis** look at six technologies that could offer businesses the opportunity to innovate for climate adaptation and lock in long-term benefits.



Cyclone Michaung that hit Chennai nearly three months back was yet another wake-up call that the impacts of climate change are not distant scenarios but present-day realities. At the recent COP28 summit in Dubai, experts warned that the cyclone was a 'clear sign of climate change' and called for more climate-proofing measures.<sup>43</sup>

Climate proofing then is the need of the hour and while the effects of climate change are becoming more pronounced across the globe, the ramifications may be particularly alarming for India. Extreme heat waves, droughts and unpredictable monsoons threaten to endanger lives and jeopardise the country's agrarian landscape,<sup>44</sup> risking food security for 1.4 billion people. The sub-continent is also poised to see a greater rise in sea levels than higher latitudes due to its proximity to the equator.<sup>45</sup> The consequences of climate change for the economy, too, would be far reaching. The labour hours lost due to extreme heat and humidity could cost India up to 4.5% of its GDP by 2030.<sup>46</sup>

Businesses acknowledge the risks. In a PwC analysis, 100 major businesses said that physical climate risks had had financial impacts on them – equal to about 10% of annual sales and 4% of their market value.<sup>47</sup> But climate risks also offer an opportunity to innovate. Adaptation efforts will generate

43 The New Indian Express, Michaung clear sign of climate change  
44 World Bank, India: Climate change impacts  
45 Ibid.  
46 India Today, How climate change will hurt India's economy  
47 World Economic Forum and PwC, Accelerating business action on climate change adaptation

demand for products and services that help businesses, communities and ecosystems adapt and build resilience to climate risk.<sup>48</sup> At least 31 of the businesses reviewed by PwC had identified adaptation-related opportunities. For instance, an insurance company has designed a new type of insurance for adaptation,<sup>49</sup> offering insurance solutions to help clients scale up nature-based solutions for adaptation. Others are developing alternative construction materials, risk modelling tools, climate risk insurance and improved seed varieties.<sup>50</sup>

## Adaptation is as important as mitigation

In the past few years, countries that are party to the UN Framework Convention on Climate Change (UNFCCC) have stepped up efforts to emphasise climate adaptation alongside mitigation.

**77%** of countries have at least one national-level adaptation planning instrument – a policy, strategy or plan – in place.<sup>51</sup>

**25%** of countries have developed laws and acts that require national governments to prepare a national adaptation planning instrument.<sup>52</sup>

**69%** of countries have a central administrative body to oversee adaptation action.<sup>53</sup>

**67%** of countries have allocated domestic finance towards implementing adaptation priorities.<sup>54</sup>

Nevertheless, there is a need for more significant advancements. Progress on climate adaptation is slowing across all fronts – finance, planning and implementation – with the current adaptation finance gap estimated to be USD 194–366 billion per year.<sup>55</sup> Even as adaptation needs are growing, adaptation finance flows to developing countries reduced by as much as 15% in 2021. This is despite commitments made at COP26 in Glasgow that USD 40 billion per year would be provided in adaptation finance support by 2025.<sup>56</sup>



48 Ibid.  
49 Ibid.  
50 PwC, How climate adaptation can both protect and grow your business  
51 United Nations Environment Programme (UNEP), Adaptation Gap Report 2023  
52 Ibid.  
53 Ibid.  
54 Ibid.  
55 Ibid.  
56 Ibid.

Thus, the need to bolster climate finance and make the right investments – for example, into the right technologies – is imperative to safeguard livelihoods and business models.

### Current trends in climate tech investments in India

#### Climate-focused investments are gaining momentum

The climate tech startup ecosystem is still in its early phases in India, but it's growing rapidly. 2021 was a landmark year for the climate tech sector with funding reportedly increasing over four times compared to the previous year.<sup>57</sup> While the total climate tech investment in 2021 was estimated at USD 20 billion,<sup>58</sup> in 2022, it increased to USD 22.5 billion.<sup>59</sup>

In 2022, equity funding for climate tech amounted to USD 4.7 billion.<sup>60</sup> The top three sectors with the largest share of the pie were energy transition at USD 2.25 billion, followed by clean mobility (USD 1.44 billion) and sustainable agriculture (USD 755 million).<sup>61</sup>

Globally, tough conditions in private markets in 2023 have

pushed climate tech startup funding back to the level it was at five years ago.<sup>62</sup>

In 2023, climate tech investments from venture capital and private equity were down by 40%. Notably, this drop was mainly due to macroeconomic factors that led to a subdued outlook. The dip, however, is less severe than the investment in other categories, which reduced by 50%.<sup>63</sup>

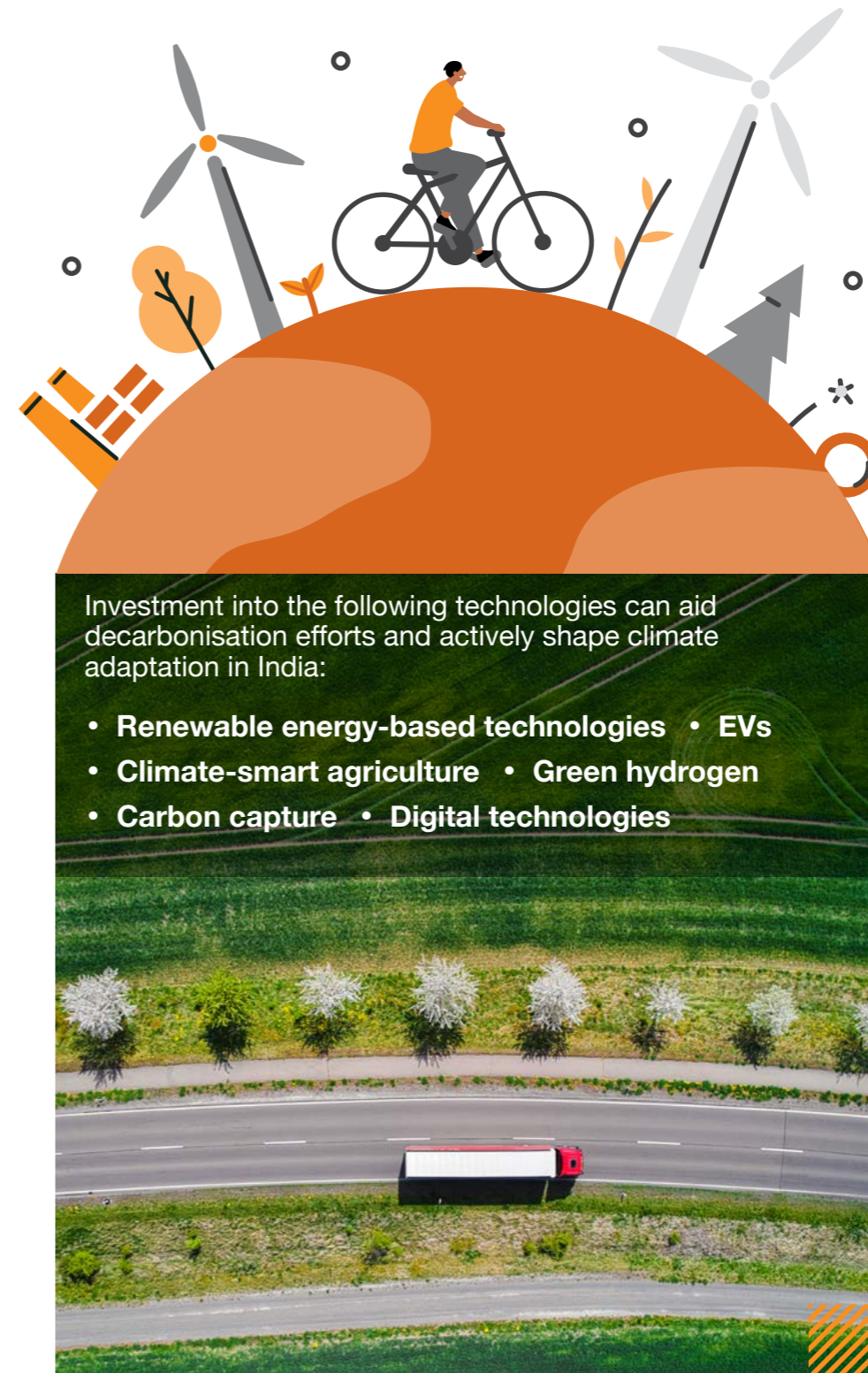
#### There is a growing interest in climate tech among new investors

India has a thriving startup landscape, with at least 22,000 startups working on renewable energy, AgriTech and green technologies.<sup>64</sup> Investors, too, have awakened to the threat posed by climate change. In 2022, the climate technology landscape witnessed 130 new investors in India, increasing the size of the equity investor community to over 310.<sup>65</sup> Angel investors are also playing a pivotal role in climate tech investments. In 2022, 37% of climate investments were at the seed stage.<sup>66</sup> Large corporations make up 14% of the country's climate tech funders.<sup>67</sup>

#### Investments are moving beyond EVs and renewables

Investment is shifting towards hard-to-abate sectors with higher levels of emissions and towards technologies with greater emissions reduction potential such as carbon capture, utilisation and storage (CCUS) and green hydrogen.<sup>68</sup> India, too, is diversifying its climate technology investments beyond the energy sector. In 2021, electric vehicles (EVs) and energy<sup>69</sup> accounted for a large part of the USD 7 billion raised by climate tech startups, but newer technologies such as green hydrogen have since gained traction. In 2022, funding allocated to waste management and circularity solutions went up by five times, while the AgriTech sector saw a 20% increase in venture funding.<sup>70</sup>

Adaptation is a critical part of India's nationally determined contributions (NDCs) and aims to boost investments in development programmes in sectors and regions at risk of climate change.<sup>71</sup> Climate technologies can tackle environmental challenges while opening up business opportunities in an eco-conscious world.



Investment into the following technologies can aid decarbonisation efforts and actively shape climate adaptation in India:

- Renewable energy-based technologies
- EVs
- Climate-smart agriculture
- Green hydrogen
- Carbon capture
- Digital technologies

### Renewable energy-based technologies

Renewable energy is acknowledged as a measure for both mitigation and adaptation. At least 34% of the 190 countries that had submitted NDCs by the end of 2020 mentioned renewable energy in their adaptation component.<sup>72</sup> India, too, has focused on renewable energy to aid its adaptation efforts. Though, in 2022, India fell short of its renewable target of 175 gigawatt (GW) comprising 100 GW from solar, 60 GW from wind, 5 GW from 'small' hydro and the remaining 10 GW from bio-power – developing 120 GW of renewable energy capacity by the end of the year<sup>73</sup> – the country has seen considerable growth in the sector. It has set an ambitious goal of 500 GW of non-fossil fuel capacity by 2030.<sup>74</sup> Solar and wind energy are expected to draw in significant investment this decade due to their potential to offer sustainable, commercial returns to businesses.<sup>75</sup> India's solar and wind power base is the fourth largest in the world.<sup>76</sup> Hybrid projects have piqued interest as well. For example, a large corporation recently commissioned its third wind-solar hybrid power plant in Rajasthan.

Solar photovoltaics (PV) is among the fastest growing sub-sectors. While an estimated 12.7 million people were either directly or indirectly employed in the renewable energy sector globally

57 Unitus Capital and Climake, The State of Climate Finance in India 2022

58 Ibid.

59 Unitus Capital and Climake, The State of Climate Finance in India 2023

60 Ibid.

61 Ibid.

62 PwC, State of Climate Tech 2023

63 Ibid.

64 Unitus Capital and Climake, The State of Climate Finance in India 2023

65 Ibid.

66 Ibid.

67 Ibid.

68 Ibid.

69 Unitus Capital and Climake, The State of Climate Finance in India 2023

70 Ibid.

71 MoEF, India's NDCs

72 IRENA (2021), Bracing for climate impact: Renewables as a climate change adaptation strategy, International Renewable Energy Agency, Abu Dhabi

73 Ibid.

74 IRENA (2023), Low-cost finance for the energy transition, International Renewable Energy Agency, Abu Dhabi

75 Unitus Capital and Climake, The State of Climate Finance in India 2023

76 Ibid.



in 2021, a third of these jobs were in solar PV.<sup>77</sup> India is also making strides in solar PV, increasing its capacity to 10.3 GW in 2021, up from 4.2 GW installed in 2020. Supportive regulatory frameworks, such as the government's production-linked incentive (PLI) scheme, are giving a boost to domestic manufacturing. India is expected to add an estimated 29 GW of cell capacity and 33 GW of module capacity by 2025.<sup>78</sup>

Despite these advantages, the overall share of renewable energy in the primary energy mix needs to increase to 75% for the world to meet the 1.5°C climate goal of the Paris Agreement. This requires an annual investment of over USD 4.4 trillion.<sup>79</sup> More investments are being made in energy-related climate tech globally. The shift is especially remarkable in neighbouring China, where startup investment in energy-related tech increased to 22.2% in 2023 from just under 2% in 2018.<sup>80</sup>

Technological innovations can extend the benefits of renewable energy-based solutions to non-energy services. For instance, distributed renewable energy solutions – technologies that don't rely on centralised energy generation – are increasingly being deployed in remote regions to provide access to water.<sup>81</sup>

Decentralised solar- or wind-powered water purification systems can be a cost-effective solution in developing countries.<sup>82</sup>

Furthermore, vapour (or fog) harvesting is an emerging technology that collects water in the ambient air. Desert safaris in Dubai are using hydro panels that turn vapour in the atmosphere into drinking water using solar PV and solar thermal technologies.<sup>83</sup>

## EVs

Apart from directly reducing emissions, EVs can aid in climate adaptation efforts by helping build a more resilient transport infrastructure. The market for EVs is a small but growing one. Currently, 591 brands sell EVs in India. Of these, 456 are in three-wheelers alone, making up 53% of all three-wheeler sales.<sup>84</sup> However, the share of EVs in the two-wheeler (5%) and four-wheeler segments (1%) is small.<sup>85</sup>

Technological advancements are required to address the two elements that are crucial for EV adoption at scale – a robust charging infrastructure and lower battery prices. The government has already rolled out initiatives to address both. Under the Faster Adoption and Manufacturing

of Hybrid and Electric Vehicles (FAME) scheme, 862 hybrid/ electric buses had been deployed in various cities by 2021.<sup>86</sup> Under Phase-II of the initiative, charging infrastructure is being developed in the country. The government has also introduced a PLI scheme for manufacturing of advanced chemistry cell (ACC) in the country to enable a dip in battery prices. The private sector, too, is getting on board with EVs. An Indian engineering and construction firm is rolling out EVs across its campuses,<sup>87</sup> while a power company has developed EV charging stations along national highways.<sup>88</sup>

## Climate-smart agriculture (CSA)

CSA is playing a pivotal role in fortifying adaptive strategies to cope with climate change. Soilless farming, bioengineering to make plants more resistant to disease or temperature, and precision farming are all techniques that can help farmers optimise resources. Precision technologies allow farmers to manage different zones of an agricultural field separately instead of applying the same crop treatment to the entire field. This means treatment is automatically adjusted to meet each site's

unique needs.<sup>89</sup> Satellite imagery and drone technology are used in precision farming to take images of the field for timely interventions.

Climate-smart tech is being embraced by farmer communities at the grassroots. For instance, in the drought-prone state of Maharashtra, recent initiatives signal a concerted effort to bring about a positive shift. In affected regions, farmers are adopting smart agriculture practices. To cultivate high-yielding crop varieties, greenhouse farming is being deployed.<sup>90</sup> Farmers have changed their cropping pattern by shifting to less water-intensive crops and are also experimenting with artificial cross-breeding of crops.<sup>91</sup> Elsewhere, farmers have also been adopting climate-resilient strategies to grow heat-resistant varieties of crops.

AgriTech developments are vital to sustain these efforts. Over 1,300 agri startups operating in India are using technologies like machine learning (ML) artificial intelligence (AI), and IoT. Most of these agri startups are concentrated in Karnataka, Maharashtra and Delhi-NCR.<sup>92</sup> To encourage agri startups and to modernise agricultural practices, the government has also announced a new 'Agriculture Accelerator Fund' last year.

## Green hydrogen

The green component of green hydrogen comes from the source of the electricity used, which comes from renewable energy sources. With an eye on becoming the leading producer and supplier of green hydrogen, India launched its National Green Hydrogen Mission in 2022. The country has set an ambitious target of developing a green hydrogen production capacity of at least 5 million metric tonne (MMT) per annum. Along with this, India is aiming at an associated renewable energy capacity of about 125 GW.<sup>93</sup> As part of the mission, regions that can support large-scale hydrogen production will be developed as 'green hydrogen hubs' and financial incentives will be provided to target domestic manufacturing of electrolysers and production of green hydrogen.<sup>94</sup>

The mission will support pilot projects in hard-to-abate sectors like steel, long-range heavy-duty mobility, shipping and energy storage. Currently, hydrogen produced from natural gas is utilised for production of nitrogenous fertilisers and petrochemicals. Replacing this with green hydrogen could pave the way for use of renewable energy in these sectors and bring

down import dependence.<sup>95</sup> Fuel cell electric vehicles (FCEVs) that run on hydrogen fuel will have an advantage over EVs since batteries required for EVs are dependent on imported raw materials like lithium and cobalt<sup>96</sup> while India has the capacity and resources to become self-reliant in the hydrogen fuel cell supply chain.

## Carbon capture

While carbon capture is primarily aimed at mitigation, its associated benefits can aid in adaptation. The market for carbon capture solutions is growing. CCUS, including CO2 removal, is the only category of climate tech globally to show an absolute rise in investment over the past two years.<sup>97</sup> In India, startups enabling carbon credit access for nature-based solutions raised USD 11 million even as industrial-based carbon capture remained minimal, mostly due to significant costs.<sup>98</sup> Another form of carbon capture, direct air capture (DAC) technologies – that capture CO2 from the air – are also at a nascent stage with cost and scale of operations yet to be clearly defined.<sup>99</sup>

Wider adoption of CCUS technologies will require policy support and economic incentives

77 IRENA, Renewable energy and Jobs: Annual review 2022

78 Ibid.

79 IRENA (2023), Low-cost finance for the energy transition, International Renewable Energy Agency, Abu Dhabi

80 PwC, State of Climate Tech 2023

81 IRENA (2021), Bracing for climate impact: Renewables as a climate change adaptation strategy, International Renewable Energy Agency, Abu Dhabi

82 Ibid.

83 Ibid.

84 Unitus Capital and Climake, The State of Climate Finance in India 2023

85 Ibid.

86 PIB, Press release

87 strategy+business, Indian engineering firm mapping new growth

88 strategy+business, Pursuit of a renewable future

89 USDA, Precision agriculture in crop production

90 PwC, Climate, community, cooperation: An Indian approach to adaptation in the Global South

91 Ibid.

92 Inventiva, Agritech in India: An overview

93 PIB, National Hydrogen Mission

94 Ibid.

95 Ibid.

96 Ibid.

97 PwC, State of Climate Tech 2023

98 Ibid.

99 NITI Aayog, CCUS



such as tax or cash subsidy on the captured CO2 and loan guarantee.<sup>100</sup> The captured CO2 can also contribute to a circular economy. For example, conversion of CO2 to various polymers – with applications in laptop packaging and cell phone casings – has been attempted globally.<sup>101</sup> CO2 utilisation technologies are relatively less developed compared to capture technologies,<sup>102</sup> necessitating investment in R&D in utilisation technologies.

### Digital technologies

Digital technology solutions are helping build climate resilience among communities, offering real-time tracking and data-driven decision making. Such technologies include advanced climate modelling, remote sensing and satellite technology, and IoT. In Maharashtra, a cutting-edge IT-driven, remote sensing information system can analyse water resources in real time.<sup>103</sup> Satellites and ML are being used to issue detailed flood alerts while AI is helping detect wildfires and send early warnings.<sup>104</sup> The United Nations' 'Early Warnings for All' initiative plans to use early warning systems (EWS) to protect people against extreme weather events within five years.<sup>105</sup> India is constantly looking to improve its forecasting and EWS system. By 2025, the Doppler Weather Radar

Network is likely to cover the entire country and will predict extreme weather events more accurately.<sup>106</sup>

### Key challenges to climate-tech adaptation

- **Mitigation takes precedence over adaptation when it comes to finance flows:** Mitigation actions are perceived to have more direct consequences than adaptation action. For instance, reduction in carbon emissions can provide a measurable metric for assessing the effectiveness of mitigation action. But the impact of a community-based flood resilience programme is hard to quantify. Therefore, international funding has prioritised mitigation.
- **Lack of integration with business strategy:** Businesses often view adaptation as a corporate social responsibility rather than a business imperative.<sup>107</sup> This requires a mindset change. Businesses need to acknowledge that climate change poses tangible risks to operations and supply chains, and align an understanding of climate adaptation with the broader business strategy.
- **High costs of new adaptation solutions:** Many technologies designed to enhance resilience can have high implementation

costs. Innovative technologies also require continuous R&D so that they can be cost-effective and scalable. There are further challenges to scalability as effective adaptation measures are not 'one-size-fits-all' solutions and need to be customised according to the local context.

### Recommendations

Technological innovations present India with the unique opportunity to catalyse resources for adaptation efforts. Concerted efforts along with supportive policies can help embrace sustainable technologies. Our recommendations include:

- mobilise private finance
- provide global funding for local solutions
- rethink the industrial system.

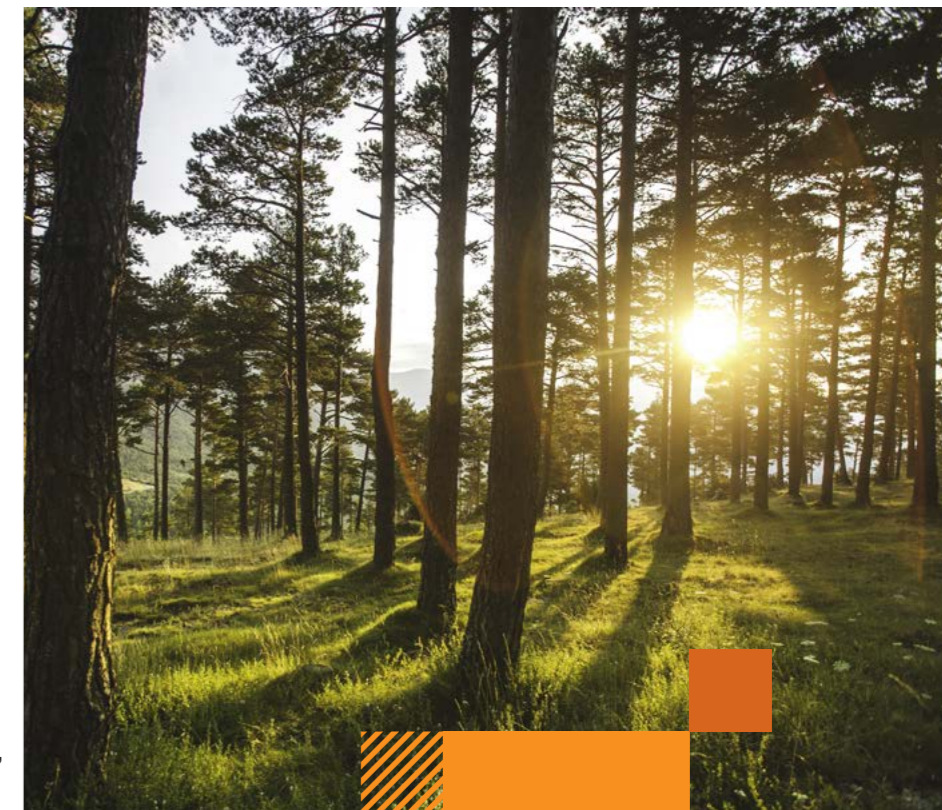
### Mobilise private finance

The major source of adaptation funding in India is domestic, with adaptation measures being funded by Central and state government budgets.<sup>108</sup> To support India's green transition, the private sector needs to play a much bigger role. One way to encourage private investors is strategic transfer of risks linked to commercialisation and deployment of new technologies. While risks can be mitigated through many

risk instruments, existing risk instruments do not adequately cover policy and market risks for climate technology investments.<sup>109</sup> In practice, blended and concessional finance models are frequently employed to shift some of the risk burden from private to public entities.<sup>110</sup>

Initiatives such as the Climate Finance Leadership Initiative (CFLI) – which mobilises private capital for climate solutions – can fast-track adaptation solutions. At COP28, CFLI announced climate finance solutions across e-mobility, green hydrogen, circular economy and renewables that have the potential to mobilise over USD 6.5 billion in support of India's low-carbon, climate-resilient development.<sup>111</sup> Some of the new solutions that private players will be leading include:

- A first-of-its-kind blended finance platform that will encourage e-vehicle adoption among fleet operators by providing specialised counterparty financing options.<sup>112</sup>
- Leasing solutions and loans for EVs with an aim to achieve 10–12% EV penetration by 2030.<sup>113</sup>
- Innovative financing frameworks to enable public-private partnerships (PPPs). Such structures have the potential to mobilise USD 2 billion worth of private capital via PPPs by 2030.<sup>114</sup>



### Provide global funding for local solutions

International investors often face challenges due to lack of in-country presence, local experience and limited financial appetite for small projects.<sup>115</sup> Mechanisms that aggregate smaller constituent assets and projects in developing countries into larger, tradeable assets can draw in larger institutional investors.<sup>116</sup> For example, a fund could be set up to pool in several small-scale renewable energy projects in remote villages in a country, creating a larger, more manageable entity.

100 NITI Aayog, CCUS

101 Ibid.

102 Ibid.

103 PwC, Climate, community, cooperation: An Indian approach to adaptation in the Global South

104 Ibid.

105 PwC, How climate adaptation can both protect and grow your business

106 PwC, Climate, community, cooperation: An Indian approach to adaptation in the Global South

107 World Economic Forum and PwC, Accelerating business action on climate change adaptation

108 Climate Policy Initiative, Landscape of green finance in India 2022

109 UNFCCC, Enhancing access to climate technology financing

110 Ibid.

111 Bloomberg, CFLI India announces climate finance solutions

112 Ibid.

113 Ibid.

114 Ibid.

115 OECD, Scaling up the mobilisation of private finance for climate action

116 Ibid.



Moreover, international financial support needs to converge with grassroots initiatives for meaningful long-term adaptation. By involving local communities in decision making, adaptation strategies can cater to the specific needs of each community.

A great example of community collaboration can be seen in coastal regions which are particularly exposed to climate change. To overcome floods that batter their region every year, the Mishing tribe in the Brahmaputra plains of eastern Assam have re-engineered their housing.<sup>117</sup> The community now resides in houses built on bamboo stilts with mud foundations. The floor height of these structures can be adjusted according to the flood levels. A light raft is also secured underneath the houses.<sup>118</sup> Farmer field schools (FFS) are another success story from the grassroots. FFS include a group of farmers that gather once a week under a trained facilitator to brainstorm sustainable agriculture solutions.<sup>119</sup>

### Rethink the industrial system

To expedite the shift to a sustainable world, ecosystems must swiftly adapt to emerging commercial realities.<sup>120</sup> Technologies that are required to shift to a carbon-neutral industrial system already exist, for example, drought-resistant crops that produce higher yields and solar panels and wind turbines that

provide clean energy at the lowest cost.<sup>121</sup> But multiple factors slow down the change that is required.

Technology adoption is slow due to reliance on existing technologies and high investment requirements.<sup>122</sup> Businesses may want to wait for technologies to mature and offer better returns before making an investment. Therefore, rethinking the industrial system would require organisations to reinvent internally. For businesses, this would mean becoming future-ready by cutting down bad costs and developing differentiated capabilities.<sup>123</sup>

Also contributing to this article were **Vishnupriya Sengupta** and **Ruchika Uniyal**.

**Deepak Mahurkar** is Partner and Leader, Oil and Gas sector.

**Shardul Fadnavis** is Partner and Markets Leader, Climate and Energy.



117 UNFCCC, Enhancing access to climate technology financing

118 Ibid.

119 Ibid.

120 strategy+business, The reconfiguration imperative

121 Ibid.

122 Ibid.

123 Ibid.